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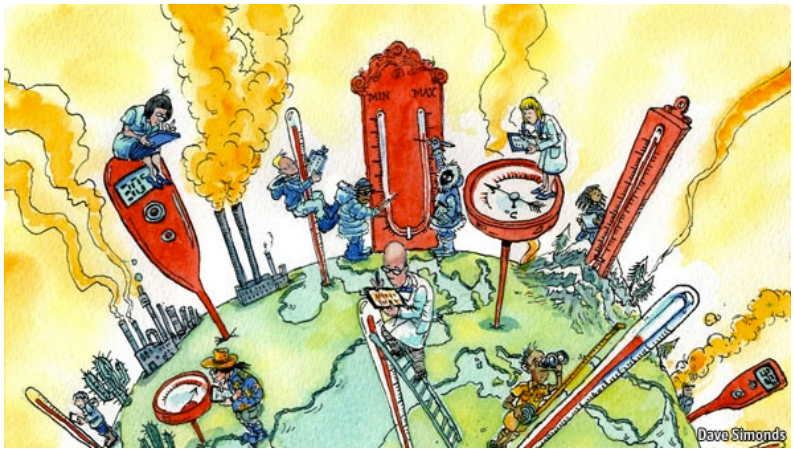
Climate change

The heat is on

A new analysis of the temperature record leaves little room for the doubters. The world is warming

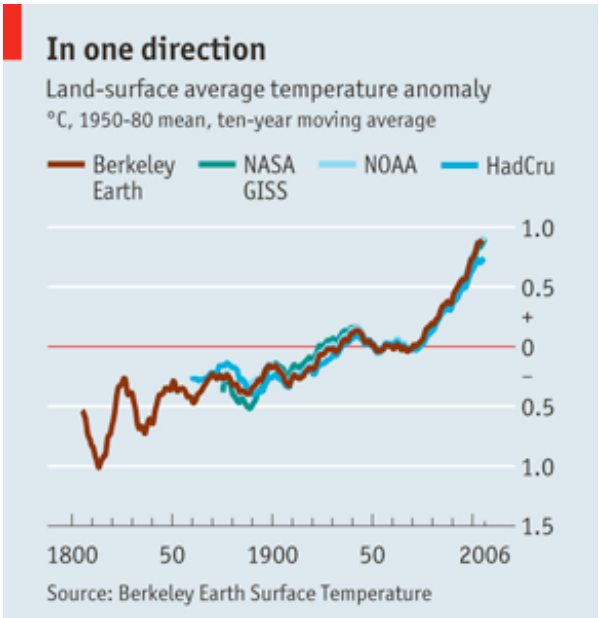


FOR those who question whether global warming is really happening, it is necessary to believe that the instrumental temperature record is wrong. That is a bit easier than you might think.

There are three compilations of mean global temperatures, each one based on readings from thousands of thermometers, kept in weather stations and aboard ships, going back over 150 years. Two are American, provided by NASA and the National Oceanic and Atmospheric Administration (NOAA), one is a collaboration between Britain's Met Office and the University of East Anglia's Climate Research Unit (known as Hadley CRU). And all suggest a similar pattern of warming: amounting to about 0.9°C over land in the past half century.

To most scientists, that is consistent with the manifold other indicators of warming—rising sea-levels, melting glaciers, warmer ocean depths and so forth—and convincing. Yet the consistency among the three compilations masks large uncertainties in the raw data on which they are based. Hence the doubts, husbanded by many eager sceptics, about their accuracy. A new study, however, provides further evidence that the numbers are probably about right.

The uncertainty arises mainly because weather stations were never intended to provide a climatic record. The temperature series they give tend therefore to be patchy and even where the stations are relatively abundant, as in western Europe and America, they often contain inconsistencies. They may have gaps, or readings taken at different times of day, or with different kinds of thermometer. The local environment may have changed. Extrapolating a global average from such data involves an amount of tinkering—or homogenisation.



It might involve omitting especially awkward readings; or where, for example, a heat source like an airport has sprung up alongside a weather station, inputting a lower temperature than the data show. As such cases are mostly in the earlier portions of the records, this will exaggerate the long-term warming trend. That is at best imperfect. And for those—including Rick Perry, the Republican governor of Texas and would-be president —who claim to see global warming as a hoax by grant-hungry scientists, it may look like a smoking gun.

To build confidence in their methodologies, NASA and NOAA already publish their data and algorithms. Hadley CRU is now doing so. A grander solution, outlined in a forthcoming *Bulletin of the American Meteorological Society*, would be to provide a single online databank of all temperature data and analysis. Part of the point would be to encourage more scientists and statisticians to test the existing analyses—and a group backed by Novim, a research outfit in Santa Barbara, California, has recently done just that.

Inconvenient data

Marshalled by an astrophysicist, Richard Muller, this group, which calls itself the Berkeley Earth Surface Temperature, is notable in several ways. When embarking on the project 18 months ago, its members (including Saul Perlmutter, who won the Nobel prize for physics this month for his work on dark energy) were mostly new to climate science. And Dr Muller, for one, was mildly sceptical of its findings. This was partly, he says, because of “climategate”: the 2009 revelation of e-mails from scientists at CRU which suggested they had sometimes taken steps to disguise their adjustments of inconvenient palaeo-data. With this reputation, the Berkeley Earth team found it unusually easy to attract sponsors, including a donation of $150,000 from the Koch Foundation.

Yet Berkeley Earth's results, as described in four papers currently undergoing peer review, but which were nonetheless released on October 20th, offer strong support to the existing temperature compilations. The group estimates that over the past 50 years the land surface warmed by 0.911°C: a mere 2% less than NOAA's estimate. That is despite its use of a novel methodology—designed, at least in part, to address the concerns of what Dr Muller terms "legitimate sceptics".

Most important, Berkeley Earth sought an alternative way to deal with awkward data. Its algorithm attaches an automatic weighting to every data point, according to its consistency with comparable readings. That should allow for the inclusion of outlandish readings without distorting the result. (Except where there seems to be straightforward confusion between Celsius and Fahrenheit, which is corrected.) By avoiding traditional procedures that require long, continuous data segments, the Berkeley Earth methodology can also accommodate unusually short sequences: for example, those provided by temporary weather stations. This is another innovation that allows it to work with both more and less data than the existing compilations, with varying degrees of certainty. It is therefore able to compile an earlier record than its predecessors, starting from 1800. (As there were only two weather stations in America, a handful in Europe and one in Asia for some of that time, it has a high degree of uncertainty.) To test the new technique, however, much of the analysis uses the same data as NOAA and NASA.

Heat maps

In another apparent innovation, the Berkeley team has written into its analysis a geospatial technique, known as kriging, which uses the basic spatial correlations in weather to estimate the temperature at points between weather stations. This promises to provide a more nuanced heat map than presented in the existing compilations, which either consign an average temperature to an area defined by a grid square or, in the case of NASA, attempt a less ambitious interpolation.

It will be interesting to see whether this makes it past the review process. Peter Thorne, a climatologist at the Co-operative Institute for Climate and Satellites, in North Carolina, describes it as "quite a hard sell in periods that are data sparse". He adds: "That doesn't mean you can't do it. It means you've got to prove it works."

Two of the Berkeley Earth papers address narrower concerns. One is the poor location of many weather stations. A crowd-sourcing campaign by a meteorologist and blogger, Anthony Watts, established that most of America's stations are close enough to asphalt, buildings or other heat sources to give artificially high readings. The other is the additional warming seen in built-up areas, known as the "urban heat-island effect". Many sceptics fear that, because roughly half of all weather stations are in built-up areas, this may have inflated estimates of a temperature rise.

The Berkeley Earth papers suggest their analysis is able to accommodate these biases. That is a notable, though not original, achievement. Previous peer-reviewed studies—including one on the location of weather stations co-authored by Mr Watts—have suggested the mean surface temperatures provided by NOAA, NASA and Hadley CRU are also not significantly affected by them.

Yet the Berkeley Earth study promises to be valuable. It is due to be published online with a vast trove of supporting data, merged from 15 separate sources, with duplications and other errors clearly signalled. At a time of exaggerated doubts about the instrumental temperature record, this should help promulgate its main conclusion: that the existing mean estimates are in the right ballpark. That means the world is warming fast.