No. 05-1120

In the Supreme Court of the United States

COMMONWEALTH OF MASSACHUSETTS, *et al.*,
Petitioners,

v.

U.S. ENVIRONMENTAL PROTECTION AGENCY, *et al.*,
Respondents.

On Petition of Writ of Certiorari to the United States Court of Appeals for the District of Columbia Circuit

BRIEF OF *AMICI CURIAE* CLIMATE SCIENTISTS DAVID BATTISTI, CHRISTOPHER FIELD, INEZ FUNG, JAMES E. HANSEN, JOHN HARTE, EUGENIA KALNAY, DANIEL KIRK-DAVIDOFF, JAMES C. MCWILLIAMS, JONATHAN T. OVERPECK, F. SHERWOOD ROWLAND, JOELLEN RUSSELL, SCOTT R. SALESKA, JOHN M. WALLACE, AND STEVEN C. WOFSY IN SUPPORT OF PETITIONER

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INTEREST OF THE *AMICI CURIAE*[1]

Amici Curiae Climate Scientists are David Battisti, Christopher Field, Inez Fung, James E. Hansen, John Harte, Eugenia Kalnay, Daniel Kirk-Davidoff, James C. McWilliams, Jonathan T. Overpeck, F. Sherwood Rowland, Joellen L. Russell, Scott R. Saleska, John M. Wallace, and Steven C. Wofsy (hereinafter "Climate Scientists").[2] The Climate Scientists are individual climate scientists who are actively involved in research on changes to the Earth's climate that are being caused by anthropogenic emissions of carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons ("greenhouse gases" or "GHGs") and the effects of those changes. Most of these scientists are members of the National Academy of Sciences ("NAS")[3] or Engineering, or have served on one or both of two recent National Academy of Sciences/National Research Council ("NAS/NRC") panels that have reviewed the state of the science on climate change and the impacts of human activities on climate.[4] The NRC, the Academy's principal

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[1] All parties have consented to the filing of this brief. Pursuant to this Court's Rule 37.6, *Amici* state that no counsel for any party in this case authored this brief or the appended Statement in whole or in part, and no person other than *Amici* and their counsel have made a monetary contribution to the preparation and submission of this brief or the appended Statement.

[2] The Climate Scientists are appearing in their individual capacity and not as representatives of any institution with which any of them is affiliated.

[3] "The National Academy of Sciences ("NAS") is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of a charter granted to it in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters." NATIONAL RESEARCH COUNCIL, CLIMATE CHANGE SCIENCE: AN ANALYSIS OF SOME KEY QUESTIONS (2001) ["CLIMATE CHANGE SCIENCE" or "2001 NAS/NRC Report"], Preface.

[4] *Id.*; COMMITTEE ON ABRUPT CLIMATE CHANGE, NATIONAL RESEARCH COUNCIL, ABRUPT CLIMATE CHANGE: INEVITABLE SURPRISES (2002.)

operating arm, was formed in 1916 to further scientific and technological knowledge and to advise the federal government. NATIONAL RESEARCH COUNCIL, CLIMATE CHANGE SCIENCE: AN ANALYSIS OF SOME OF THE KEY QUESTIONS, preface (2001). *Amicus* David Battisti is the Tamaki Professor of Atmospheric Sciences at the University of Washington. He has a Ph.D. from the University of Washington in the field of atmospheric sciences. He has been involved in the field of climate dynamics and climate change since 1984 and his research involves climate variability (El Nino, drought in the Sahel, decadal variability in the climate system), paleoclimate (abrupt climate change during the last glacial period), and climate change. He served for three years on the NAS Committee for Climate Research and for six years was co-chair of the United States Climate Variability and Predictability Science Steering Committee.

Amicus Christopher Field is the founding director of the Department of Global Ecology of the Carnegie Institution of Washington and Professor of Biological Sciences at Stanford University. He has a Ph.D. from Stanford University in the field of biological sciences. He has been involved in the study of climate change impacts and the global carbon cycle since 1988. He is a member of the National Academy of Science.

Amicus Inez Fung is Professor of Atmospheric Science and Co-Director of the Berkeley Institute of the Environment at the University of California at Berkeley. Dr. Fung received her Sc.D. from the Massachusetts Institute of Technology. Her research expertise is in large-scale numerical modeling of biogeochemical cycles and their interaction with climate. Her research also includes climate change, remote sensing of earth systems, investigations of atmosphere-ocean interactions, and atmosphere-biosphere interactions. She is a member of the National Academy of Sciences and served on the National Research Council's Committee on Climate Change Science

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["ABRUPT CLIMATE CHANGE" or "2002 NAS/NRC Report"].

that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[5]

Amicus James E. Hansen is head of the NASA Goddard Institute for Space Studies. Dr. Hansen received his Ph.D. from the University of Iowa. His research interests include radiative transfer in planetary atmospheres, development of global climate models, current climate trends from observational data, and projections of man's impact on climate. He is a member of the National Academy of Sciences and served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[6]

Amicus John Harte is a Professor in the Energy and Resources Group and the Ecosystem Sciences Division of the College of Natural Resources at the University of California at Berkeley. He received a B.A, in physics from Harvard University in 1961 and a Ph.D. in theoretical physics from the University of Wisconsin in 1965. He has been involved in the study of earth system science since 1973 and his research currently focuses on the ecological consequences of climate change and the climate consequences of ecological changes. He has served on six different panels of the National Academy of Sciences/National Research Council.

Amicus Eugenia Kalnay is a Distinguished University Professor at the University of Maryland. Previously she was Director of the Environmental Modeling Center at the National Weather Service and Head of the Global Modeling Branch at the NASA Goddard Space Flight Center. She has a Ph.D. in meteorology from MIT. Her research expertise is in numerical modeling of the atmosphere, data assimilation and predictability, El Nino prediction, and applications of satellite remote measurements to weather and climate problems. She is a

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[5] CLIMATE CHANGE SCIENCE, *supra,* note 3.

[6] *Id.*

member of the National Academy of Engineering, and has served on many panels of the National Academy of Sciences/National Research Council.

Amicus Daniel Kirk-Davidoff is an Assistant Professor in the Department of Meteorology at the University of Maryland. He received a Ph.D. in Meteorology from the Massachusetts Institute of Technology in 1997. He is a climate dynamicist with interests in the stratospheric water vapor budget, paleoclimate modeling, satellite climate monitoring, and the use of satellite data to improve climate models.

Amicus James C. McWilliams is the Louis Slichter Professor of Earth Sciences at University of California, Los Angeles. He has a Ph.D. from Harvard University in the field of applied mathematics. He has been involved in the study of oceanic and atmospheric circulations and climate since 1970. He is a member of the National Academy of Sciences and a Fellow of the American Geophysical Union. He served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[7]

Amicus Jonathan T. Overpeck is a Professor of Geosciences and a Professor of Atmospheric Sciences at the University of Arizona. He has a Ph.D. from Brown University in the field of geological sciences. He has been involved in the study of climate science since 1979. His research focuses on using models and the climate record of the past million years to understand climate variability and future change. He has served on the NAS/NRC Committee on Abrupt Climate Change.[8]

Amicus Prof. F. Sherwood Rowland is the Bren Research Professor of Chemistry and Earth System Science at the University of California Irvine. He has a Ph.D. in Chemistry from the University of Chicago in the field of Physical Chemistry. He has been involved in the study of

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[7] *Id.*

[8] ABRUPT CLIMATE CHANGE, *supra,* note 4.

the atmosphere since 1973, and received the 1995 Nobel Prize in Chemistry (with Mario Molina and Paul Crutzen) for his "work on atmospheric chemistry, particularly concerning the formation and decomposition of ozone." He is a member of the National Academy of Sciences, and received the Roger Revelle Medal of the American Geophysical Union. He is a member of the Board on Atmospheric Sciences and Climate of the National Research Council, and served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[9]

Amicus Joellen L. Russell is an Assistant Professor of Geosciences at the University of Arizona. She received her B.A. in Environmental Geoscience from the Department of Earth and Planetary Sciences at Harvard University in 1993, and her Ph.D. in Oceanography from the Scripps Institution of Oceanography at the University of California, San Diego, in 1999. Her research focuses on biogeochemical dynamics, the interactions between the biological, geological and chemical components of Earth's environment.

Amicus Scott R. Saleska is an Assistant Professor of Ecology and Evolutionary Biology at the University of Arizona. He received a B.S. in Physics from the Massachusetts Institute of Technology in 1986 and a Ph.D. in Energy and Resources from the University of California at Berkeley in 1998. His research focuses on how climate interacts with plant physiology, demography, and ecological processes to influence or control biogeochemical cycling from local to global scales.

Amicus John M. Wallace is a Professor in the Department of Atmospheric Sciences at the University of Washington. He has a Ph.D. from the Massachusetts Institute of Technology in the field of meteorology. He has been involved in the study of climate variability and change since 1980 and his research involves El Nino and

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[9] CLIMATE CHANGE SCIENCE, *supra,* note 3.

other patterns of climate variability. He served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[10] He is a member of the National Academy of Sciences and served on the NAS/NRC Committee on Abrupt Climate Change: Science and Public Policy.[11]

Amicus Steven C. Wofsy is the Abbott Lawrence Rotch Professor of Atmospheric and Environmental Science at Harvard University. He has been involved in the study of atmospheric science since 1971 and his research focuses on climate and the global carbon cycle. He serves on many scientific advisory groups of the federal government.

Amici curiae Climate Scientists are concerned about the possible, likely and virtually certain impacts on the Earth's climate from manmade emissions of GHGs. They are also concerned about the legal interpretation of concerns about scientific uncertainty on this issue and the misinterpretation of relevant scientific conclusions in the decision below.

The Climate Scientists submit the attached Statement (Appendix) and this brief to assist this Court in understanding the nature and extent of scientific uncertainty related to human induced climate change. *Amici Curiae* support the position of petitioners and urge that this Court grant *certiorari* to review the decision of the Court of Appeals for the District of Columbia.

SUMMARY OF ARGUMENT

The Court should grant *certiorari* to review the decision of the Court of Appeals on the issue of global climate change--a matter of great importance under both the Clean Air Act and a treaty to which the United States is a party. As the appended Statement by the Climate Scientists demonstrates, the Earth's climate is changing in ways that

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[10] CLIMATE CHANGE SCIENCE, *supra* note 3.

[11] ABRUPT CLIMATE CHANGE, *supra* note 4.

are significantly increasing the risk of adverse impacts on public welfare. Time is of the essence because delay in greenhouse gas regulation will only accelerate global climate change. EPA must begin regulating greenhouse gas emissions from motor vehicles now to slow climate change in time to reduce the risk of adverse impacts.

This Court should also grant *certiorari* because the Court of Appeals ignored this Court's decisions directing a reviewing court to conduct a searching inquiry of the facts upon which the agency relied, and directing that reviewing courts not simply accept the agency's invocation of scientific or technical uncertainty as the basis for their decision. The Court of Appeals assumed that EPA has the statutory authority to regulate greenhouse gas emissions from motor vehicles, but decided that EPA had properly exercised its discretion in refusing to regulate these emissions. The Court of Appeals decision, however, simply summarized the areas of lesser certainty without even discussing areas of greater certainty. Contrary to the understanding of the Court of Appeals, there is reasonable scientific certainty that emissions of carbon dioxide and other greenhouse gases from mobile sources and other anthropogenic sources have already had an effect on the Earth's climate and will continue to affect climate in the future.

In addition, the Court of Appeals ignored this Court's decisions requiring agencies to follow the plain language of their statutory delegation, and prohibiting agencies from adding factors not enumerated in the statute.. In so doing, the Court of Appeals ignored the plain language of Section 202(a)(1) of the Clean Air Act, 42 U.S.C. § 7521(a)(1), allowed EPA to consider factors that are not contained in the statute, and seriously devalued the scientific advice that the government had requested in the first place. This Court should grant *certiorari* to require EPA to make a decision based on the plain language of Section 202(a)(1) and based on the science that the government requested from the National Academy of Sciences. This conclusion is reinforced by Article 3,

paragraph 3, of the United Nations Framework Convention on Climate Change, U.N. Doc. A/AC 237/18 (1992), *reprinted in* 31 I.L.M. 849 (1992) [UNFCCC], which the United States has ratified, and which directs parties not to employ "lack of full scientific certainty" as a reason to postpone measures to address climate change.

ARGUMENT

THE COURT SHOULD GRANT CERTIORARI TO REQUIRE EPA TO FOLLOW THE CLEAN AIR ACT AND SETTLE A GLOBALLY SIGNIFICANT ISSUE REGARDING THE IMPACT OF GREENHOUSE GASES ON THE EARTH'S ENVIRONMENT.

I. The Court of Appeals Ignored Reasonable Scientific Certainty That Emissions of Carbon Dioxide and Other Greenhouse Gases from Mobile Sources and Other Anthropogenic Sources Have Already Had an Effect on the Earth's Climate and Will Continue to Affect Climate in the Future.

A consensus of scientists now working on climate change holds that it is likely that emissions of carbon dioxide and other greenhouse gases from mobile sources and other anthropogenic sources have already had an effect on the earth's climate and are changing the Earth's climate in ways that are significantly increasing the risk of adverse impacts on public welfare. That consensus was contained in the 2001 NAS/NRC report that the federal government requested to provide the Bush Administration with an assessment of the areas of greater and lesser certainty in climate change science.[12] EPA said: "We rely in this decision on NRC's objective and independent assessment of the relevant science." 68 Fed. Reg. 52,922, 52,930 (Sept. 8, 2003) (adding that nothing received during

[12] Letter from John M. Bridgeland and Gary Edson to Bruce Alberts (May 11, 2001), reprinted in *id.* at 27.

the public comment period "causes us to question the validity of the NRC's conclusions").

In its decision upholding EPA, however, the Court of Appeals significantly misrepresented the findings of the 2001 NAS/NRC Report by emphasizing uncertainties in climate change science while failing even to mention the existence of fundamental areas of certainty or consensus. *Massachusetts v. EPA,* 415 F.3d. 50, 57 (D.C. Cir. 2005). The Court then used scientific uncertainty (which it had misrepresented) as a basis for upholding EPA's decision. *Id.* at 58. As this Court has made clear, however, reviewing courts are obliged to conduct a "searching and careful" review of the facts to determine whether "there has been a clear error of judgment," *Citizens to Preserve Overton Park v. Volpe*, 401 U.S. 402, 416 (1971), and to determine, even in cases of scientific or technical uncertainty, whether the agency has adequately explained the available evidence and offered a "rational connection between the facts found and the choice made." *Motor Vehicle Manufacturers Ass'n v. State Farm Mutual Automobile Ins. Co.*, 463 U.S. 29, 43 (1983), *citing Burlington Truck Lines, Inc. v. United States*, 371 U.S. 156, 168 (1962). By not conducting that kind of review of EPA's decision, the Court of Appeals decision so departs from this Court's decisions as to warrant a grant of *certiorari* .

To provide this Court with an understanding of the areas of greater and lesser certainty, the Climate Scientists (including many of the authors of the Report cited by EPA and the Appeals Court) state the following:[13]

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[13] The *Amici* Climate Scientists characterize scientific uncertainties using the same system employed by the Intergovernmental Panel on Climate Change. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE ("IPCC"), CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS 2 fn. 7 (2001) : "'the following words have been used where appropriate to indicate judgmental estimates of confidence: virtually certain (greater than 99% chance that a result is true); very likely (90-99% chance); likely (66-90% chance); medium likelihood (33-66% chance); unlikely (10-33% chance); very unlikely (1-10% chance); exceptionally unlikely (less than 1% chance).'" Thus, findings that are virtually certain, very likely and likely, all meet the "more likely than not" standard and many determinations of "medium" likelihood are "more likely than not."

1. The basic physics underlying the greenhouse effect is firmly established. Two principles in particular are as certain as any phenomena in planetary sciences. First, certain atmospheric gases absorb radiation that otherwise would be lost to space (thereby making a planet with those gases in its atmosphere warmer than it would be without them). Second, greater atmospheric concentrations of greenhouse gases, all other things being equal, cause higher temperatures at the surface of a planet. The Earth is habitable for its current life forms in part because natural levels of greenhouse gases in the atmosphere warm the planet.
2. Over the last two centuries, it is virtually certain that human activities have increased the amount of greenhouse gases in the atmosphere to a level not seen in all of human experience, and likely not seen for at least 3 million years.
3. It is likely or very likely that human-induced increases in greenhouse gases are already causing global climate to change. The average global surface temperature has risen (human activities likely caused most of the approximately 0.6°C -- 1.1° F -- rise over the 20th century), global average sea level has risen (by 0.1 to 0.2 meters -- 1/3 to 2/3 feet -- over the 20th century), snow cover and ice extent in the Arctic has decreased by about 10% and 25%, respectively, since the late 1960s, and stratospheric temperatures have dropped (a virtually certain consequence of both stratospheric ozone depletion and greenhouse gas increases). A variety of other related climate factors are changing in a way that is consistent with greenhouse gas-induced planetary warming. By contrast, it is very difficult to find global scale measures of climate that indicate cooling.
4. It is virtually certain that what has been observed so far is only the beginning, and that continued greenhouse gas emissions along current trajectories will cause *additional* warming of the earth system as a

whole, and very likely that such perturbation would cause the rate of surface warming and sea level rise in the 21st century to be substantially larger and faster than that experienced in the 20th century and without precedent in the past 10,000 years.

5. Although the general link between increased greenhouse gases in the atmosphere and increased warming of the earth system is virtually certain, the complexity of the climate system means that predictions of specific details that follow from this general link are subject to varying degrees of certainty. Among the more certain future predictions are the following:

a. It is likely, based on both models and on data from the ice ages over the last 400,000 years, that if atmospheric carbon dioxide doubled from pre-industrial times, and then rose no further, the long-term warming response of global average surface temperature (the "climate sensitivity") would be in the range of 1.5° to 4.5° C (2.7° - 8.1° F).

b. In the absence of emissions reductions, however, carbon dioxide and other greenhouse gases in the atmosphere are very likely to much more than double, and the consequent rise in global average temperature during the 21st century, projected to be 1.4° to 5.8° C (2.5° to 10° F), will likely continue rising well beyond 2100.

c. This amount of warming is very likely to drive steady melting of arctic ice sheets and further increases in global average sea level, which is projected to reach an additional 0.1 - 0.9 meters (1/3 - 3 feet) by 2100, and to continue rising to much higher levels in the decades to millennia following 2100.

d. This amount of sea level rise, especially when combined with likely increases in hurricane intensities, would exacerbate storm surges and have negative impacts on health and welfare in the United States, and globally. These negative impacts would

be concentrated in low-lying coastal regions, such as Boston or Cape Cod, Massachusetts, the Louisiana/Mississippi Gulf coast, and southern Florida.

e. Rising temperatures are also likely to lead to increases in extreme weather events (e.g. heat waves) and altered patterns of rainfall (e.g. droughts) that will disrupt natural and agricultural ecosystems, and increase the risk of extinction of animal and plant species.

f. Ocean acidity is likely to increase by several tenths of a pH unit due to continued uptake of carbon dioxide, and this acidification is likely to cause substantial stress to key marine organisms, and hence to whole marine ecosystems, particularly in cold water regions.

6. The possibilities of the above-mentioned climate changes have been carefully and extensively assessed, and there is a broad scientific consensus that these changes are likely or very likely.[14] The exact timing of the climate change and the exact magnitude of the impact are harder to determine, because the climate system has a great deal of inertia (especially in the ice sheets and oceans), and greenhouse gases already in the atmosphere will continue to contribute to future warming. This inertia heightens the threat to human welfare because continuing unregulated greenhouse gas emissions commit us to large-scale, long-term (centuries) climate change consequences before the exact nature of those consequences can be known with greater certainty.

7. Apart from the likely, very likely, and virtually certain gradual climate changes outlined in points 4 and 5, there is also an as yet unquantifiable probability that continued greenhouse gas emissions will trigger abrupt climate change surprises that could very rapidly impose large impacts on ecosystems and

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[14] *Id.;* CLIMATE CHANGE SCIENCE, *supra* note 3.

human societies.[15] We know that such abrupt climate changes (*e.g.* large local cooling or warming, widespread droughts, shifts in hurricane intensity or flood regimes that occur in only a decade or so) are possible because they have happened in the past, before recorded human history began. Such abrupt shifts were triggered when gradual changes pushed the earth system across a threshold, abruptly switching the climate system into a new state. We do not understand these switches very well, but it is very likely that they exist within the climate system, and there is a significant but unknown risk that continued emission of greenhouse gases will trigger some kind of climate change surprise.

8. An example of surprise in global change science is the problem of stratospheric ozone depletion and the Antarctic "ozone hole." Models predicted that the emission of chlorofluorocarbons (CFCs) and other chlorinated halocarbons by human activities would gradually deplete stratospheric ozone, but no model predicted the stratospheric ozone hole in advance of its discovery in the mid-1980s. The reality of ozone depletion turned out to be worse than even the worst-case modeled scenario because none of the models anticipated the novel chemistry of ozone depletion via polar stratospheric clouds above the south (and north) poles.

II. The Court of Appeals Erred in Not Requiring EPA to Apply the "Reasonably Be Anticipated to Endanger Public Health or Welfare" Standard in Section 202(a)(1) of the Clean Air Act.

Section 202(a)(1) of the Clean Air Act provides:

The Administrator shall by regulation prescribe (and from time to time revise) in accordance with the

[15] ABRUPT CLIMATE CHANGE, *supra* note 3.

> provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment cause, *or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare*."

42 U.S.C. § 7521(a)(1) (emphasis added). EPA's judgment under the statute extends only to the narrow questions of whether motor vehicle emissions cause or contribute to air pollution and whether such air pollution may reasonably be anticipated to endanger health or welfare. *See e.g., BedRoc Ltd., L.L.C. v. United States,* 541 U.S. 176 183 (2004) ("Thus our inquiry begins with the statutory text, and ends there as well if the text is unambiguous."). The statutory language does not contemplate the injection of other considerations.[16] *See Whitman v. American Trucking Assn.,* 531 U.S. 457, 467 (2001) (EPA is prohibited from considering factors not expressly mentioned in a statutory delegation). Congress did not authorize EPA to consider such elephantine factors as how regulation of GHGs from mobile sources "interface[s] with fuel economy standards," 68 Fed. Reg. at 52929, or differs from the President's climate change policy, *id.* at 592930. Although EPA could elect not to regulate ***if*** it reasonably found that emissions from motor vehicles did not contribute to the air pollution in question or ***if*** the agency found that, in its judgment, the air pollution could not reasonably be anticipated to have an adverse effect on welfare, neither finding was made here.

This was a serious mistake. Failure to make such findings, and to measure them against the statutory standard means that EPA, in deciding not to regulate, never properly applied the science that the 2001 NAS/NRC Report provides, and failed to carry out its

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[16] Because petitioners in this case seek a decision from this Court that the other factors upon which EPA relied were impermissible, it follows that, upon remand, EPA would be obliged to consider the climate science without reference to these other factors.

statutory obligation under section 202(a)(1). The Court should grant *certiorari* to require EPA to carry out its statutory obligation. As explained by the Climate Scientists, EPA's failure is not without significant consequence. Had EPA properly limited its discretion to the statutory standard and applied that standard to the facts of climate change science, it likely would have concluded that regulation is warranted:

> 9. Scientific knowledge is usually developed incrementally, using experiment and observation to test and prove or disprove hypotheses. To ensure that new knowledge is really knowledge and not opinion, scientific norms require a high level of certainty about the accuracy of new information. But there is no such thing as absolute certainty in climate science, just as there is no absolute certainty in medicine. Indeed, a large part of the work of science is directed at understanding and carefully quantifying such uncertainties, and accurately reporting them. Likewise, scientific uncertainty is a double-edged sword: outcomes may turn out better than our current prediction, but it is just as possible that they will turn out worse (as in the case of stratospheric ozone depletion cited in point 8). Thus, it is a mistake to infer that because a prediction of an undesirable outcome is uncertain, that the risk posed by that undesirable outcome is low.
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> 10. The absence of absolute certainty in science does not by itself provide a rational reason for avoiding policy action on a scientifically identified public risk (like global climate change), any more than the absence of absolute certainty prevents decisions or actions in other areas such as health care, financial decisions, or national security. Similarly, low probability of a potentially large harm does not by itself rationally justify inaction any more than the low probability of devastating fire rationally justifies non-purchase of home insurance policies.

11. We would not decline to regulate a likely, or very likely, cancer-causing agent being emitted into the atmosphere, and wait 20 years to observe if cancer cases begin to occur. But this appears to be the approach being taken with respect to greenhouse gas emissions. Regulated chemicals are usually believed to be likely, or very likely, carcinogens based on non-human tests and on theory, but direct tests of human harm are not required.

12. In the face of scientific uncertainty, a decision about whether to take steps to mitigate climate change cannot be a purely scientific question, but requires a standard of risk (derived from policy, economic, legal and/or political considerations) against which the scientifically determined risk or uncertainty can be compared.

13. Section 202(a)(1) of the Clean Air Act provides such a standard for comparison. In our judgment, the level of certainty is more than strong enough to conclude that greenhouse gas emissions "may reasonably be anticipated to endanger public health or welfare," based on the effects enumerated in paragraphs 1 through 7.

14. Because responsible scientific reports generally depict both the high and low ends of uncertainty ranges, it is possible to selectively quote from such reports to make the scientific findings appear either more or less certain than they actually are. We are concerned that the lead opinion of the Appeals Court in *Massachusetts v. EPA* cites the 2001 National Academy of Sciences/National Research Council (NAS/NRC) report on climate change[17] in ways that emphasize uncertainties in the details while neglecting fundamental areas of certainty or consensus, giving the impression that climate science is more uncertain than it actually is.

For example, the lead opinion of the Court of

[17] CLIMATE CHANGE SCIENCE, *supra* note 3.

Appeals includes six citations to the 2001 NAS/NRC report , all of them presented and interpreted in a way that will likely leave a reader with the mistaken impression that the connection between greenhouse gas emissions/concentrations and climate change consequences is fundamentally uncertain. Though the NAS/NRC report also reviews many areas where the science shows that this connection is strong, these areas are not cited by the lead opinion, giving a misrepresentation of what the NAS/NRC report actually says. The lead opinion also writes that "The National Research Council [NAS/NRC] concluded that 'a causal linkage' between greenhouse gas emissions and global warming 'cannot be unequivocally established'", *id.* at 57, perhaps giving the mistaken impression that the NAS/NRC report is characterizing as fundamentally uncertain the link between greenhouse gases and warming in general.

In fact, as we (including those of us who were members of the 2001 NAS/NRC panel) emphasize above (point 1), this general link is *virtually certain*, and even the narrower linkage to which the NAS/NRC report is actually referring (between human activities and the observed 20th century warming[18]), while not "unequivocally established," was nonetheless considered "likely" by that report. To quote the NAS/NRC report's full summary statement on this question, "The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes are also a reflection of natural variability."[19] Since publication, the evidence has only reinforced the NAS/NRC report finding that most recent climate changes are likely caused by human activities: the five warmest years since pre-industrial times were 1998, 2002, 2003, 2004, and 2005 (2005 is the

[18] *Id.* at 17.

[19] *Id.* at 1.

> warmest overall), and the reduction of ice cover in the Arctic has accelerated.

Section 202(a)(1)'s constraint on EPA's regulatory discretion is reinforced and supported by a treaty to which the United States is a party, the United Nations Framework Convention on Climate Change, which entered into force in 1994, *see* UNFCCC website at http://unfccc.int/parties_and_observers/parties/items/2228.php. In ratifying the Convention, the parties agreed not to invoke scientific uncertainty as a ground for failing to take regulatory action on greenhouse gases where there is a "threat" of serious damage:

> The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, *lack of full scientific certainty should not be used as a reason for postponing such measures*, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.

United Nations Framework Convention on Climate Change, art. 3, ¶ 3 (emphasis added); *see also id.*, art. 4, ¶4(a) ("Each of these Parties [the developed nations] shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs."). Ratified treaties, along with the Constitution itself and United States laws, are "the supreme Law of the Land." U.S. CONST. art. VI, § 2. Thus, an " act of Congress ought never to be construed to violate the law of nations if any other possible construction remains . . ." *Murray v. Schooner Charming Betsy*, 6 U.S. 64, 118 (1804); *Weinberger v. Rossi*, 456 U.S. 25, 32 (1982); *Hartford Fire Ins. Co. v. California*, 509 U.S. 764, 814-15 (1993) (Scalia, J., dissenting);

Spector v. Norwegian Cruise Line, Ltd., 545 U.S. 119, ___, 125 S.Ct. 2169, 2185 (2005) (Ginsburg, J., concurring). Section 202(a)(1) thus should be construed to prevent EPA from using scientific uncertainty to delay action.

After describing scientific uncertainties concerning climate change and planned scientific work to reduce uncertainties, 68 Fed. Reg. at 52930-31, EPA explained that "establishing GHG emission standards for U.S. motor vehicles at this time would require EPA to make scientific and technical judgments without the benefit of the studies being developed to reduce uncertainties and advance technologies." *Id.* at 52930. In invoking scientific uncertainty as a ground for postponing regulation of mobile sources under section 202(a)(1) of the Clean Air Act, EPA has done what the Framework Convention directs parties not to do.

Section 202(a)(1) of the Clean Air Act, therefore, *must* be interpreted to preclude EPA's reliance on scientific uncertainty as a ground for refusing to regulate mobile emissions of greenhouse gases in the present context. The Statement by the *Amici* Climate Scientists makes it clear that the nature of scientific uncertainty regarding climate change would not, as a matter of law, warrant the deferral of regulatory action either under the clear standard in section 202(a)(1) of the Clean Air Act or the Framework Convention.

CONCLUSION

For the foregoing reasons, this Court should grant *certiorari* to review the decision of the Court of Appeals, reverse that decision and direct that the matter be remanded to EPA to make appropriate findings employing the standard for scientific uncertainty required by Section 202(a)(1) of the Clean Air Act and Article 3, paragraph 3, of the Framework Convention.

Respectfully submitted,

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Appendix

STATEMENT OF CLIMATE SCIENTISTS ON GLOBAL CLIMATE CHANGE: DAVID BATTISTI, CHRISTOPHER FIELD, INEZ FUNG, JAMES E. HANSEN, JOHN HARTE, EUGENIA KALNAY, DANIEL KIRK-DAVIDOFF, PAMELA A. MATSON, JAMES C. MCWILLIAMS, JONATHAN T. OVERPECK, JOELLEN RUSSELL, F. SHERWOOD ROWLAND, SCOTT R. SALESKA, JOHN M. WALLACE, AND STEVEN C. WOFSY

The science of global climate change has become an issue in a legal dispute about whether the U.S. Environmental Protection Agency should regulate greenhouse gas emissions from motor vehicles.[1] In particular, leading and dissenting opinions in the case now being appealed to the Supreme Court quote from a 2001 National Academy of Sciences report on Climate Change in support of their arguments.[2] As practicing scientists in fields relevant to understanding climate change, we here provide a brief summary of the state of climate change science that the Court may find useful in deciding whether to hear this case. We will address the question as to whether the current state of climate science allows us to conclude that greenhouse gas emissions "cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare" Section 202(a)(1) of the Clean Air Act, or lead to "effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate." *Id.* at § 302(h).

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[1] *Massachusetts v. Environmental Protection Agency*, 415 F.3d 50 (D.C. Cir. 2005).

[2] NATIONAL RESEARCH COUNCIL, CLIMATE CHANGE SCIENCE: AN ANALYSIS OF SOME KEY QUESTIONS (2001) ["CLIMATE CHANGE SCIENCE" or "2001 NAS/NRC Report"].

Climate Change Science

1. The basic physics underlying the greenhouse effect is firmly established. Two principles in particular are as certain as any phenomena in planetary sciences. First, certain atmospheric gases absorb radiation that otherwise would be lost to space (thereby making a planet with those gases in its atmosphere warmer than it would be without them). Second, greater atmospheric concentrations of greenhouse gases, all other things being equal, cause higher temperatures at the surface of a planet. The Earth is habitable for its current life forms in part because natural levels of greenhouse gases in the atmosphere warm the planet.
2. Over the last two centuries, it is virtually certain that human activities have increased the amount of greenhouse gases in the atmosphere to a level not seen in all of human experience, and likely not seen for at least 3 million years.[3]
3. It is likely or very likely that this human-induced increases in greenhouse gases are already causing global climate to change. The average global surface temperature has risen (human activities likely caused most of the approximately 0.6°C -- 1.1° F -- rise over the 20th century), global average sea level has risen (by 0.1 to 0.2 meters -- 1/3 to 2/3 feet-- over the 20th century), snow cover and ice extent in the Arctic has decreased by about 10% and 25%, respectively, since the late 1960s, and stratospheric temperatures have dropped (a virtually certain consequence of both stratospheric

[3] We here characterize scientific uncertainties using the same system as found in the Intergovernmental Panel on Climate Change Working Group 1 summaries: "the following words have been used where appropriate to indicate judgmental estimates of confidence: virtually certain (greater than 99% chance that a result is true); very likely (90–99% chance); likely (66–90% chance); medium likelihood (33–66% chance); unlikely (10–33% chance); very unlikely (1–10% chance); exceptionally unlikely (less than 1% chance)." INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS 2 fn. 7 (2001).

ozone depletion and greenhouse gas increases). A variety of other related climate factors are changing in a way that is consistent with greenhouse gas-induced planetary warming. By contrast, it is very difficult to find global scale measures of climate that indicate cooling.

4. It is virtually certain that what has been observed so far is only the beginning, and that continued greenhouse gas emissions along current trajectories will cause *additional* warming of the earth system as a whole, and very likely that such perturbation would cause the rate of surface warming and sea level rise in the 21st century to be substantially larger and faster than that experienced in the 20th century and without precedent in the past 10,000 years.
5. Although the general link between increased greenhouse gases in the atmosphere and increased warming of the earth system is virtually certain, the complexity of the climate system means that predictions of specific details that follow from this general link are subject to varying degrees of certainty. Among the more certain future predictions are the following:
   a. It is likely, based on both models and on data from the ice ages over the last 400,000 years, that if atmospheric carbon dioxide doubled from pre-industrial times, and then rose no further, the long-term warming response of global average surface temperature (the "climate sensitivity") would be in the range of 1.5° to 4.5° C (2.7° - 8.1° F).
   b. In the absence of emissions reductions, however, carbon dioxide and other greenhouse gases in the atmosphere are very likely to much more than double, and the consequent rise in global average temperature during the 21st century, projected to be 1.4° to 5.8° C (2.5° to 10° F)*, will likely continue rising well beyond 2100.
   c. This amount of warming is very likely to drive steady melting of arctic ice sheets and further increases in global average sea level, which is

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* Corrected temperature range. A typographical error caused this temperature range to be mistakenly reported as "2.5 to 10°C" (rather than °F) in the original version of this brief.

projected to reach an additional 0.1 - 0.9 meters (1/3 - 3 feet)* by 2100, and to continue rising to much higher levels in the decades to millennia following 2100.

d. This amount of sea level rise, especially when combined with likely increases in hurricane intensities, would exacerbate storm surges and have negative impacts on health and welfare in the United States, and globally. These negative impacts would be concentrated in low-lying coastal regions, such as Boston or Cape Cod, Massachusetts, the Louisiana/Mississippi Gulf coast, and southern Florida.

e. Rising temperatures are also likely to lead to increases in extreme weather events (e.g. heat waves) and altered patterns of rainfall (e.g. droughts) that will disrupt natural and agricultural ecosystems, and increase the risk of extinction of animal and plant species.

f. Ocean acidity is likely to increase by several tenths of a pH unit due to continued uptake of carbon dioxide, and this acidification is likely to cause substantial stress to key marine organisms, and hence to whole marine ecosystems, particularly in cold water regions.

6. The possibilities of the above-mentioned climate changes have been carefully and extensively assessed, and there is a broad scientific consensus that these changes are likely or very likely.[4] The exact timing of the climate change and the exact magnitude of the impact are harder to determine, because the climate system has a great deal of inertia (especially in the ice sheets and oceans), and greenhouse gases already in the atmosphere will continue to contribute to future warming. This inertia heightens the threat to human welfare because continuing unregulated greenhouse gas emissions commit us to large-scale, long-term (centuries) climate change consequences before the

[4] *Id.;* CLIMATE CHANGE SCIENCE, *supra* note 2.

* Corrected sea-level rise. Because of a unit-conversion error, the upper end of the range was mistakenly reported as 1 foot, rather than 3 feet, in the original version of this brief.

exact nature of those consequences can be known with greater certainty.

7. Apart from the likely, very likely, and virtually certain gradual climate changes outlined in points 4 and 5, there is also an as yet unquantifiable probability that continued greenhouse gas emissions will trigger abrupt climate change surprises that could very rapidly impose large impacts on ecosystems and human societies.[5] We know that such abrupt climate changes (e,g, large local cooling or warming, widespread droughts, shifts in hurricane intensity or flood regimes that occur in only a decade or so) are possible because they have happened in the past, before recorded human history began. Such abrupt shifts were triggered when gradual changes pushed the earth system across a threshold, abruptly switching the climate system into a new state. We do not understand these switches very well, but it is very likely that they exist within the climate system, and there is a significant but unknown risk that continued emission of greenhouse gases will trigger some kind of climate change surprise.
8. An example of surprise in global change science is the problem of stratospheric ozone depletion and the Antarctic "ozone hole." Models predicted that the emission of chlorofluorocarbons (CFCs) and other chlorinated halocarbons by human activities would gradually deplete stratospheric ozone, but no model predicted the stratospheric ozone hole in advance of its discovery in the mid-1980s. The reality of ozone depletion turned out to be worse than even the worst-case modeled scenario because none of the models anticipated the novel chemistry of ozone depletion via polar stratosphere clouds above the south (and north) poles.

<u>Decision-making in the face of Scientific Uncertainty</u>

[5] NATIONAL RESEARCH COUNCIL, ABRUPT CLIMATE CHANGE: INEVITABLE SURPRISES (2002) [ABRUPT CLIMATE CHANGE].

9. Scientific knowledge is usually developed incrementally, using experiment and observation to test and prove or disprove hypotheses. To ensure that new knowledge is really knowledge and not opinion, scientific norms require a high level of certainty about the accuracy of new information. But there is no such thing as absolute certainty in climate science, just as there is no absolute certainty in medicine. Indeed, a large part of the work of science is directed at understanding and carefully quantifying such uncertainties, and accurately reporting them. Likewise, scientific uncertainty is a double-edged sword: outcomes may turn out better than our current prediction, but it is just as possible that they will turn out worse (as in the case of stratospheric ozone depletion cited in point 8). Thus, it is a mistake to infer that because a prediction of an undesirable outcome is uncertain, that the risk posed by that undesirable outcome is low.
10. The absence of absolute certainty in science does not by itself provide a rational reason for avoiding policy action on a scientifically identified public risk (like global climate change), any more than the absence of absolute certainty prevents decisions or actions in other areas such as health care, financial decisions, or national security. Similarly, low probability of a potentially large harm does not by itself rationally justify inaction any more than the low probability of devastating fire rationally justifies non-purchase of home insurance policies.
11. We would not decline to regulate a likely, or very likely, cancer-causing agent being emitted into the atmosphere, and wait 20 years to observe if cancer cases begin to occur. But this appears to be the approach being taken with respect to greenhouse gas emissions. Regulated chemicals are usually believed to be likely, or very likely, carcinogens based on non-human tests and on theory, but direct tests of human harm are not required.

12. In the face of scientific uncertainty, a decision about whether to take steps to mitigate climate change cannot be a purely scientific question, but requires a standard of risk (derived from policy, economic, legal and/or political considerations) against which the scientifically determined risk or uncertainty can be compared.
13. Section 202(a)(1) of the Clean Air Act provides such a standard for comparison. In our judgment, the level of certainty is more than strong enough to conclude that greenhouse gas emissions "may reasonably be anticipated to endanger public health or welfare," based on the effects enumerated in paragraphs 1 through 7.
14. Because responsible scientific reports generally depict both the high and low ends of uncertainty ranges, it is possible to selectively quote from such reports to make the scientific findings appear either more or less certain than they actually are. We are concerned that the lead opinion of the Appeals Court in *Massachusetts v. EPA* cites the 2001 National Academy of Sciences/National Research Council (NAS/NRC) report on climate change[6] in ways that emphasize uncertainties in the details while neglecting fundamental areas of certainty or consensus, giving the impression that climate science is more uncertain than it actually is.

    For example, the lead opinion of the Court of Appeals includes six citations to the 2001 NAS/NRC study, all of them presented and interpreted in a way that will likely leave a reader with the mistaken impression that the connection between greenhouse gas emissions/concentrations and climate change consequences is fundamentally uncertain. Though the NAS/NRC study also reviews many areas where the science shows that this connection is strong, these areas are not cited by the lead opinion, giving a misrepresentation of what the NAS/NRC report actually says. The lead opinion also writes that "The National Research Council [NAS/NRC] concluded that

[6] CLIMATE CHANGE SCIENCE, *supra* note 2.

'a causal linkage' between greenhouse gas emissions and global warming 'cannot be unequivocally established'", *id.* at 57, perhaps giving the mistaken impression that the NAS/NRC report is characterizing as fundamentally uncertain the link between greenhouse gases and warming in general.

In fact, as we (including those of us who were members of the 2001 NAS/NRC panel) emphasize above (point 1), this general link is *virtually certain*, and even the narrower linkage to which the NAS/NRC report is actually referring (between human activities and the observed 20th century warming[7]), while not "unequivocally established," was nonetheless considered "likely" by that report. To quote the NAS/NRC report's full summary statement on this question, "The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes are also a reflection of natural variability."[8] Since publication, the evidence has only reinforced the NAS/NRC report finding that most recent climate changes are likely caused by human activities: the five warmest years since pre-industrial times were 1998, 2002, 2003, 2004, and 2005 (2005 is the warmest overall), and the reduction of ice cover in the Arctic has accelerated.

15. The authors of this Statement are David Battisti, Inez Fung, James E. Hansen, John Harte, Daniel Kirk-Davidoff, Pamela A. Matson, James C. McWilliams, Jonathan T. Overpeck, F. Sherwood Rowland, Scott R. Saleska, John M. Wallace, and Steven C. Wofsy (hereinafter "Climate Scientists").[9] The Climate Scientists are individual climate scientists who are

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[7] *Id*. at 17

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[8] *Id.* at 1.

[9] The Climate Scientists make this Statement in their individual capacities and not as representatives of any institution with which any of them is affiliated.

actively involved in research on changes to the Earth's climate that are being caused by anthropogenic emissions of carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons, and perfluorocarbons ("greenhouse gases" or "GHGs") and the effects of those changes. Many of these scientists are members of the National Academy of Sciences, and/or have served on two recent National Academy of Sciences/National Research Council ("NAS/NRC") panels that have reviewed the state of the science on climate change and the impacts of human activities on climate.[10] The NRC, the Academy's principal operating arm, was formed in 1916 to further scientific and technological knowledge and to advise the federal government. NATIONAL RESEARCH COUNCIL, CLIMATE CHANGE SCIENCE: AN ANALYSIS OF SOME OF THE KEY QUESTIONS, preface (2001).

David Battisti is the Tamaki Professor of Atmospheric Sciences at the University of Washington. He has a Ph.D. from the University of Washington in the field of atmospheric sciences. He has been involved in the field of climate dynamics and climate change since 1984 and his research involves climate variability (El Nino, drought in the Sahel, decadal variability in the climate system), paleoclimate (abrupt climate change during the last glacial period), and climate change. He served for three years on the NAS Committee for Climate Research and for six years was co-chair of the United States Climate Variability and Predictability Science Steering Committee.

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[10] CLIMATE CHANGE SCIENCE, *supra* note 2; ABRUPT CLIMATE CHANGE, *supra* note 5. The NAS "is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of a charter granted to it in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters." CLIMATE CHANGE SCIENCE, *supra* note 2, preface.

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James E. Hansen is head of the NASA Goddard Institute for Space Studies. Dr. Hansen received his Ph.D. from the University of Iowa. His research interests include radiative transfer in planetary atmospheres, development of global climate models, current climate trends from observational data, and projections of man's impact on climate. He is a member of the National Academy of Sciences and a Fellow of the American Geophysical Union. He served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[12]

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[11] CLIMATE CHANGE SCIENCE, *supra,* note 3.
[12] *Id.*

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agricultural ecosystems, and interactions of forest and agricultural ecosystems with the atmosphere and water. She has served on the National Research Council's Board on Global Change, and is currently co-chair of the NAS Roundtable on Science and Technology for Sustainability. Dr. Matson is not an *amicus curiae* only because of the timing of her request to participate.

James C. McWilliams is the Louis Slichter Professor of Earth Sciences at University of California, Los Angeles. He has a Ph.D. from Harvard University in the field of applied mathematics. He has been involved in the study of oceanic and atmospheric circulations and climate since 1970. He is a member of the National Academy of Sciences and a Fellow of the American Geophysical Union. He served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[13]

Jonathan T. Overpeck is a Professor of Geosciences and a Professor of Atmospheric Sciences at the University of Arizona. He has a Ph.D. from Brown University in the field of geological sciences. He has been involved in the study of climate science since 1979. His research focuses on using models and the climate record of the past million years to understand climate variability and future change. He has served on the NAS/NRC Committee on Abrupt Climate Change.[14]

F. Sherwood Rowland is the Bren Research Professor of Chemistry and Earth System Science at the University of California Irvine. He has a Ph.D. in Chemistry from the University of Chicago in the field of Physical Chemistry. He has been involved in the study of the atmosphere since 1973, and received the 1995 Nobel Prize in Chemistry (with Mario Molina and Paul Crutzen) for his "work on atmospheric chemistry,

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[13] *Id.*

[14] ABRUPT CLIMATE CHANGE, *supra,* note 5.

particularly concerning the formation and decomposition of ozone." He is a member of the National Academy of Sciences, and received the Roger Revelle Medal of the American Geophysical Union. He is a member of the Board on Atmospheric Sciences and Climate of the National Research Council, and served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[15]

Joellen L. Russell is an Assistant Professor of Geosciences at the University of Arizona. She received her B.A. in Environmental Geoscience from the Department of Earth and Planetary Sciences at Harvard University in 1993, and her Ph.D. in Oceanography from the Scripps Institution of Oceanography at the University of California, San Diego, in 1999. Her research focuses on biogeochemical dynamics, the interactions between the biological, geological and chemical components of Earth's environment.

Scott R. Saleska is an Assistant Professor of Ecology and Evolutionary Biology at the University of Arizona. He received a B.S. in Physics from the Massachusetts Institute of Technology in 1986 and a Ph.D. in Energy and Resources from the University of California at Berkeley in 1998. His research focuses on how climate interacts with plant physiology, demography, and ecological processes to influence or control biogeochemical cycling from local to global scales.

John M. Wallace is a Professor in the Department of Atmospheric Sciences at the University of Washington. He has a Ph.D. from the Massachusetts Institute of Technology in the field of meteorology. He has been involved in the study of climate variability and change since 1980 and his research involves El Nino and other patterns of climate variability. He is a member of the National Academy of Sciences, a Fellow of the American Geophysical Union, and a recipient of the

[15] CLIMATE CHANGE SCIENCE, *supra,* note 2.

Rossby Medal of the American Meteorological Society and the Roger Revelle Medal of the American Geophysical Union. He served on the National Research Council's Committee on Climate Change Science that reviewed the state of climate science for President Bush and produced the 2001 NAS/NRC Report.[16] From 2000 to 2001, he served on the NAS/NRC Committee on Abrupt Climate Change: Science and Public Policy.[17]

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[16] CLIMATE CHANGE SCIENCE, *supra* note 2.

[17] ABRUPT CLIMATE CHANGE, *supra* note 5.