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Position Summary. Human-induced increases in greenhouse gases, especially CO₂, are the main drivers of recent global warming. Sound public policy and successful climate change mitigation and adaptation require scientifically validated assessment of current and future climate impacts.

This position statement (1) summarizes the scientific basis for the consensus among earth scientists that human activities are the primary cause of recent global warming; (2) describes the significant effects on humans and ecosystems as greenhouse-gas concentrations and global climate change reach projected levels; (3) provides information for policy decisions guiding mitigation and adaptation strategies that are designed to address the current and future impacts of human-induced climate change; and (4) recommends opportunities for GSA members to advance understanding of climate change.

CONCLUSIONS AND RECOMMENDATIONS

Government, educational, and private sector organizations, individually and collectively, should address the following adaptation and mitigation challenges:

- **Efficient use of Earth's energy resources**-The economic cost of future adaptation efforts should be reduced through investments to improve the efficient use of Earth's energy resources. The need to reduce greenhouse-gas emissions and rates of climate change should be considered in the context of costs to global and national economies, and impacts on the health, safety, and welfare of humans and ecosystems.
- **Future climate change**-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 on studies of previous environmental changes and on predictive modeling.
- **Adaptation**-Sustained, public investment in climate-related research is needed to (1) improve our understanding of how climate change affects society at all scales; (2) formulate adaptation measures; and (3) improve our ability to assess the response and resilience of natural and human systems to past, present, and future changes in the climate system.
- **Education**-Although the public is increasingly aware of recent climate change, its present-day effects, human causes, rates of climate change, and possible future scenarios are more poorly known. Formal and informal education efforts at all levels are needed to extend and improve broad understanding of the causes and impacts of global climate change.
- **International collaboration**-Mitigation of and adaptation to climate change will require sustained coordination among Earth's nations. Open communication and collaboration are necessary and should be promoted.

RATIONALE

The Geological Society of America (GSA) concurs with the National Academies of Science, Engineering, and Medicine^{1,2}, the National Research Council³, the U.S. Global Change Research Program^{4,5}, and the Intergovernmental Panel on Climate Change⁶ that global climate has warmed recently in response to increasing concentrations of greenhouse gases, especially carbon dioxide (CO₂), and that human activities (mainly greenhouse-gas emissions) are the dominant cause of rapid warming since the middle 1900s, while other natural factors contribute, at most, only marginally.

The concentration of CO₂ in the atmosphere is now higher than it has been for at least three million years⁴. Global warming by ~1 °C since 1900^{2,5} is consistent with decreasing northern hemisphere snow and ice, ongoing rise in global sea level, and numerous records from ice cores, tree rings, lake sediments, boreholes, cave deposits, and corals^{5,6}. Diverse measurements and proxies, including land- and satellite-based measurements, indicate rapid warming, such that global mean temperatures today are at their highest in 1700 years, while the rate of sea-level rise is the fastest in 2,700 years⁴⁻⁶.

Tangible effects of recent climate change are already occurring^{4,5}, and a continuing upward trend in greenhouse-gas concentrations will result in increasingly significant impacts on humans and other species by the end of the twenty-first century. Addressing the challenges posed by climate change will require a combination of adaptation to the changes that are likely to occur and mitigation of future impacts through global reductions of CO₂ and other greenhouse gas emissions from anthropogenic sources.



Photo by USGS (public domain).

If no effort is made to stabilize emissions, CO₂ concentrations will reach three to four times pre-industrial levels by 2100, and Earth will warm by 2.6 °C to 4.8 °C compared to 1986–2005 temperatures⁴⁻⁶. These changes will substantially alter the functioning of the planet and lead to (1) continued shrinking of Arctic sea ice, with effects on native cultures and ice-dependent biota; (2) decreased summer water supplies in mountainous areas; (3) increased evaporation from soils and stress on crops; (4) extreme precipitation and high-temperature events; (5) longer and more intense fire seasons; (6) severe insect outbreaks in vulnerable forests; (7) acidification of the global ocean for tens of thousands of years, with accompanying likely extinctions; (8) compromised economic and national security because of accelerating decay of infrastructure and increased human conflict and displacement; and (9) fundamental changes in the composition, functioning, and biodiversity across

ecosystems. Sea levels will rise significantly, affecting densely populated coastal regions, inundating farmlands, and dislocating large populations; 15%–40% of the anthropogenic CO₂ “pulse” may stay in the atmosphere for more than a thousand years, extending the duration of global warming and its effects on humans and other species⁴⁻⁶.

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ABOUT THE GEOLOGICAL SOCIETY OF AMERICA

The Geological Society of America (GSA), founded in 1888, is a scientific society with over 25,000 members from academia, government, and industry in more than 100 countries. Through its meetings, publications, and programs, GSA advances the geosciences, 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 geologic issues, and supports all levels of earth-science education. Inquiries about 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:

- Become technically informed through recent peer-reviewed syntheses of climate-science research, and through meetings, workshops, symposia, etc., that address recent advances in climate science.
- Help educate the public, both formally (primary, secondary, and higher levels of instruction), and informally (museums, science centers, zoos, aquariums, etc.). Actively engage and collaborate with organizations seeking to promote climate change education.
- Participate in outreach activities to explain the science of climate change, for example, in community schools, discussion groups, meetings with community leaders and congressional staffs, GSA's Congressional Visits Day, op-ed articles, and/or online forums. Support organizations that seek to mitigate and adapt to global climate change.
- Discuss with businesses and policy makers the causes and consequences of climate change, as well as opportunities to transition to low-carbon energies and to implement energy efficiencies.
- Actively engage and collaborate with other science and/or policy organizations in recommending and formulating national and international strategies to address approaching impacts of anthropogenic climate change.
- Take advantage of the accompanying list of references for a current scientific assessment of global climate change.

WEBSITES

Intergovernmental Panel on Climate Change

1. <https://www.ipcc.ch/>

U.S. National Academies of Science, Engineering, and Medicine

2. Climate Change at the National Academies: <https://sites.nationalacademies.org/sites/climate/index.htm>
3. Climate at the National Academies, Discover: https://sites.nationalacademies.org/sites/climate/SITES_190724

U.S. Global Change Research Program

4. <http://www.globalchange.gov/>

REFERENCES

1. National Academy of Sciences and the Royal Society (England). Climate Change: Evidence and Causes (2020).
2. National Academies of Science, Engineering, and Medicine. <https://sites.nationalacademies.org/sites/climate> (2020).
3. National Research Council. America's Climate Choices. (The National Academies Press, 2011).
4. USGCRP. Climate science special report: Fourth National Climate Assessment, Volume 1. (U.S. Global Change Research Program, Washington, DC, 2017).
5. USGCRP. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume 2. (U.S. Global Change Research Program, Washington, DC, 2018).
6. IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (IPCC, Geneva, Switzerland, 2014)