COMMENTARY

GSA Position Statement on Climate Change

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GSA recently released its new position statement on climate change. Because this issue has been highly controversial in recent years, this article is written to provide information on the history of developing the statement and its scientific basis. I write this in my former capacity as chair of the panel that assembled the early draft statement, and as a GSA member since 1966 and Fellow since 1971.

In 2007, I was invited to become a member of the Critical Issues Caucus (CIC), a group of about two-dozen GSA scientists who exchange opinions about emerging environmental issues with the goal of suggesting new initiatives to the GSA, and specifically to the GSA Geology and Public Policy Committee (GPPC). In spring 2008, I concluded that the next GSA position statement on climate change needed to reflect the many recent advances in scientific understanding occurring in that field. I wrote a draft of a possible future statement, circulated it within the CIC, and received suggestions for improvements. In June 2008, a draft position was approved without dissent by the CIC and sent forward in July to the GPPC, chaired at that time by Dick Berg. The GPPC considered the draft during its October 2008 meeting and concluded that a revision to the existing statement was timely. The GPPC wrote a proposal recommending appointment of an expert panel, chaired by me, to develop a draft revised statement. The proposal was forwarded to and approved by Council in January 2009.

Early in 2009, the GPPC and I assembled the panel (see sidebar). We sought highly respected scientists who had international reputations and were recognized leaders in the disciplines and subdisciplines involved in the climate issue. The eight panel members, who have worked for decades in the climate/paleoclimate area, have a total of nearly 900 published papers. Three are members of the National Academy of Science, many are AGU or GSA Fellows (or both), and several have won prestigious medals from major scientific societies. Thure Cerling provided continuity to the panel that had produced the 2006 climate statement. Hydrogeologist Jean Bahr (then GSA president-elect) volunteered as a liaison to the GPPC, and Don Paul served because of his industry perspective and his interest in the climate problem. The panel members have not been outspoken advocates on either side of the global warming issue. I have spoken out against exaggerations on the climate issue in a trade book for Princeton University Press and invited contributions to the AGI publication, *EARTH*, but I have criticized both extremes.

Working by e-mail starting in early March 2009, the panel produced a draft statement by May and sent it to the GPPC. The GPPC refined the draft and approved it in June 2009. The statement was then sent to GSA members via the e-news magazine, *GSA Connection*, on 17 August and via *GSA Today* in early September for a comment period. Because of delays some members experience in receiving their *GSA Today* issues, the comment period was extended to the end of the month.

Those GSA members who submitted statements were assured of anonymity so that they would feel free to speak out regardless of possible workplace constraints. Rex Buchanan, the new chair of GPPC, and I were charged with reading the comments and deciding on appropriate response(s). We received comments from ~60 members, or just under 0.3% of GSA's 22,000 members. The responses fell into three categories: (1) generally favorable comments, some of which suggested changes or additions to improve the statement; (2) more neutral or moderately unfavorable (but still constructive) responses that in many cases suggested changes or clarifications on various issues; and (3) responses that were critical of the entire process and in many cases dismissive of the motives of anyone who had taken part.

Faced with these highly divergent reactions from GSA members, mindful of the very controversial nature of this issue, and holding to the guarantee of anonymity for those who had commented, I proposed in late August 2009 that the panel respond to those major criticisms that we chose not to incorporate into the revised statement. I tabulated the criticisms and condensed them to a short list of seven, which I sent to the panel (with no member names attached), and we produced the response printed at the end of this article. Those GSA members who remain unsure about the anthropogenic warming issue will find within this document arguments that counter many common misconceptions about (and objections to) anthropogenic warming, as well as references with which to check out the scientific basis of the counter-arguments. A few items in the Aug.–Sept. 2009 panel response have been updated in minor ways to reflect subsequent developments, including recent publications of relevance.

In October 2009, the GSA Executive Committee voted unanimously to forward a slightly amended draft of the position statement to GSA Council for a vote. Council discussed the statement during its October meeting, held shortly after receiving the draft from GPPC, but felt the need for additional review and comment prior to voting. The comments and suggested edits from Council were referred back to GPPC for consideration, including clarification on several scientific issues. Although the panel formally disbanded on 1 February 2010, individual members helped to supply the information requested by the GPPC as it prepared a revision of the draft statement and responses to GSA Council comments. The GPPC approved a new revision of the draft statement during its March 2010 meeting and forwarded the revised draft to Council. In April

2010, GSA Council voted on and approved that version of the revised statement without modification.

I add several personal perspectives about this process:

1. The operations of the panel were remarkably consensual throughout. We soon came to basic agreement on the major issues in the statement and spent most of our time refining the wording to make sure it accorded fully with the latest science. We agreed to characterize the large climatic changes currently projected for the future as "risky," but we did not think it was our role to try to choose among possible policy options.
2. Many members of the public and the media seem confused about which sources to trust on the subject of global warming. The members of this panel are not only highly respected but also typical of the large body of mainstream climate scientists who spend most of their time "doing the science" and rarely, if ever, speak out on policy issues. This position statement qualifies as a mainstream climate science document.
3. Given that *any* position statement on climate change was inevitably going to be seen as controversial by one part of the GSA membership or another, the GSA leadership showed excellent judgment and considerable courage in supporting this climate statement and thereby weighing in on the side of mainstream climate science.

PANEL RESPONSES TO GSA MEMBER COMMENTS

(Oct. 2009; updated Apr. 2010)

Is the panel qualified?

Cumulatively, the panel members have published ~900 peer-reviewed research papers on paleoclimate/climate, ranging across the Paleozoic, Mesozoic, and Cenozoic, and including the Pleistocene and Holocene. Barron was director of the National Center for Atmospheric Research and is now president of Florida State University. Cerling, Kutzbach, and Lean are members of the

PANEL MEMBERS

Jean M. Bahr: Hydrogeology. Professor and past chair of the Dept. of Geoscience, Univ. of Wisconsin; 2009–2010 Geological Society of America president and panel liaison to the GPPC. Fellow: GSA. Learn more at www.geology.wisc.edu/people/display.html?id=4.

Eric J. Barron: Mesozoic climate. President, Florida State Univ. Former director, National Center for Atmospheric Research; former dean, Jackson School of Geosciences, Univ. of Texas at Austin. Recipient of the NASA Distinguished Public Service Medal. Fellow: AAAS, AGU, AMS, GSA. Learn more at http://president.fsu.edu/biography/index.html.

Julie Brigham-Grette: Cenozoic to Holocene climate. Geosciences Dept. professor, Univ. of Massachusetts. Past chair, PAGES Steering Committee; past president, American Quaternary Association. Member, National Academy of Sciences Polar Research Board. Learn more at www.geo.umass.edu/faculty/jbg.

Thure Cerling: Mesozoic to Quaternary climate. Distinguished professor, Dept. of Geology and Geophysics, Univ. of Utah. Member, National Academy of Sciences. Fellow: GSA, AAAS, and International Association of Geochemistry. Learn more at www.biology.utah.edu/faculty2.php?inum=55.

Peter U. Clark: Quaternary climate. Professor, Dept. of Geosciences, Oregon State Univ. Recipient of the Easterbrook Distinguished Scientist Award (GSA). Fellow: GSA, AGU. Learn more at geo.oregonstate.edu/people/faculty/clarkp.htm.

John E. Kutzbach: Paleozoic to Holocene climate. Associate Director, Univ. of Wisconsin–Madison Center for Climatic Research, Gaylord Nelson Institute for Environmental Studies. Member, National Academy of Sciences; recipient of the Roger Revelle Medal (AGU), the Milankovitch Medal (EGU), and the William Smith Award (Geological Society of London). Fellow: AGU, AMS. Learn more at http://ccr.aos.wisc.edu/contact/kutzbach_john.php.

Judith Lean: Historical to Recent climate and solar physics. Senior Scientist, Naval Research Laboratory. Member, National Academy of Sciences. Fellow: AGU. Learn more at http://eospso.gsfc.nasa.gov/ess20/docs/lean_bio.pdf.

Donald L. Paul: Exploration geologist. Director, Univ. of Southern California Energy Institute, William Keck Chair in Energy Resources. Past vice-president and chief technology officer, Chevron-Texaco Corporation. Learn more at www.usc.edu/schools/sppd/faculty/detail.php?id=74.

William F. Ruddiman: Cenozoic climate. Past professor and chair, Dept. of Environmental Science, Univ. of Virginia. Past associate director, Lamont-Doherty Earth Observatory; past director, CLIMAP project. Recipient of the Lyell Medal (Geological Society of London). Fellow: GSA, AGU. Learn more at www.evsc.virginia.edu/faculty/ruddiman-william-f.

Cathy Whitlock: Cenozoic climate. Professor, Dept. of Earth Sciences, Montana State Univ. Past geography dept. chair, Univ. of Oregon; past president, American Quaternary Association; chair, U.S. National Committee, International Quaternary Union. Learn more at www.montana.edu/wwwes/facstaff/whitlock.htm.

National Academy of Sciences. Ruddiman wrote the widely used college textbook, *Earth's Climate*. Seven are GSA members, and many are Fellows of the GSA, AGU, AMS, and past presidents of other organizations. The panel's four women and six men are distributed among eight states and the District of Columbia. None has been outspoken at either the alarmist or skeptic extreme of the spectrum of views on global warming.

Was there an "inappropriate" IPCC influence?

Some critics claim that the 2007 IPCC process was flawed and that its conclusions were accepted uncritically by the members of the National Academy and the panel. In this view, recognized experts in the field appear for some reason ill-informed and easily misled on important issues that lie within their expertise. In contrast, the panel views the 2007 IPCC statement as a valid synthesis and assessment of current knowledge of global warming that received thorough and extensive review from many members of the scientific community (despite minor errors discovered recently).

Could the last 125 years of warming be natural?

Because Earth's climate is always changing, some claim that the recent warming is natural, not anthropogenic. This criticism is refuted by a growing body of evidence closely scrutinized by panel members with a wide range of experience studying natural climate change on time scales ranging from tectonic to orbital to recent/instrumental. Given this experience, panel members took into account competing hypotheses in arriving at their conclusions. The warming of the last century is unusual in both speed and size, and it cannot be explained by natural factors, except for the modest solar contribution during the first half of the century.

Was there a larger solar influence?

Some claim that the Sun is responsible for most twentieth-century climate change, including the net warming since 1980. Contrary to this claim, satellite measurements of solar radiation over the last 30 years find no significant persistent trend other than 11-year cycles. These cycles vary in amplitude by 0.1% (1 W/m^2) around a mean value of 1361 W/m^2, and empirically based studies indicate that global surface temperature responds with an amplitude of ~0.1 °C. Possible indirect effects of solar ultraviolet radiation on the stratosphere and troposphere are being investigated, with some recent studies indicating a small effect. In summary, Earth's response to solar variability during the satellite era is ~0.1 °C, much smaller than the projected warming of <2 °C to >5 °C in the next century from greenhouse gases.

Some have also claimed that solar variability over century to millennial time scales has influenced climate, but we lack direct solar irradiance observations to show how the Sun varied this far in the past. Two proposed proxies of solar forcing on centennial time scales are compromised by other factors tied to climate. The age difference between ^{14}C and tree-ring counts is affected by changes in ocean circulation and carbon reservoirs, and ^{10}Be variations in ice cores are affected by changes in snow accumulation rates. As a result, it is difficult to separate solar forcing from internal climate system responses. In addition, proxy measurements of climate during previous millennia are highly variable both from site to site and for multiple proxies at single sites. Circumstantial evidence points to a link between solar and climatic proxies at some sites, but widespread evidence of a strong link remains ambiguous.

What is the significance of the recent cooling?

The 150-year instrumental record of global temperature shows an obvious long-term increase. Superimposed on this increase are shorter-term rises and falls caused by natural fluctuations due to ENSO (El Niño–Southern Oscillation; or decadal-scale atmosphere-ocean oscillations such as the Pacific Decadal Oscillation [PDO]), volcanic eruptions, the 11-year solar cycle, and perhaps other factors. A very small cooling occurred from 2005 to 2008, but 2009 was a warmer year. The last 10 years make up the warmest 10-year interval in the entire instrumental record, as are the averages for the last 15 years, 20 years, and longer. Every previous pause or dip in the long-term warming trend was followed by new record warmth.

What about the urban heat-island effect?

Some claim that compilations of surface temperature are compromised by anomalous warmth at stations located in "heat islands" warmed by urban growth, but urban areas cover less than 2% of Earth's land surface. Station data from the Arctic demonstrate that this non-urbanized region has experienced a warming larger than the global average, a conclusion also supported by decreasing snow cover and sea ice trends measured by satellites and borehole temperature trends. In addition, many stations from other non-urbanized areas show warming trends larger than the global average. Early attempts to estimate global average temperature were compromised by the heat-island effect, but methods have now removed most of this overprint. Any such effect remaining in the observations is estimated to contribute <5% to the warming trend in hemispheric and global-average temperatures.

Can models predict future climate?

Another criticism is that models are useless for predicting climate change far in the future. One part of this argument is that models can't even predict weather two weeks from now, so how can they predict the distant future? This criticism is based on a misunderstanding of how models are used.

Weather models start from initial observations of present weather conditions, and they rely on equations to anticipate how specific weather systems will develop in the near future. But the current "weather" is not known perfectly, and thus the model forecasts start out with small errors. As the model forecasts progress, non-linear processes inherent to the climate system cause actual weather to diverge from the model forecasts. After 10 days to two weeks, model predictions of features such as specifics storm at a particular time and place are no longer reliable.

The use of models for future climate forecasts is entirely different. Climate models rely on analogous equations, but not to predict day-to-day weather in the far-distant future, which is obviously impossible. Instead, they estimate *average* annual or seasonal changes expected when factors that determine modern-day climate—such as sun strength, greenhouse gases, and aerosols—change by specified amounts.

Climate models are initially evaluated by how well they reproduce the main characteristics of modern climate, such as temperature, precipitation, pressure, and wind direction and strength. On balance, they simulate these features well, although more successfully for temperature than for regional precipitation. One criticism is that these models are "tuned" to simulate modern climate. Although tuning is a part of the modeling process, it is not an unconstrained exercise. Models have to capture basic climatic characteristics both vertically and spatially at global, hemispheric, and regional scales, and over average annual and daily cycles. Simultaneously reproducing all these features reasonably well is a highly challenging test that cannot be met by simply tweaking a few "knobs."

In addition, climate models have been tested by their ability to simulate times in the past when the average climate was very different due to changes in well-constrained factors, such as orbital parameters (the mid-Holocene 6000 years ago) and ice sheets, carbon dioxide levels, and sea level (the last glacial maximum 20,000 years ago). This ongoing process of testing and successfully validating climate models against past observations is a major reason scientists feel confident in relying on them to predict average conditions in future centuries. Many scientists in GSA (including several panel members) have made important contributions to these scientific advances.

As the draft position statement notes, these projections of average future climate carry uncertainties tied to (1) the uncertain range of future gas emissions and atmospheric concentrations, and (2) climate feedbacks that are not yet tightly constrained. Over shorter intervals, such as the next decade or two, changes are difficult to predict because of natural variability in the climate system ("noise") and because models assign different strengths to key factors. Farther in the future (a century from now), these uncertainties will have become progressively less important as the response to growing CO_2 concentrations increasingly overwhelms natural variability.

In summary, the model capabilities noted above show that they provide a firm basis for assessing the plausible range of future climates that could result from greenhouse-gas forcing. Even the lower end of the projected range will bring a global warming of 1.5–2 °C (~3 times larger than that experienced to date). The middle-to-upper range of the estimates (4–6 °C) would make future climate on Earth as much warmer than it was colder during the peak of the last glacial maximum 20,000 years ago.

FURTHER READING

Several scientific references that support key statements in the 2010 GSA position statement on climate change are listed with that document. The following additional references address common misconceptions about (and resulting criticisms of) mainstream scientific views on anthropogenic global warming.

Solar Influence

Lockwood, M., 2008, Recent changes in solar outputs and global mean surface temperature. III. Analysis of contributions to global mean air surface temperature rise: Proceedings of the Royal Society A, v. 464, p. 1387–1404, doi: 10.1098/rspa.2007.0348.

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Peterson, T.C., 2003, Assessment of urban versus rural in situ temperature differences in the contiguous United States: No difference found: Journal of Climate, v. 16, p. 2941–2959.

Parker, D.E., 2006, A demonstration that large-scale warming is not urban: Journal of Climate, v. 19, p. 2882–2895.

Recent Cooling

Peterson, T.C., Connolley, W.M., and Fleck, J., 2008, The myth of the 1970s global cooling scientific consensus: Bulletin of the American Meteorological Society, Sept., p. 1325–1337, doi: 10.1175/2008BAMS2370.

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Fawcett, R., 2007, Has the world cooled since 1998?: Bulletin of the Australian Meteorological and Oceanographic Society: v. 20, p. 141–148.

Murphy, D.M., Solomon, S., Portmann, R.W., Rosenlof, K.H.., Forster, P.M., and Wong, T., 2009, An observationally based energy balance for the Earth since 1950: Journal of Geophysical Research, v. 114, D17017, doi: 10.1029/2009JD012105.

von Shuckmann, K., Gaillard, F., and Le Traon, P.-Y., 2009, Global hydrographic variability patterns during 2003–2008: Journal of Geophysical Research, v. 114, C00907, doi: 10.1029/2008JC005237.

Model Testing Based on Paleo Data

Ruddiman, W.F., 2007, Earth's Climate: Past and Future: New York, W.H. Freeman & Company, 465 p. (Note: Several chapters [and references therein] give examples of the interplay between geologic observations and modeling: Ch. 2: general use of models; Ch. 4: Supermonsoons on Pangaea; Ch. 5: Cretaceous greenhouse climate; Ch. 6: Cenozoic cooling; Ch. 8: insolation control of ice sheets; Ch. 11: orbital-scale interactions; Ch. 12: last glacial maximum; Ch. 13: last deglaciation and Holocene. Some of many studies not mentioned in the book follow.)

Lunt, D.J., Haywood, A.M., Schmidt, G.A., Salzmann, U., Valdes, P.J., and Dowsett, H.J., 2009, Earth system sensitivity inferred from Pliocene modelling and data: Nature Geoscience, v. 3, p. 60–64, doi: 10.1038/ngeo706.

DeConto, R.M., and Pollard, D., 2003, Rapid Cenozoic glaciation of Antarctica induced by declining atmospheric CO_2: Nature, v. 421, p. 245–249, doi: 10.1038/nature01290.

Oto-Bleisner, B.L, Marshall, S.J., Overpeck, J.T., Miller, G.H., Hu, A., and CAPE Last Interglacial Project members, 2010, Simulating Arctic climate warmth and icefield retreat in the last interglaciation: Science, v. 311, p. 1751–1753, doi: 10.1126/science.1120808.

Model Simulations of Recent/Future Warming

Meehl, G.A., Washington, W.M., Ammann, C.M, Arblaster, J.M., Wigley, T.M.L., and Tebaldi, C., 2004, Combinations of natural and anthropogenic forcings in twentieth-century climate: Journal of Climate, v. 17, p. 3721–3727.