

Surface Temperature Reconstructions for the Last 2,000 Years

Statement of

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Good morning, Mr. Chairman and members of the Committee. My name is Jerry North. I am the Harold J. Haynes Endowed Chair in Geosciences and a Distinguished Professor in the Department of Atmospheric Sciences at Texas A&M University, and I served as chair of the National Research Council's Committee on Surface Temperature Reconstructions for the Last 2,000 Years. The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine, chartered by Congress in 1863 to advise the government on matters of science and technology.

My comments today will highlight the key findings of our committee's recent report on Surface Temperature Reconstructions for the Last 2,000 Years, which was prepared in response to a request from Chairman Boehlert of the House Committee on Science. Our task was to assess the state of scientific efforts to reconstruct surface temperature records for the Earth over the past few hundred to few thousand years, and to comment on the implications of these efforts for our understanding of global climate change. I would like to stress, in advance, that surface temperature reconstructions are only one of multiple lines of evidence supporting the conclusion that the climate is warming in response to human activities, and they are not the primary evidence. In fact, man-made climate change is quite real. However, our report did not examine projections of future climate change in any detail, and it does not make policy recommendations.

Let me begin by briefly explaining how scientists go about reconstructing surface temperatures for the past few millennia. Because widespread thermometer measurements are only available for the last 150 years or so, scientists estimate temperatures in the more distant past by analyzing what we call proxy evidence. Common proxies include tree

rings, corals, ocean and lake sediments, cave deposits, ice cores, glacier records, boreholes, and historical documents. To give one example, the annual growth rings in a tree can tell us about the climate at that location when the growth occurred -- a thicker ring indicates better growing conditions than a narrow ring. Likewise, the advances and retreats of glaciers around the world provide evidence of warming and cooling.

Starting in the 1990s, scientists began using sophisticated methods to combine proxy evidence from many different locations in an effort to estimate surface temperature changes averaged over broad geographic regions during the last few hundred to few thousand years. These large-scale surface temperature reconstructions have enabled researchers to estimate past temperature variations over the Northern Hemisphere or even the entire globe, often with time resolution as fine as decades or even individual years.

The papers that have attracted the most attention in this research area were written by Michael Mann, Raymond Bradley and Malcolm Hughes in 1998 and 1999. Dr. Mann and his colleagues used a new methodology to combine data from a number of sources to estimate temperatures in the Northern Hemisphere for the last six centuries, and then for the last 1,000 years. This research received wide attention, in part because the authors concluded that the Northern Hemisphere was warmer during the late 20th century than at any other time during the past millennium, and also because it was illustrated with a simple graphic, the so-called hockey stick curve, that was featured prominently in the 2001 Intergovernmental Panel on Climate Change report.

Our committee was composed of 12 members with expertise in a range of fields including climate modeling, statistics, climate change and variability, and each of the types of proxies commonly used for climate reconstructions. The committee took

multiple steps to accomplish its charge. First, we hosted a two-day workshop in March 2006 and invited numerous speakers from all perspectives in the debate to participate. We examined the scientific literature in great depth, and considered written input from many sources. The evidence we considered included large-scale surface temperature reconstructions from a number of different research teams, as well as local and regional proxy evidence collected from a number of locations around the world. We also looked at the instrumental record and examined various statistical considerations.

Let me summarize five key conclusions we reached after reviewing the evidence:

1. The instrumentally measured warming of about 1°F during the 20th century is also reflected in borehole temperature measurements, the retreat of glaciers, and other observational evidence, and can be simulated with climate models.
2. Large-scale surface temperature reconstructions yield a generally consistent picture of temperature trends during the preceding millennium, including relatively warm conditions centered around A.D. 1000 (identified by some as the “Medieval Warm Period”) and a relatively cold period (or “Little Ice Age”) centered around 1700.
3. It can be said with a high level of confidence that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries. This statement is justified by the consistency of the evidence from a wide variety of geographically diverse proxies.
4. Less confidence can be placed in large-scale surface temperature reconstructions for the period A.D. 900 to 1600. Presently available proxy evidence indicates that temperatures at many, but not all, individual locations were higher during the past 25 years than during any period of comparable length since A.D. 900. The uncertainties

increase substantially backward in time through this period and are not yet fully quantified.

5. Very little confidence can be assigned to statements concerning the hemispheric mean or global mean surface temperature prior to about A.D. 900.

The main reason that our confidence in large-scale surface temperature reconstructions is lower before A.D. 1600 and especially before A.D. 900 is the relative scarcity of precisely dated proxy evidence. Other factors limiting our confidence in surface temperature reconstructions include the relatively short length of the instrumental record, the fact that all proxies are influenced by many climate variables, and the possibility that the relationship between proxy data and local surface temperatures may have varied over time. All of these considerations introduce uncertainties that are difficult to quantify.

Overall, the committee finds that efforts to reconstruct temperature histories for broad geographic regions using multiproxy methods are an important contribution to climate research and that these large-scale surface temperature reconstructions contain meaningful climatic signals. The individual proxy series used to create these reconstructions generally exhibit strong correlations with local environmental conditions, and in most cases there is a physical, chemical, or physiological reason why the proxy reflects local temperature variations. Our confidence in the results of these reconstructions becomes stronger when multiple independent lines of evidence point to the same general result, as in the case of the Little Ice Age cooling and the 20th century warming.

The basic conclusion of the 1999 paper by Dr. Mann and his colleagues was that the late 20th century warmth in the Northern Hemisphere was unprecedented during at least the last 1,000 years. This conclusion has subsequently been supported by an array of evidence that includes both additional large-scale surface temperature reconstructions and pronounced changes in a variety of local proxy indicators, such as melting on icecaps and the retreat of glaciers around the world, which in many cases appear to be unprecedented during at least the last 2,000 years.

Based on the analyses presented in the original papers by Mann et al. (1998, 1999) and this newer supporting evidence, the committee finds it plausible that the Northern Hemisphere was warmer during the last few decades of the 20th century than during any comparable period over the preceding millennium. However, the substantial uncertainties currently present in the quantitative assessment of large-scale surface temperature changes prior to about A.D. 1600 lower our confidence in this conclusion compared to the high level of confidence we place in the Little Ice Age cooling and 20th century warming. Even less confidence can be placed in the original conclusions by Mann et al. (1999) that “the 1990s are likely the warmest decade, and 1998 the warmest year, in at least a millennium” because the uncertainties inherent in temperature reconstructions for individual years and decades are larger than those for longer time periods, and because not all of the available proxies record temperature information on such short timescales. We also question some of the statistical choices made in the original papers by Dr. Mann and his colleagues. However, our reservations with some aspects of the original papers by Mann et al. should not be construed as evidence that our

committee does not believe that the climate is warming, and will continue to warm, as a result of human activities.

Large-scale surface temperature reconstructions are only one of multiple lines of evidence supporting the conclusion that climatic warming is occurring in response to human activities, and they are not the primary evidence. The scientific consensus regarding human-induced global warming would not be substantively altered if, for example, the global mean surface temperature 1,000 years ago was found to be as warm as it is today. This is because reconstructions of surface temperature do not tell us *why* the climate is changing. To answer that question, one would need to examine the factors, or forcings, that influence the climate system. Prior to the Industrial Revolution, the primary climate forcings were changes in volcanic activity and in the output of the Sun, but the strength of these forcings is not very well known. In contrast, the increasing concentrations of greenhouse gases in the atmosphere over the past century are consistent with both the magnitude and the geographic pattern of warming seen by thermometers.

One significant part of the controversy on this issue is related to data access. The collection, compilation, and calibration of paleoclimatic proxy data represent a substantial investment of time and resources, often by large teams of researchers. The committee recognizes that access to research data is a complicated, discipline-dependent issue, and that access to computer models and methods is especially challenging because intellectual property rights must be considered.

Our view is that all research benefits from full and open access to published datasets and that a clear explanation of analytical methods is mandatory. Peers should have access to the information needed to reproduce published results, so that increased

confidence in the outcome of the study can be generated inside and outside the scientific community. Paleoclimate research would benefit if individual researchers, professional societies, journal editors, and funding agencies continued their efforts to ensure that existing open access practices are followed.

So where do we go from here? Large-scale surface temperature reconstructions have the potential to further improve our knowledge of temperature variations over the last 2,000 years, particularly if additional proxy evidence can be identified and obtained from areas where the coverage is relatively sparse and for time periods before A.D. 1600 and especially before A.D. 900. It would also be helpful to update proxy records that were collected decades ago, in order to develop more reliable calibrations with the instrumental record.

New analytical methods, or more careful use of existing ones, may also help circumvent some of the existing limitations of surface temperature reconstructions performed using multiple proxy data. Efforts to improve our understanding of how solar output and volcanic activity have varied over the past few thousand years are also important. Finally, because some of the most important potential consequences of climate change are linked to changes in regional circulation patterns, hurricane activity, and the frequency and intensity of droughts and floods, regional and large-scale reconstructions of changes in other climatic variables, such as precipitation, over the last 2,000 years would provide a valuable complement to those made for temperature.

In summary, as science has made progress over the past few years, we have learned that large-scale surface temperature reconstructions are important tools in our understanding of global climate change. Surface temperature reconstructions are a useful

source of information about the variability and sensitivity of the climate system, and they contribute evidence that allows us to say, with a high level of confidence, that global mean surface temperature was higher during the last few decades of the 20th century than during any comparable period during the preceding four centuries. Further research, especially the collection of additional proxy evidence, would help to reduce uncertainties and allow us to make more definitive conclusions over longer time periods.

Thank you for your attention. My colleagues and I would be happy to address and questions the Subcommittee might have.