‘Peak Oil’ Paper Revised and Temperature Analysis Code

(1) The paper “Implications of ‘Peak Oil’ for Atmospheric CO_2 and Climate”, recently revised and resubmitted to *Environmental Research Letters*, is available at http://pubs.giss.nasa.gov/abstracts/submitted/Kharecha_Hansen.html

A principal concern of both referees was our use of a pulse-response function, fit to the Bern carbon cycle model, as opposed to a detailed carbon cycle model. We have clarified limitations of a pulse-response function, but frankly we consider the simplicity and transparency of this approach to be a merit, not a fault. We are concerned mainly with scenarios that have a chance of avoiding ‘dangerous’ CO_2 levels, in which case the strong positive feedbacks found in some climate-carbon models are less likely, and in any case such feedbacks only add to the dichotomy between scenarios with declining emissions and “business-as-usual” scenarios.

We have minimized reference to a “dangerous” atmospheric CO_2 level to satisfy one of the referees. We retained one reference to our recent papers, which are published in peer-reviewed journals and, we believe, make a strong case that we are already close to a dangerous CO_2 level.

The principal conclusion of this paper is that it is possible to keep atmospheric CO_2 at a much lower limit than commonly assumed, provided that coal use is phased out except where the CO_2 is captured and stored, and use of unconventional fossil fuels, if it occurs, is also accompanied by CO_2 capture and storage. This paper provides some of the rationale for the discussion in “Old King Coal II”: http://www.columbia.edu/~jeh1/distro_OldKingCoalII_70730.pdf

(2) Temperature Analysis Code

Reto Ruedy has organized into a single document, as well as practical on a short time scale, the programs that produce our global temperature analysis from publicly available data streams of temperature measurements. These are a combination of subroutines written over the past few decades by Sergej Lebedeff, Jay Glascoe, and Reto. Because the programs include a variety of languages and computer unique functions, Reto would have preferred to have a week or two to combine these into a simpler more transparent structure, but because of a recent flood of demands for the programs, they are being made available as is. People interested in science may want to wait a week or two for a simplified version. The documentation/programs are at: http://data.giss.nasa.gov/gistemp/sources/

An introduction (History) to the program description defines the scientific purposes. We have also made a few graphs that may help clarify the significance (or lack thereof) of criticisms in the blogosphere. The one aspect of our procedure where subjectivity could come into play is the choice of which stations are eliminated from the record. This is based on identifying the (small fraction of) stations that raise a red flag (e.g., deviation of 5 standard deviations or more, or a large temporal discontinuity, as defined in our papers). The records of these stations were compared with records of the nearest neighboring stations; if neighboring stations displayed similar features the records were retained. The documentation lists stations/data eliminated.

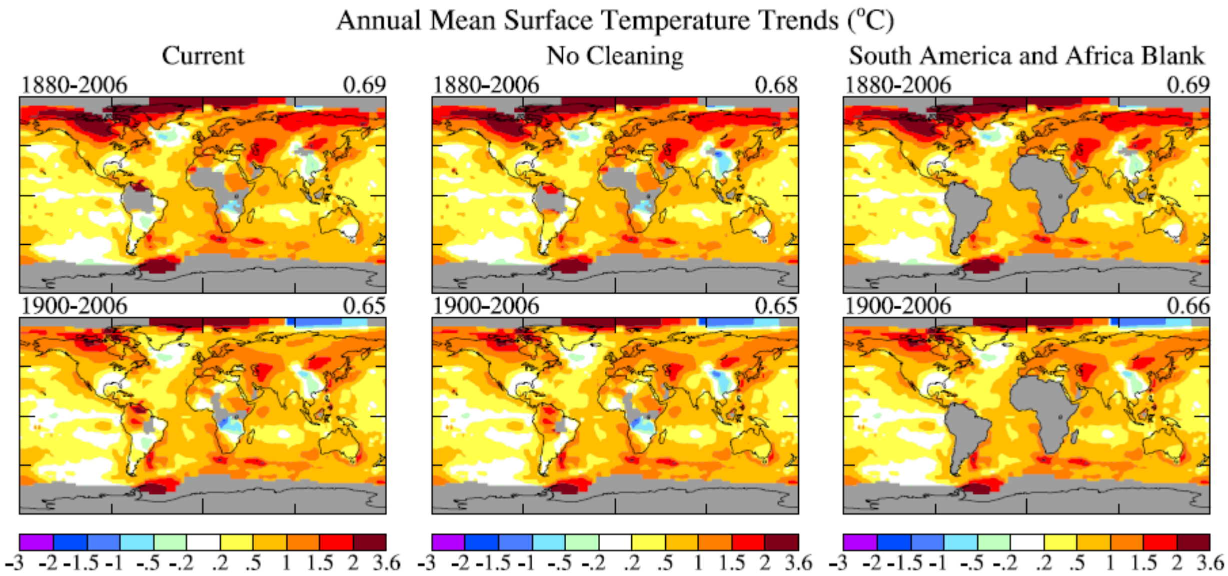
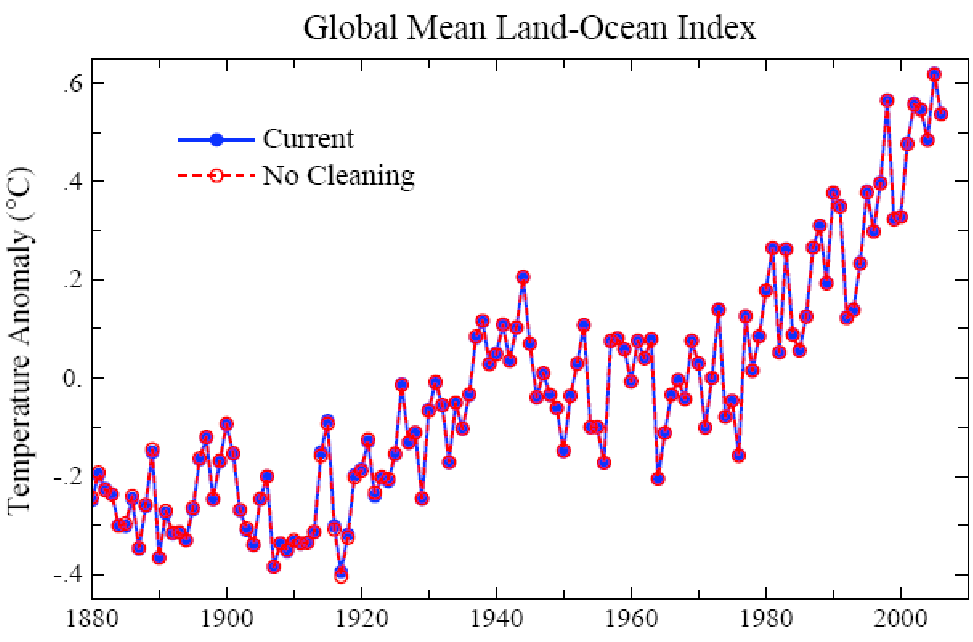


Figure 1 shows maps of the 1880-2006 and 1900-2006 changes of global temperature with and without these stations, and Figure 2 shows the global mean temperature with and without these station/data changes. The effect is practically imperceptible and clearly insignificant.



Another favorite target of those who would raise doubt about the reality of global warming is the lack of quality data from South America and Africa, a legitimate concern. You will note in our maps of temperature change some blotches in South America and Africa, which are probably due to bad data. Our procedure does not throw out data because it looks unrealistic, as that would be subjective. But what is the global significance of these regions of exceptionally poor data? As shown by Figure 1, omission of South America and Africa has only a tiny effect on the global temperature change. Indeed, the difference that omitting these areas makes is to increase the global temperature change by (an entirely insignificant) 0.01C.

This is all the time that I intend to give to this subject, but in case you wonder why we subject ourselves to the shenanigans, there are scientific reasons, repeated here from the "history" introduction to the program description.

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GISS Temperature Analysis
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History

The basic GISS temperature analysis scheme was defined in the late 1970s by Jim Hansen when a method of estimating global temperature change was needed for comparison with one-dimensional global climate models. Prior temperature analyses, most notably those of Murray Mitchell, covered only 20-90N latitudes. Our rationale was that the number of Southern Hemisphere stations was sufficient for a meaningful estimate of global temperature change, because temperature anomalies and trends are highly correlated over substantial geographical distances. Our first published results (Hansen et al., Climate impact of increasing atmospheric carbon dioxide, *Science* **213**, 957, 1981) showed that, contrary to impressions from northern latitudes, global cooling after 1940 was small, and there was net global warming of about 0.4C between the 1880s and 1970s.

Hansen and Lebedeff (Global trends of measured surface air temperature, *J. Geophys. Res.* **92**, 13345, 1987) documented the analysis method, showing that the correlation of temperature change was reasonably strong for stations separated by up to 1200 km, especially at middle and high latitudes. They obtained quantitative estimates of the error in annual and 5-year mean temperature change by sampling at station locations a spatially complete data set of a long run of a global climate model, which was shown to have realistic spatial and temporal variability.

This derived error bar only addressed the error due to incomplete spatial coverage of measurements. As there are other potential sources of error, such as urban warming near meteorological stations, etc., many other methods have been used to verify the approximate magnitude of inferred global warming. These methods include inference of surface temperature change from vertical temperature profiles in the ground (bore holes) at many sites around the world, rate of glacier retreat at many locations, and studies by several groups of the effect of urban and other local human influences on the global temperature record. All of these yield consistent estimates of the approximate magnitude of global warming, which has now increased to about twice the magnitude that we reported in 1981. Still further affirmation of the reality of the warming is its spatial distribution, which shows largest values at locations remote from any local human influence, with a global pattern consistent with that expected for response to global climate forcings (larger in the Northern Hemisphere than the Southern Hemisphere, larger at high latitudes than low latitudes, larger over land than over ocean).

Some improvements in our analysis were made several years ago (*J. Geophys. Res.* **104**, 30997, 1999; **106**, 23947, 2001) including use of satellite-observed night lights to determine which stations in the United States are located in urban and peri-urban areas, the long-term trends of those stations being adjusted to agree with long-term trends of nearby rural stations.

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[As you will see in the latter paper we found 1934 and 1998 to be in a statistical tie for warmest U.S. year, 1934 being warmer by an insignificant couple hundredths of a degree. We still find that result. The minor flaw recently found in our data analysis, which affected U.S. temperatures by 0.15C after 2000, did not alter this result. Pundits picking up on this non-story did not get this right, and further they tried to leave the impression that they were talking about global temperature. Ah me.]

You may wonder why we bother to put up with this hassle and the nasty e-mails that it brings. Well, there are at least a couple of good reasons.

First, there is scientific value in having a near-real-time global temperature analysis, it is fairly easy to run the program as new data come in each month, and a lot of people tell us that our analysis and presentations are useful to them. There is merit in having more than one group do the analyses because the results differ somewhat. For example, in 2005 we were the only group initially reporting 2005 as being, on global mean, the warmest year in the record. We would not have obtained that result without our method of extrapolating estimates of anomalies out to distances of 1200 km from the nearest station. Later checks with satellite infrared data indicated that our Arctic and Greenland warm anomalies were, if anything, conservative. And the interactions with the NOAA and British groups have been extremely friendly and fruitful and in the spirit of good science, and good science is fun.

Second, the climate change problem is important.

Jim