Has Global Warming Stopped?

Berkeley Earth Memo
by Richard Muller
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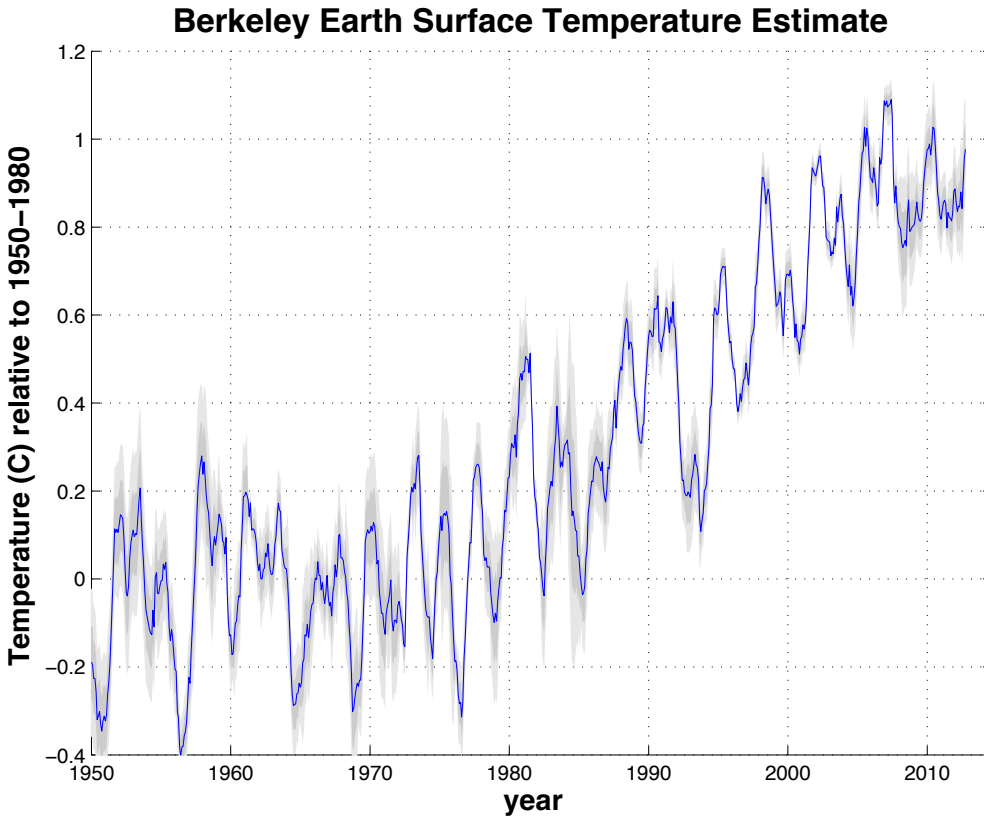
In this memo I give my personal perspective on the widely discussed slowing of global warming over the past decade. My Op Ed on this subject appears in the New York Times on 26 Sept 2013. However, that Op Ed does not include the data plots that I find more compelling than a thousand words.

The Berkeley Earth plot of land temperature change since 1950 is shown below. (For the full plot from 1753, see http://berkeleyearth.org/summary-of-findings.) The monthly data were smoothed with a one-year running average. The dark and light grey regions are the one and two standard deviation uncertainty estimates. The digital data to make this plot are available at http://berkeleyearth.lbl.gov/auto/Global/Full_TAVG_complete.txt

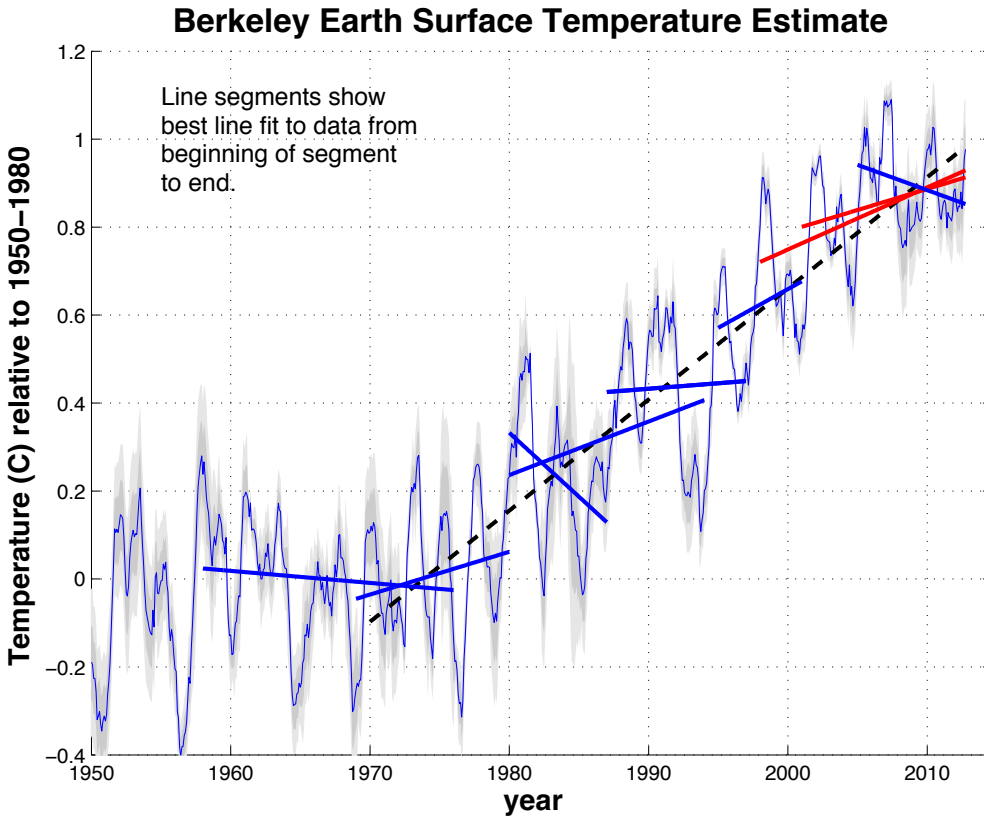


These are the land-only data. Such data have a higher precision than the global data (which includes oceans) since there are many more land stations then in the oceans, and the systematic uncertainties are better understood than for those obtained at sea. Moreover, the land variations are somewhat less susceptible to the known chaotic variations in oceanic currents, although (of course) sea temperature does affect that on land.

The temperature curve above shows rapid up and down bumps that are strongly correlated with the Atlantic multidecadal oscillation and El Nino. For detailed discussion of the correlation, see our peer-reviewed and published papers, available online at
http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50458/abstract
and
http://www.scitechnol.com/2327-4581/2327-4581-1-101.pdf

Now look at the temperature graph plotted above. The temperature has bounced around. The last few years appear to show an end to warming, even a drop. Nevertheless, I will show that this "pause" in global warming is statistically apocryphal.

As aficionados of optical illusions know (and as all scientists have learned) eyeball impressions can be misleading. It is better to do a linear least-squares fit to the data. The plot below shows the results of picking some "interesting" time segments and doing such fits.



The long dashed line shows the global warming rise from 1970 to the present. The short segments show the results of fitting line segments to time periods that seem (to my eye) to show "anomalous" behavior – intervals that might appear to some to be inconsistent with the general rise. Of course, I could have picked

segments that would show steeper than average rises too. In fact, the 2001 IPCC report drew attention to the abrupt rise that occurred in 1999. There was widespread fear that the sudden temperature increase could be due to a tipping point and that runaway warming was imminent. In retrospect, that sharp rise is now attributed to the instability in the Pacific equatorial ocean flow related to El Niño, and it was followed by a very strong dip.

What you will note is that the temperature record is full of fits and spurts, starts and stops, with many segments that are well below the average slope of the global warming rise, or even negative – brief periods of cooling. From 2001 to the present (the data for the current century) the slope significantly reduced. This is the pause that gives skeptics joy and puts the global warming community on the defensive.

But similar pauses and even more severe drops occur at several spots on the recent record. Any one of these, in the past, might have drawn attention as a slowing or reversal of warming. In fact, on June 24, 1974, Time Magazine noted the drop in temperature in an article "Another Ice Age?" Newsweek followed on April 28, 1975, with an article "The Cooling World". Some of the pauses have been attributed to volcanic eruptions (Mt. Pinatubo erupted in June 1991) but the much larger swings are more closely associated with variations in ENSO, and the slower ones with the Atlantic Multidecadal Oscillation or AMO (again, see our paper http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50458/abstract).

Note that the variations, the departures from the linear trend, have high statistical significance; the small error uncertainties (grey regions) indicate that the swings occur all around the world simultaneously. They are real – just not immediately related to the more gradual global warming trend. In fact, when we study the long-term trend, these variations are mathematically treated as noise, since they are not predictable even though they are real. I like to call this figure, with the line segment fits, the "stair step" plot.

Is the recent pause statistically significant? Because of the ENSO and AMO variations, similar variations have occurred in the past. Are these the latest incarnations of ENSO/AMO? Without a fuller understanding of ENSO/AMO, we can't be sure. Based on the record from 1970 to 2001, how likely is a pause similar to the one we see, based simply on the unrelated behavior o ENSO and AMO? Statistical significance is usually described as the likelihood that such a variation might occur given the past behavior of the data. In this case, since similar fluctuations are evident in the data, the current "pause" is not statistically significant.

Bottom line: a look at the recent data gives the impression that global warming may have stopped. Maybe negative cloud cover feedback has kicked in! We can hope it has. But although such a pause may be occurring, as evaluated scientifically it has not yet achieved statistical significance.