

**STATEMENT TO THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY  
OF THE UNITED STATES HOUSE OF REPRESENTATIVES**

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**Executive Summary**

The Berkeley Earth Surface Temperature project was created to make the best possible estimate of global temperature change using as complete a record of measurements as possible and by applying novel methods for the estimation and elimination of systematic biases. It was organized under the auspices of Novim, a non-profit public interest group. Our approach builds on the prior work of the groups at NOAA, NASA, and in the UK (Hadley Center – Climate Research Unit, or HadCRU).

Berkeley Earth has assembled 1.6 billion temperature measurements, and will soon make these publicly available in a relatively easy to use format.

The difficult issues for understanding global warming are the potential biases. These can arise from many technical issues, including data selection, substandard temperature station quality, urban vs rural effects, station moves, and changes in the methods and times of measurement.

We have done an initial study of the station selection issue. Rather than pick stations with long records (as done by the prior groups) we picked stations randomly from the complete set. This approach eliminates station selection bias. Our results are shown in the Figure; we see a global warming trend that is very similar to that previously reported by the other groups.

We have also studied station quality. Many US stations have low quality rankings according to a study led by Anthony Watts. However, we find that the warming seen in the “poor” stations is virtually indistinguishable from that seen in the “good” stations.

We are developing statistical methods to address the other potential biases.

I suggest that Congress consider the creation of a Climate-ARPA to facilitate the study of climate issues.

Based on the preliminary work we have done, I believe that the systematic biases that are the cause for most concern can be adequately handled by data analysis techniques. The world temperature data has sufficient integrity to be used to determine global temperature trends.

## Testimony of Richard A. Muller

Thank you Chairman Hall and Ranking Member Johnson for this opportunity to testify before the Committee.

I am a Professor of Physics at UC Berkeley and Faculty Senior Scientist at the Lawrence Berkeley Laboratory. I founded the Berkeley Earth Surface Temperature project under the auspices of Novim, a non-profit public interest group. My testimony represents my personal views and not those of the above organizations.

*[[Italic part for written statement only, not to be read aloud]]*

*I've published papers on climate change in Science, Nature, and other refereed journals; I am the author of a technical book on the subject.*

*My papers on climate change have appeared in Nature, Science, Paleoceanography, and the Journal of Geophysical Research. I wrote a technical book on the Earth's past temperature changes: "Ice Ages and Astronomical Causes", Springer 2000. I am the author of "Physics for Future Presidents", a popular book which describes many misuses of data in climate. I was a cited referee on the report of the NRC on the hockey stick controversy. For two years I wrote an online column for MIT's Technology Review. My major awards for scientific achievement include the Alan T. Waterman Award of the National Science Foundation, the Texas Instruments Founders Prize, a MacArthur Prize Fellowship, and election to the American Academy of Arts and Sciences and to the California Academy of Sciences.*

*The Berkeley Earth Surface Temperature study has received a total of \$623,087 in financial support from:*

*The Lee and Juliet Folger Fund (\$20,000)*

*Lawrence Berkeley National Laboratory (\$188,587)*

*William K. Bowes, Jr. Foundation (\$100,000)*

*Fund for Innovative Climate and Energy Research (created by Bill Gates) (\$100,000)*

*Charles G. Koch Charitable Foundation (\$150,000)*

*The Ann & Gordon Getty Foundation (\$50,000)*

*We have also received funding from a number of private individuals, totaling \$14,500.*

*For more information on Berkeley Earth, see [www.BerkeleyEarth.org](http://www.BerkeleyEarth.org)*

*For more information on Novim, see [www.Novim.org](http://www.Novim.org)*

I begin by talking about

### **Global Warming**

Prior groups at NOAA, NASA, and in the UK (*HadCRU*) estimate about a 1.2 degree C land temperature rise from the early 1900s to the present. This 1.2 degree rise is what we call **global warming**. Their work is excellent, and the Berkeley Earth project strives to build on it.

**Human caused** global warming is somewhat smaller. According to the most recent IPCC report (2007), the human component became apparent only after 1957, and it

amounts to “most” of the 0.7 degree rise since then. Let’s assume the **human-caused warming is 0.6 degrees**.

The magnitude of this temperature rise is a key scientific and public policy concern. A 0.2 degree uncertainty puts the human component between 0.4 and 0.8 degrees – a factor of two uncertainty. Policy depends on this number. It needs to be improved.

Berkeley Earth is working to improve on the accuracy of this key number by using a more complete set of data, and by looking at biases in a new way.

*The project has already merged 1.6 billion land surface temperature measurements from 16 sources, most of them publicly available, and is putting them in a simple format to allow easy use by scientists around the world. By using all the data and new statistical approaches that can handle short records, and by using novel approaches to estimation and avoidance of systematic biases, we expect to improve on the accuracy of the estimate of the Earth’s temperature change.*

I’ll now talk about potential  
**Bias in Data Selection**

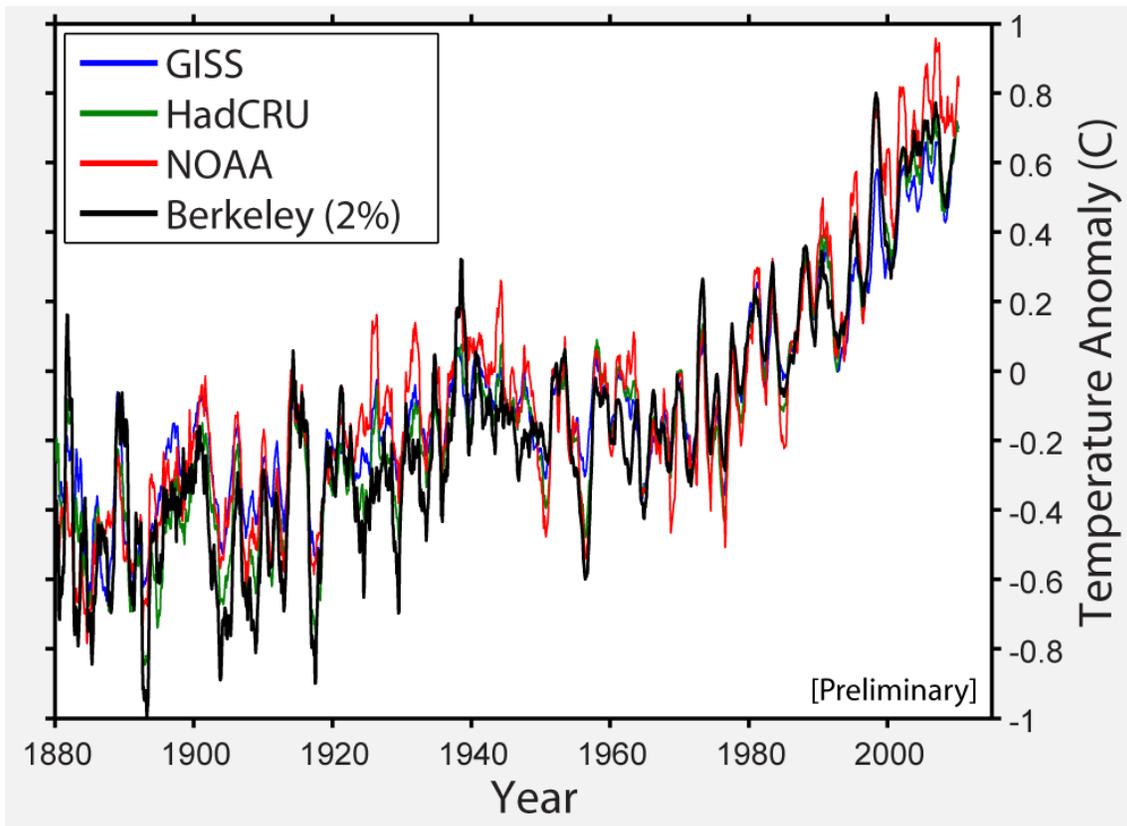
Prior groups (*NOAA, NASA, HadCRU*) selected for their analysis 12% to 22% of the roughly 39,000 available stations. (*The number of stations they used varied from 4,500 to a maximum of 8,500.*)

They believe their station selection was unbiased. Outside groups have questioned that, and claimed that the selection picked records with large temperature increases. Such bias could be inadvertent, for example, a result of choosing long continuous records. (*A long record might mean a station that was once on the outskirts and is now within a city.*)

To avoid such station selection bias, Berkeley Earth has developed techniques to work with all the available stations. *This requires a technique that can include short and discontinuous records.*

In an initial test, Berkeley Earth chose stations randomly from the complete set of 39,028 stations. Such a selection is free of station selection bias.

In our preliminary analysis of these stations, we found a warming trend that is shown in the figure. It is very similar to that reported by the prior groups: a rise of about 0.7 degrees C since 1957. (*Please keep in mind that the Berkeley Earth curve, in black, does not include adjustments designed to eliminate systematic bias.*)



*Figure: Land average temperatures from the three major programs, compared with an initial test of the Berkeley Earth dataset and analysis process. Approximately 2 percent of the available sites were chosen randomly from the complete set of 39,028 sites. The Berkeley data are marked as preliminary because they do not include treatments for the reduction of systematic bias.*

The Berkeley Earth agreement with the prior analysis surprised us, since our preliminary results don't yet address many of the known biases. When they do, it is possible that the corrections could bring our current agreement into disagreement.

Why such close agreement between our uncorrected data and their adjusted data? One possibility is that the systematic corrections applied by the other groups are small. We don't yet know.

*The main value of our preliminary result is that it demonstrates the Berkeley Earth ability to use all records, including those that are short or fragmented. When we apply our approach to the complete data collection, we will largely eliminate the station selection bias, and significantly reduce statistical uncertainties.*

Let me now address the problem of  
**Poor Temperature Station Quality**

Many temperature stations in the U.S. are located near buildings, in parking lots, or close to heat sources. Anthony Watts and his team has shown that most of the current stations in the US *Historical Climatology* Network would be ranked “poor” by NOAA’s own standards, with error uncertainties up to 5 degrees C.

Did such poor station quality exaggerate the estimates of global warming? We’ve studied this issue, and our preliminary answer is **no**.

The Berkeley Earth analysis shows that over the past 50 years the poor stations in the U.S. network do not show greater warming than do the good stations.

Thus, although poor station quality might affect absolute temperature, it does not appear to affect trends, and for global warming estimates, the trend is what is important.

*Our key caveat is that our results are preliminary and have not yet been published in a peer reviewed journal. We have begun that process of submitting a paper to the Bulletin of the American Meteorological Society, and we are preparing several additional papers for publication elsewhere.*

*NOAA has already published a similar conclusion – that station quality bias did not affect estimates of global warming – -- based on a smaller set of stations, and Anthony Watts and his team have a paper submitted, which is in late stage peer review, using over 1000 stations, but it has not yet been accepted for publication and I am not at liberty to discuss their conclusions and how they might differ. We have looked only at average temperature changes, and additional data needs to be studied, to look at (for example) changes in maximum and minimum temperatures.*

*In fact, in our preliminary analysis the good stations report more warming in the U.S. than the poor stations by  $0.009 \pm 0.009$  degrees per decade, opposite to what might be expected, but also consistent with zero. We are currently checking these results and performing the calculation in several different ways. But we are consistently finding that there is no enhancement of global warming trends due to the inclusion of the poorly ranked US stations.*

*Berkeley Earth hopes to complete its analysis including systematic bias avoidance in the next few weeks. We are now studying new approaches to reducing biases from:*

- 1. Urban heat island effects. Some stations in cities show more rapid warming than do stations in rural areas.*
- 2. Time of observation bias. When the time of recording temperature is changed, stations will typically show different mean temperatures than they did previously. This is sometimes corrected in the processes used by existing groups. But this cannot be done easily for remote stations or those that do not report times of observations.*

3. *Station moves. If a station is relocated, this can cause a “jump” in its temperatures. This is typically corrected in the adjustment process used by other groups. Is the correction introducing another bias? The corrections are sometimes done by hand, making replication difficult.*
4. *Change of instrumentation. When thermometer type is changed, there is often an offset introduced, which must be corrected.*

## **Potential Legislation**

I was asked what legislation could advance our knowledge of climate change. After some consideration, I felt that the creation of a Climate Advanced Research Project Agency, or Climate-ARPA, could help.

Without the efforts of Anthony Watts and his team, we would have only a series of anecdotal images of poor temperature stations, and we would not be able to evaluate the integrity of the data.

This is a case in which scientists receiving no government funding did work crucial to understanding climate change. Similarly for the work done by Steve McIntyre. Their “amateur” science is not amateur in quality; it is true science, conducted with integrity and high standards.

Government policy needs to encourage such work. **Climate-ARPA** could be an organization that provides quick funding to worthwhile projects without regard to whether they support or challenge current understanding.

## **In Summary**

Despite potential biases in the data, methods of analysis can be used to reduce bias effects well enough to enable us to measure long-term Earth temperature changes. Data integrity is adequate. Based on our initial work at Berkeley Earth, I believe that some of the most worrisome biases are less of a problem than I had previously thought.