



September 29, 2014

Alan I. Leshner
Chief Executive Officer and
Executive Publisher, *Science*

Barbara Cargill, Chair
Thomas Ratliff, Vice Chair
Texas State Board of Education
William B. Travis Building
1701 N. Congress Avenue
Austin, Texas 78701

Dear Chairwoman Cargill and Vice Chairman Ratliff:

On behalf of the American Association for the Advancement of Science (AAAS), the world's largest general scientific society, I am writing to express concern about the treatment of climate change in certain social studies textbooks up for approval this year by the Texas State Board of Education. Issues with the books are laid out in a report by the National Center for Science Education (<http://ncse.com/files/Texas-social-studies-report-2014.pdf>).

There are not “two sides to the story” of climate science. The truth is that there is virtually no scientific controversy among the overwhelming majority of researchers on the core facts of climate change. Observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver. These conclusions are based on multiple independent lines of evidence. Moreover, there is strong evidence that ongoing climate change will have broad impacts on society, including the global economy and on the environment. Asserting that there are significant scientific controversies about the overall nature of these concepts when there are none will only confuse students, not enlighten them.

We urge the Board to only approve textbooks with a strong and accurate presentation of the state of climate science. To truly benefit the students of Texas, textbooks and curricula must present the best peer-reviewed research. Only in this way will students gain the strong understanding necessary to compete for high-skill jobs in an increasingly high-tech world economy.

For more information, please visit the AAAS website What We Know (whatweknow.aaas.org). AAAS has a longstanding expertise in science and science education, and we stand ready to work with you.

Sincerely,

Alan I. Leshner, CEO



Barbara Cargill
State Board of Education
Texas Education Agency
1701 N. Congress Avenue
Austin, Texas, 78701

Dear Chair Cargill,

I am writing to urge you to ensure that the publishers of proposed social-studies textbooks (listed at the end of this letter) for Texas K-12 schools revise their books to accurately reflect current scientific knowledge on the subject of climate change. The American Geophysical Union (AGU) strongly encourages you to consult a report developed by the National Center for Science Education that highlights textbook excerpts that represent the factual errors. These textbooks must be revised to be scientifically accurate before being released.

Humanity is the major influence on the global climate change observed over the past 50 years. This scientific consensus is reflected in the official positions of scientific associations and societies, including AGU, and national academies of science from 80 nations. Human-caused increases in greenhouse gases are responsible for most of the observed global average surface warming of roughly 0.8°C (1.5°F) over the past 140 years. For these textbooks to present climate change as a “debate,” or to suggest that there is scientific uncertainty around the drivers of climate change, is to misrepresent our scientific understanding and do a disservice to our children.

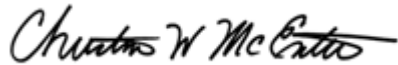
The global economy increasingly requires an understanding of Earth and space sciences. Therefore, it is important to have a public that is able to make informed choices on critical societal issues related to Earth and space sciences, including climate change. In the U.S., the only opportunity for most people to learn science in a formal setting occurs in grades K-12. It is crucial that K-12 students be given accurate representations of science and the state of scientific knowledge, including climate change, in all their educational materials and classes.

AGU is a scientific society with more than 62,000 members worldwide. Many of our members have conducted research fundamental to our understanding of climate change, and many have

served as authors and reviewers for comprehensive climate-science assessments such as the U.S. National Climate Assessment and the National Academy of Sciences' America's Climate Choices. AGU recognizes the rigor and value of the science as well as the need for it to be taught well and presented accurately in our schools.

That is why I hope you will ensure that the content of the textbooks you approve for Texas schools provides students with the accurate information they need and deserve.

Sincerely yours,

A handwritten signature in black ink, reading "Christine W. McEntee". The signature is fluid and cursive, with the first name "Christine" and last name "McEntee" clearly legible.

Christine McEntee
Executive Director/CEO
American Geophysical Union

Textbooks and publishers:

- *McGraw-Hill Education* (World Cultures & Geography)
- *Pearson* (Social Studies K-5)
- *Studies Weekly Publications* (Social Studies K-5)
- *WorldView Software* (Economics)

Report by the National Center for Science Education: [Analysis of Climate Change in Proposed Social Studies Textbooks for Texas Public Schools](#)

cc: Josh Rosenau, Programs and Policy Director, National Center for Science Education;
McGraw-Hill Education; Pearson; Studies Weekly Publications; WorldView Software



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3 November 2014

Barbara Cargill
State Board of Education
Texas Education Agency
1701 N. Congress Avenue
Austin, Texas 78701

Dear Chair Cargill:

A recent study by the National Center for Science Education (NCSE)¹ found that several of the textbooks being considered for your adoption contain factual errors in scientific information related to global climate change. In particular, some of the textbook material implies — incorrectly — that the role of humans in changing the Earth's climate is not well established. As noted in the American Meteorological Society's statement "Climate Science is Core to Science Education"²

The primary findings of climate change science have been well established in the peer-reviewed science literature and replicated by numerous independent investigators and methodologies. Blue-ribbon panels of scientists convened by organizations such as the National Academy of Sciences have carried out formal evaluations of scientific studies and provide a consensus opinion regarding climate change. Leading scientific organizations beyond the AMS³ (e.g., American Association for the Advancement of Science, American Geophysical Union, and European Geophysical Union) have considered the state of the science and are in consensus on the topic as well. There are small scientific differences as research continues to refine the details, but there is strong agreement on the primary findings and essentially no controversy with respect to them.

Presenting the science correctly is just as important in textbooks covering the social sciences as it is in those used to teach science. We urge the Board to only adopt textbooks that are as scientifically accurate as possible and to insist that publishers ensure that their texts are as accurate as possible in all respects.

The American Meteorological Society and the American Association of Physics Teachers would be happy to help connect you with members of the scientific community who could review textbooks for scientific accuracy.

Sincerely,

Dr. Keith L. Seitter
Executive Director
American Meteorological Society

Dr. Beth A. Cunningham
Executive Officer
American Association of Physics Teachers

cc: Josh Rosenau, Programs and Policy Director, National Center for Science Education;
McGraw Hill; Pearsons

¹ <http://ncse.com/files/Texas-social-studies-report-2014.pdf>

² http://www.ametsoc.org/policy/2013climatesciencecorescienceducation_amsstatement.html

³ <http://www.ametsoc.org/policy/2012climatechange.html>



Ecological Society of America
1990 M Street, NW
Suite 700
Washington, DC 20036

October 28, 2014

Barbara Cargill
State Board of Education
Texas Education Agency
1701 N. Congress Avenue
Austin, Texas 78701

Dear Chair Cargill,

I am writing to you on behalf of the Ecological Society of America (ESA), the world's largest community of professional ecologists and a trusted source of ecological knowledge, committed to advancing the understanding of life on Earth. The 10,000-member Society publishes six [journals](#) and broadly shares ecological information through policy and media outreach and education initiatives.

We are requesting that the social-studies textbook publishers (listed on the next page) for Texas K-12 be required to revise their textbooks to reflect accurately the current scientific knowledge on the subject of climate change.

The scientific evidence tells an unambiguous story: the planet is warming, and over the last half century, this warming has been driven primarily by human activity. U.S. average temperature has increased by 1.3°F to 1.9°F since 1895, and most of this increase has occurred since 1970. Temperatures are projected to rise another 2°F to 4°F in most areas of the United States over the next few decades.

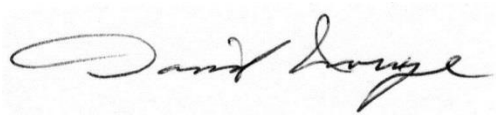
A [report](#) developed by the National Center for Science Education highlights textbook excerpts that represent the factual errors. Textbooks for our children should cultivate the foundation for understanding the full scope of what peer-reviewed Ph.D. research has revealed about climate change and its consequences for human society.

Comprehensive scientific reports, both national and international, have affirmed the current scientific consensus. Scientists and engineers from around the world have meticulously collected this evidence, using satellites and networks of weather balloons, thermometers, buoys, and other observing systems. The recently published National Climate Assessment [outlines](#) the impacts of climate change in detail region by region. It notes that sea level rise will contribute to greater storm damage for coastal Texas and other states along the Gulf Coast. Texas communities will be among regions of the continental US that suffer increasing frequencies of extreme heat leading to water shortages due to climate change impacts.

Policy implications of climate change are far-reaching and impact both public and private sector decisions related to agriculture, energy, water, forests, human health, transportation and infrastructure. Misrepresenting the level of scientific consensus stands to diminish our capacity to understand, mitigate and adapt to the real long-term threats to human society posed by these environmental changes.

Consequently, it is important that our children have accurate textbooks that reflect a real-world understanding of climate change, its causes and what can be done to manage its multifaceted impacts.

Sincerely,

A handwritten signature in black ink, appearing to read "David Inouye", written in a cursive style.

Dr. David W. Inouye
ESA President

Textbooks and publishers:

- *McGraw-Hill Education* (World Cultures & Geography)
- *Pearson* (Social Studies K-5)
- *Studies Weekly Publications* (Social Studies K-5)
- *WorldView Software* (Economics)

Report by the National Center for Science Education: [Analysis of Climate Change in Proposed Social Studies Textbooks for Texas Public Schools](#)

cc: Josh Rosenau, Programs and Policy Director, National Center for Science Education;
McGraw-Hill Education; Pearson; Studies Weekly Publications; WorldView Software



Barbara Cargill, Chair
Thomas Ratliff, Vice Chair
Texas State Board of Education
William B. Travis Building
1701 N. Congress Avenue
Austin, Texas 78701

Dear Chairwoman Cargill and Vice Chairman Ratliff:

Texas textbooks shape the education of millions of students both within Texas and throughout the United States. A recent report by the National Center for Science Education has brought to light a number of factual errors regarding the coverage of climate change and the ozone layer¹ in textbooks currently under review by the Texas State Board of Education. On behalf of the Natural Resource Defense Council's 1.4 million members and supporters, including more than 13,000 members in Texas, we urge you to require that publishers correct these errors.

Three of the social studies textbooks currently before the Board make fundamental errors when describing climate change. Social Studies K-5 by Pearson states that "Some scientists believe that... carbon dioxide could lead to a slow heating of Earth's overall climate... Scientists disagree about what is causing climate change." Social Studies K-5 by Studies Weekly Publications states that "Scientists believe the Earth is absorbing more of the sun's harmful rays. . . . Some scientists say it is natural for the Earth's temperature to be higher for a few years. They predict we'll have some cooler years and things will even out." Finally, World Cultures & Geography [Teacher Version] by McGraw-Hill Education states :

Scientists agree that Earth's climate is changing. They do not agree on what is causing the change. Is it just another natural warming cycle like so many cycles that have occurred in the past? Scientists who support this position cite thousands of years' worth of natural climatic change as evidence. Or is climate change anthropogenic—caused by human activity? Scientists who support this position cite the warming effect of rapidly increasing amounts of greenhouse gases in the atmosphere. Greenhouse gases occur naturally, but they also result from the burning of fossil fuels. Which side's evidence is more convincing?

The statement that "scientists disagree" about the causes of climate change is extremely misleading as there is virtually no scientific controversy among the overwhelming majority of researchers on the core facts of climate change. There is a clear scientific consensus that current

¹ <http://ncse.com/files/Texas-social-studies-report-2014.pdf>

changes in the climate cannot be explained without reference to human-caused emissions of greenhouse gases. Moreover, peer-reviewed studies have shown that more than 97% of climate researchers most actively publishing in the field agree that climate change is anthropogenic, and more than 97% of all scientific papers that take a position on anthropogenic climate change support the conclusion that humans are causing climate change.² Describing the current state of climate science as if it is entirely up for grabs is fundamentally in error and it is well within the power of the State Board of Education to require corrections to the textbooks.

The Teacher's Version of World Cultures & Geography further compounds these errors through the contrasting "primary source" paragraphs included in its text. The two paragraphs take differing views on a scientific question: whether climate change is the result of human activity. Readers of this text are provided no information on the authors of the two texts and, without knowing more, would naturally believe that the authors of both paragraphs are scientists. In fact, one of the paragraphs is from a non-academic paper written by two non-scientists at the Heartland Institute, a right-wing advocacy group.³ This is paired with a paragraph from a Working Group of the Fourth Assessment Report of the International Panel on Climate Change. The text fails to explain that the Working Group paper is produced by hundreds of international scientific experts assessing hundreds of peer-reviewed scientific publications.⁴ Comparing these two works without providing adequate context regarding the qualifications of the authors and their peer-reviewed status (or lack thereof) is an irresponsible and unacceptable way to teach our children about critical thinking on climate change issues.

Two textbooks also make fundamental errors when describing the ozone hole. Economics by WorldView software states that "Holes in the ozone layer allow sunlight to come through and be trapped beneath airborne pollution." Social Studies Grade 6 & 8 from Social Studies School Service state that "Fossil fuel emissions have also caused a hole in the ozone layer over Antarctica." Both of these statements are factually wrong. The research explaining the ozone hole earned a Nobel Prize for the scientists who carried it out. First, the ozone hole does not contribute to global warming.⁵ The depletion of the ozone layer allows more dangerous ultra-violet radiation to reach the ground, which can increase risks of skin cancer, cataracts, and other harms.⁶ Also, the depletion of ozone is not caused by emissions from burning forests or fossil fuels. Chlorofluorocarbons (CFCs), emitted from a range of products including aerosol spray cans, air conditioning, and refrigeration, are the major ozone depleting substance.⁷ (CFCs do contribute to climate change, but not through their effect on the ozone layer.) The

² Anderegg, William RL, et al. "Expert credibility in climate change." *Proceedings of the National Academy of Sciences* 107.27 (2010): 12107-12109; Cook, John, et al. "Quantifying the consensus on anthropogenic global warming in the scientific literature." *Environmental Research Letters* 8.2 (2013): 024024.

³ <http://heartland.org/joseph-bast>; <http://heartland.org/james-m-taylor-jd>

⁴ *Climate Change 2007 – The Physical Science Basis*. New York: Cambridge University Press, 2007. Print.

⁵ <http://www2.ucar.edu/climate/faq/what-does-ozone-hole-have-do-climate-change>; UNEP, Environmental Effects of Ozone Depletion: 2010 Assessment, United Nations Environment Programme, available at http://ozone.unep.org/Assessment_Panels/EEAP/eeap-report2010.pdf.

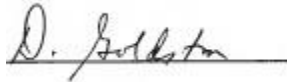
⁶ *Id.*

⁷ Molina, Mario J., and F. S. Rowland. "Stratospheric sink for chlorofluoromethanes- Chlorine atom catalyzed destruction of ozone." *Nature* 249 (1974), 810 - 812.

production of these chemicals has been eliminated world-wide, and scientific studies show that the ozone layer is beginning to recover as a result.⁸

Textbooks adopted by the Texas State Board of Education will be in circulation for many years to come, making it all the more important that their coverage of the ozone hole and climate change is factually accurate. Texas students should not be left unequipped to understand one of the defining challenges for the next generation of Americans.

Signed,

A handwritten signature in dark ink, appearing to read "D. Goldston", written over a horizontal line.

David Goldston
Director of Government Affairs
Natural Resources Defense Council

⁸ WMO (World Meteorological Organization), Scientific Assessment of Ozone Depletion: 2010, Global Ozone Research and Monitoring Project—Report No. 52, 516 pp., Geneva, Switzerland, 2011, *available at* <http://www.esrl.noaa.gov/csd/assessments/ozone/2010/>.



SCIENCE ■ STEWARDSHIP ■ SERVICE

November 3, 2014

Barbara Cargill, Chair
State Board of Education
Texas Education Agency
1701 N. Congress Avenue
Austin, Texas 78701

Dear Chair Cargill,

On behalf of the 26,000 members of The Geological Society of America (GSA), with more than 2200 residing in Texas, I am writing to express our concerns with the treatment of climate change in proposed social studies textbooks being reviewed by the Texas Board of Education.

As GSA states in its Position Statement on Climate Change: “The Geological Society of America (GSA) concurs with assessments by the National Academies of Science (2005), the National Research Council (2011), and the Intergovernmental Panel on Climate Change (IPCC, 2007) that global climate has warmed and that human activities (mainly greenhouse-gas emissions) account for most of the warming since the middle 1900s. If current trends continue, the projected increase in global temperature by the end of the twenty-first century will result in significant impacts on humans and other species.”

The full statement is enclosed and makes clear that there is not ongoing debate on the drivers of climate change from a scientific perspective. We encourage you to ensure that textbooks convey accurate scientific information to better inform the students of Texas and help them obtain the scientific and technical knowledge needed to succeed.

Sincerely,

John W. Hess, Ph.D.
Executive Director, GSA

Climate Change

Position Statement. Decades of scientific research have shown that climate can change from both natural and anthropogenic causes. The Geological Society of America (GSA) concurs with assessments by the National Academies of Science (2005), the National Research Council (2011), and the Intergovernmental Panel on Climate Change (IPCC, 2007) that global climate has warmed and that human activities (mainly greenhouse-gas emissions) account for most of the warming since the middle 1900s. If current trends continue, the projected increase in global temperature by the end of the twenty-first century will result in significant impacts on humans and other species. Addressing the challenges posed by climate change will require a combination of adaptation to the changes that are likely to occur and global reductions of CO₂ emissions from anthropogenic sources.

Purpose. This position statement (1) summarizes the strengthened basis for the conclusion that humans are a major factor responsible for recent global warming; (2) describes the significant effects on humans and ecosystems as greenhouse-gas concentrations and global climate reach projected levels; and (3) provides information for policy decisions guiding mitigation and adaptation strategies designed to address the future impacts of anthropogenic warming.

RATIONALE

Scientific advances in the first decade of the 21st century have greatly reduced previous uncertainties about the amplitude and causes of recent global warming. Ground-station measurements have shown a warming trend of ~0.8 °C since the mid-1800s, a trend consistent with (1) retreat of northern hemisphere snow and Arctic sea ice in the last 40 years; (2) greater heat storage in the ocean over the last 50 years; (3) retreat of most mountain glaciers since 1850; (4) an ongoing rise of global sea level for more than a century; and (5) proxy reconstructions of temperature change over past centuries from archives including ice cores, tree rings, lake sediments, boreholes, cave deposits and corals. Both instrumental records and proxy indices from geologic sources show that global mean surface temperature was higher during the last few decades of the 20th century and the first decade of the 21st than during any comparable period during the preceding four centuries (National Research Council, 2006).

Measurements from satellites, which began in 1979, initially did not show a warming trend, but later studies (Mears and Wentz, 2005; Santer et al., 2008) found that the satellite data had not been fully adjusted for losses of satellite elevation through time, differences in time of arrival over a given location, and removal of higher-elevation effects on the lower tropospheric signal. With these factors taken into account, the satellite data are now in basic agreement with ground-station data and confirm a warming trend since 1979. In a related study, Sherwood et al. (2005) found problems with corrections of tropical daytime radiosonde measurements and largely resolved a previous discrepancy with ground-station trends. With instrumental discrepancies having been resolved, recent warming of Earth's surface is now consistently supported by a wide range of measurements and proxies and is no longer open to serious challenge.

The geologic record contains unequivocal evidence of former climate change, including periods of greater warmth with limited polar ice, and colder intervals with more widespread glaciation. These and other changes were accompanied by major shifts in species and ecosystems. Paleoclimatic research has demonstrated that these major changes in climate and biota are associated with significant changes in climate forcing such as continental positions and topography, patterns of ocean circulation, the greenhouse gas composition of the atmosphere, and the distribution and amount of solar energy at the top of the atmosphere caused by changes in Earth's orbit and the evolution of the sun as a main sequence star. Cyclic changes in ice volume during glacial periods over the last three million years have been correlated to orbital cycles and

changes in greenhouse gas concentrations, but may also reflect internal responses generated by large ice sheets. This rich history of Earth's climate has been used as one of several key sources of information for assessing the predictive capabilities of modern climate models. The testing of increasingly sophisticated climate models by comparison to geologic proxies is continuing, leading to refinement of hypotheses and improved understanding of the drivers of past and current climate change.

Given the knowledge gained from paleoclimatic studies, several long-term causes of the current warming trend can be eliminated. Changes in Earth's tectonism and its orbit are far too slow to have played a significant role in a rapidly changing 150-year trend. At the other extreme, large volcanic eruptions have cooled global climate for a year or two, and El Niño episodes have warmed it for about a year, but neither factor dominates longer-term trends. Extensive efforts to find any other natural explanation of the recent trend have similarly failed.

As a result, greenhouse gas concentrations, which can be influenced by human activities, and solar fluctuations are the principal remaining factors that could have changed rapidly enough and lasted long enough to explain the observed changes in global temperature. Although the 3rd (2001) IPCC report allowed that solar fluctuations might have contributed as much as 30% of the warming since 1850, subsequent observations of Sun-like stars (Foukal et al., 2004) and new simulations of the evolution of solar sources of irradiance variations (Wang et al., 2005) have reduced these estimates. The 4th (2007) IPCC report concluded that changes in solar irradiance, continuously measured by satellites since 1979, account for less than 10% of the last 150 years of warming. Throughout the era of satellite observation, during periods of strong warming, the data show little evidence of increased solar influence (Foster and Rahmstorf, 2011; Lean and Rind, 2008).

Greenhouse gases remain as the major explanation for the warming. Observations and climate model assessments of the natural and anthropogenic factors responsible for this warming conclude that rising anthropogenic emissions of greenhouse gases have been an increasingly important contributor since the mid-1800s and the major factor since the mid-1900s (Meehl et al., 2004). The CO₂ concentration in the atmosphere is now ~30% higher than peak levels that have been measured in ice cores spanning 800,000 years of age, and the methane concentration is 2.5 times higher. About half of Earth's warming has occurred through the basic heat-trapping effect of the gases in the absence of any feedback processes. This "clear-sky" response to climate is known with high certainty. The other half of the estimated warming results from the net effect of feedbacks in the climate system: a large positive feedback from water vapor; a smaller positive feedback from snow and ice albedo; a negative feedback from aerosols, and still uncertain, feedbacks from clouds. The vertical structure of observed changes in temperature and water vapor in the troposphere is consistent with the anthropogenic greenhouse-gas "fingerprint" simulated by climate models (Santer et al., 2008). Considered in isolation, the greenhouse-gas increases during the last 150 years would have caused a warming larger than that actually measured, but negative feedback from aerosols and possibly clouds has offset part of the warming. In addition, because the oceans take decades to centuries to respond fully to climatic forcing, the climate system has yet to register the full effect of gas increases in recent decades.

These advances in scientific understanding of recent warming form the basis for projections of future changes. If greenhouse-gas emissions follow predicted trajectories, by 2100 atmospheric CO₂ concentrations will reach two to four times pre-industrial levels, for a total warming of 2 °C to 4.5 °C compared to 1850. This range of changes in greenhouse gas concentrations and temperature would substantially alter the functioning of the planet in many ways. The projected changes involve risk to humans and other species: (1) continued shrinking of Arctic sea ice with effects on native cultures and ice-dependent biota; (2) less snow accumulation and earlier melt in mountains, with reductions in spring and summer runoff for agricultural and municipal water; (3) disappearance of mountain glaciers and their late-summer runoff; (4) increased evaporation from farmland soils and stress on crops; (5) greater soil erosion due to increases in heavy convective summer rainfall; (6) longer fire seasons and increases in fire frequency; (7) severe insect outbreaks in vulnerable forests; (8) acidification of the global ocean; and (9) fundamental changes in the composition, functioning, and biodiversity of many terrestrial and marine ecosystems. In addition, melting of Greenland and West Antarctic ice (still highly uncertain as to

amount), along with thermal expansion of seawater and melting of mountain glaciers and small ice caps, will cause substantial future sea-level rise, affecting densely populated coastal regions, inundating farmland and dislocating large populations. Because large, abrupt climatic changes occurred within spans of just decades during previous ice-sheet fluctuations, the possibility exists for rapid future changes as ice sheets become vulnerable to large greenhouse-gas increases. Finally, carbon-climate model simulations indicate that 10–20% of the anthropogenic CO₂ “pulse” could stay in the atmosphere for thousands of years, extending the duration of fossil-fuel warming and its effects on humans and other species. The acidification of the global ocean and its effects on ocean life are projected to last for tens of thousands of years.

PUBLIC POLICY ASPECTS

Recent scientific investigations have strengthened the case for policy action to reduce greenhouse gas emissions and to adapt to unavoidable climate change. To strengthen the scientific contributions to policy discussions on how to address climate change, this statement from the Geological Society of America is intended to inform policymakers about improved knowledge of Earth’s climate system based on advances in climate science. Recent scientific investigations have contributed to this improved understanding of the climate system and supplied strong evidence for human-induced global warming, providing policy makers with a unique perspective on which to base mitigation and adaptation strategies. Carefully researched and tested adaptation strategies can both reduce and limit negative impacts and explore potential positive impacts. Future climate change will pose societal, biological, economic, and strategic challenges that will require a combination of national and international emissions reductions and adaptations. These challenges will also require balanced and thoughtful national and international discussions leading to careful long-term planning and sustained policy actions.

RECOMMENDATIONS

- There will be significant economic, health and safety impacts in the absence of global action on climate change. Public policy should include effective strategies for the reduction of greenhouse gas emissions. Cost-effective investments to improve the efficient use of Earth’s energy resources can reduce the economic impacts of future adaptation efforts. Strategies for reducing greenhouse-gas emissions should be evaluated based on their impacts on climate, on costs to global and national economies, and on positive and negative impacts on the health, safety and welfare of humans and ecosystems.
- Comprehensive local, state, national and international planning is needed to address challenges posed by future climate change. Near-, mid-, and long-term strategies for mitigation of, and adaptation to climate change should be developed, based in part on knowledge gained from studies of previous environmental changes.
- Public investment is needed to improve our understanding of how climate change affects society, including on local and regional scales, and to formulate adaptation measures. Sustained support of climate-related research to advance understanding of the past and present operation of the climate system is needed, with particular focus on the major remaining uncertainties in understanding and predicting Earth’s future climate at regional and global scales. Research is needed to improve our ability to assess the response and resilience of natural and human systems to past, present, and future changes in the climate system.

REFERENCES CITED

REPORTS

1. IPCC (Intergovernmental Panel on Climate Change), 2007, Summary for policymakers, in *Climate Change 2007: The physical science basis*: Cambridge, United Kingdom, Cambridge University Press, 18 p.
2. IPCC (Intergovernmental Panel on Climate Change), 2001, Summary for policymakers, in *Climate Change 2001: Synthesis Report*: Cambridge, United Kingdom, Cambridge University Press, 34 p.

3. National Academies of Science (2005). Joint academes statement: Global response to climate change. (<http://nationalacademies.org/onpi/06072005.pdf>)
4. National Research Council (2011). America's Climate Choices. Washington, DC: The National Academies Press, 144 p.

PEER-REVIEWED ARTICLES

1. Foster, G. and Rahmstorf, S., 2011, Global temperature evolution 1979–2010, *Environmental Research Letters*, doi: 10.1088/1748-9326/6/4/044022.
2. Foukal, P.G., et al., 2004, A stellar view on solar variations and climate: *Science*, v. 306, p. 68–69.
3. Lean, J.L., and Rind, D.H., 2008, How natural and anthropogenic influences alter global and regional surface temperatures: 1889 to 2006, *Geophysical Research Letters*, doi: 10.1029/2008GL034864.
4. Mears, C.A., and Wentz, F.J., 2005, The effect of diurnal correction on satellite-derived lower tropospheric temperature: *Science online*, doi: 10.1126/science.1114772.
5. Meehl et al., 2004, Combinations of natural and anthropogenic forcings in twentieth-century climate: *J. of Climate*, v. 17, p. 3721–3727.
6. Santer, B., et al., 2008, Consistency of modeled and observed temperature trends in the tropical troposphere: *International Journal of Climatology*, v. 28, p. 1703–1722.
7. Sherwood, S., Lanzante, J., and Meyer, C., 2005, Radiosonde biases and late-20th century warming: *Science online*, doi: 10/1126/science.1115640.
8. Wang, Y.-M., Lean, J.L., and Sheeley, N.R. Jr., 2005, Modeling the Sun's magnetic field and irradiance since 1713: *Astrophysical Journal*, v. 625, p. 522–538.

SELECTED WEB SITES

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

1. IPCC reports: <http://www.ipcc.ch/>

U.S. NATIONAL ACADEMIES

1. Climate Change at the National Academies: <http://dels.nas.edu/climatechange/>
2. Surface temperature reconstructions: http://www.nap.edu/catalog.php?record_id=11676#toc

U.S. GLOBAL CHANGE RESEARCH PROGRAM

1. Home page: <http://www.globalchange.gov/>
2. Satellite issue: <http://www.climate-science.gov/Library/sap/sap1-1/finalreport/default.htm>
3. Geologic record of abrupt changes: <http://www.climate-science.gov/Library/sap/sap3-4/final-report/>
4. Global climate change impacts in the United States: <http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts>

ABOUT THE GEOLOGICAL SOCIETY OF AMERICA

The Geological Society of America, founded in 1888, is a scientific society with more than 25,000 members from academia, government, and industry in more than 100 countries. Through its meetings, publications, and programs, GSA enhances the professional growth of its members and promotes the geosciences in the service of humankind. GSA encourages cooperative research among earth, life, planetary, and social scientists, fosters public dialogue on geoscience issues, and supports all levels of earth science education. Inquiries about the GSA or this position statement should be directed to GSA's Director for Geoscience Policy, Kasey S. White, at +1-202-669-0466 or kwhite@geosociety.org.

OPPORTUNITIES FOR GSA AND ITS MEMBERS TO HELP IMPLEMENT RECOMMENDATIONS

To facilitate implementation of the goals of this position statement, the Geological Society of America recommends that its members take the following actions:

- Actively participate in professional education and discussion activities to be technically informed about the latest advances in climate science. GSA should encourage symposia at regional, national and international meetings to inform members on mainstream understanding among geoscientists and climate scientists of the causes and future effects of global warming within the broader context of natural variability. These symposia should seek to actively engage members in hosted discussions that clarify issues, possibly utilizing educational formats other than the traditional presentation and Q&A session.
- Engage in public education activities in the community, including the local level. Public education is a critical element of a proactive response to the challenges presented by global climate change. GSA members are encouraged to take an active part in outreach activities to educate the public at all levels (local, regional, national, and international) about the science of climate change and the importance of geological research in framing policy development. Such activities can include organizing and participating in community school activities; leading discussion groups in civic organizations; meeting with local and state community leaders and congressional staffs; participating in GSA's Congressional Visits Day; writing opinion pieces and letters to the editor for local and regional newspapers; contributing to online forums; and volunteering for organizations that support efforts to mitigate and adapt to global climate change.
- Collaborate with a wide range of stakeholders and help educate and inform them about the causes and impacts of global climate change from the geosciences perspective. GSA members are encouraged to discuss with businesses and policy makers the science of climate change, as well as opportunities for transitioning from our predominant dependence on fossil fuels to greater use of low-carbon energies and energy efficiencies.
- Work interactively with other science and policy societies to help inform the public and ensure that policymakers have access to scientifically reliable information. GSA should actively engage and collaborate with other earth-science organizations in recommending and formulating national and international strategies to address impending impacts of anthropogenic climate change.
- Take advantage of the following list of references for a current scientific assessment of global climate change.