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by James Hansen

Illustrations by William Bramhall

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The American Revolution launched the radical proposition that the commonest of men should have a vote equal in weight to that of the richest, most powerful citizen. Our forefathers devised a remarkable Constitution, with checks and balances, to guard against the return of despotic governance and subversion of the democratic principle for the sake of the powerful few with special interests. They were well aware of the difficulties that would be faced, however, placing their hopes in the presumption of an educated and honestly informed citizenry.

I have sometimes wondered how our forefathers would view our situation today. On the positive side, as a scientist, I like to imagine how Benjamin Franklin would view the capabilities we have built for scientific investigation. Franklin speculated that an atmospheric "dry fog" produced by a large volcano had reduced the Sun's heating of the Earth so as to cause unusually cold weather in the early 1780s; he noted that the enfeebled solar rays, when collected in the focus of a "burning glass," could "scarce kindle brown paper." As brilliant as Franklin's insights may have been, they were only speculation as he lacked the tools for quantitative investigation. No doubt Franklin would marvel at the capabilities provided by Earth-encircling satellites and super-computers that he could scarcely have imagined.

Yet Franklin, Jefferson, and the other revolutionaries would surely be distraught by recent tendencies in America, specifically the increasing power of special interests in our government, concerted efforts to deceive the public, and arbitrary actions of government executives that arise from increasing concentration of authority in a unitary executive, in defiance of the aims of our Constitution's framers. These tendencies are illustrated well by a couple of incidents that I have been involved in recently.

In the first incident, my own work was distorted for the purposes of misinforming the public and protecting special interests. In the second incident, the mission of the National Aeronautics and Space Administration (NASA) was altered surreptitiously by executive action, thus subverting constitutional division of power. These incidents help to paint a picture that reveals consequences for society far greater than simple enrichment of special interests. The effect is to keep the public in the dark about increasing risks to our society and our home planet.

The first incident prompted *New York Times* columnist Paul Krugman to argue not long ago that I must respond to "swift boaters"—those who distort the record to impugn someone's credibility. I have had reservations about doing so, stemming from the perceptive advice of Professor Henk van de Hulst, who said, when I was a post-doc at Leiden University, "Your success will depend upon choosing what not to work on." Unfortunately, given the shrinking fuse on the global warming time bomb, Krugman is probably right: we cannot afford the luxury of ignoring swift boaters and focusing only on science.

Pat Michaels, a swift boater to whom Krugman refers, is sometimes described as a "contrarian." Contrarians address global warming as if they were lawyers, not scientists. A lawyer's job often is to defend a client, not seek the truth. Instead of following Richard Feynman's dictum on scientific objectivity ("The only way to have real success in science…is to describe the evidence very carefully without regard to the way you feel it should be"), contrarians present only evidence that supports their desired conclusion.

Skepticism, an inherent aspect of scientific inquiry, should be carefully distinguished from contrarianism. Skepticism, and the objective weighing of evidence, are essential for scientific success. Skepticism about the existence of global warming and the principal role of human-made greenhouse gases has diminished as empirical evidence and our understanding have advanced. However, many aspects of global warming need to be understood better, including the best ways to minimize climate change and its consequences. Legitimate skepticism will always have an important role to play.

However, hard-core global warming contrarians have an agenda other than scientific truth. Their target is the public. Their goal is to create an impression that global warming or its causes are uncertain. Debating a contrarian leaves an impression with today's public of an argument among theorists. Sophistical contrarians do not need to win the scientific debate to advance their cause.

Science Fiction

Consider, for example, Pat Michaels' deceit (in a 2000 article in *Social Epistemology*) in portraying climate "predictions" that I made in 1988 as being in error by "450 percent." This distortion is old news, but by sheer repetition has become received wisdom among climate-change deniers. In fact, science fiction writer Michael Crichton was duped by Michaels, although Crichton reduced my "error" to "wrong by 300 percent" in his 2004 novel *State of Fear*.

People acquainted with this topic are aware that Michaels, in comparing global warming predictions made with the GISS (Goddard Institute for Space Studies) climate model with observations, played a dirty trick by showing model calculations for only one of the three scenarios (not predictions!) that I presented in 1988. Here's why this trick has a big impact.

The three scenarios (see figure, opposite page) were intended to bracket the range of likely future climate forcings (changes imposed on the Earth's energy balance that tend to alter global temperature either way). Scenario C had the smallest greenhouse gas forcing: it extended recent greenhouse gas growth rates to the year 2000 and thereafter kept greenhouse gas amounts constant, i.e., it assumed that after 2000 human sources of these gases would be just large enough to balance removal of these gases by the "sinks." Scenario B continued approximately linear growth of greenhouse gases beyond 2000. Scenario A showed exponential growth of greenhouse gases and included a substantial allowance for trace gases that were suspected of increasing but were unmeasured.

Scenarios A, B, and C also differed in their assumptions about future volcanic eruptions. Scenarios B and C included occasional eruptions of large volcanoes, at a frequency similar to that of the real world in the previous few decades. Scenario A, intended to yield the largest plausible warming, included no volcanic eruptions, as it is not uncommon to have no large eruptions for extended periods, such as the half century between the Katmai eruption in 1912 and the Agung eruption in 1963.

Multiple scenarios are used to provide a range of plausible climate outcomes, but also so that we can learn something by comparing real-world outcomes with model predictions. How well the model succeeds in simulating the real world depends upon the realism of both the assumed forcing and the climate sensitivity (the global temperature response to a standard climate forcing) of the model.

As it turned out, in the real world the largest climate forcing in the decade after 1988, by far, was caused by the Mount Pinatubo volcanic eruption, the greatest volcanic eruption of the past century. Forcings are measured in watt-years per square meter (W-yr/m^2) averaged over the surface of the Earth (1 W-yr/m^2 is a heating of 1 W/m^2 over the entire planet maintained for one year). The small particles injected into the Earth's stratosphere by Pinatubo reflected sunlight back to space, causing a negative (cooling) climate forcing of about –5 W-yr/m^2. In contrast, the added greenhouse gas climate forcings ranged from about +1.6 W-yr/m^2 in scenario C to about +2.3 W-yr/m^2 in scenario A.

So of the four scenarios (A, B, C, and the real world) only scenario A had no large volcanic eruption. The volcanic activity modeled in scenarios B and C was somewhat weaker than in the real world and was misplaced by a few years, but by good fortune it was such as to have a cooling effect pretty similar to that of Pinatubo. Despite the fact that scenario A omitted the largest climate forcing, Michaels chose to compare scenario A—and *only* scenario A—with the real world. Is this a case of scientific idiocy or is there something else at work? Perhaps Michaels is just not very interested in learning about the real world.

Although less important for the temperature change between 1997 and 1988 that Michaels examined, measured real-world greenhouse gas changes in carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs) yielded a forcing similar to those in scenarios B and C. The reason for the slow real-world growth rate was that both CH_4 and CO_2 growth rates decreased in the early 1990s (the slowdowns may have been associated with Pinatubo; in any case the CO_2 growth rate has subsequently accelerated rapidly).

An astute reader may wonder why the world showed any warming during the period 1988–97, given that the negative (cooling) forcing by Pinatubo exceeded the positive (warming) forcing by greenhouse gases added in that period. The reason is that the climate system was also being pushed by the planetary "energy imbalance" that existed in 1988. The climate system had not yet fully responded to greenhouse gases added to the atmosphere before then. The observed continued decadal warming, despite the very large negative volcanic forcing, provides some confirmation of that planetary energy imbalance.

Noise and Distortion

Michaels' trick of comparing the real world only with the inappropriate scenario A accounts for his specious, incorrect conclusions. However, a second unscientific aspect of his method is also worth pointing out.

Scientists seek to learn something by comparing the real world with climate model calculations. Climate sensitivity is of special interest, as future climate change depends strongly upon it. In principal, we can extract climate sensitivity if we have accurate knowledge of the net forcing that drove cli-

mate change, and the global temperature change that occurred in response to that change. However, even if these demanding conditions are met, it is necessary to compare the magnitude of the calculated changes with the magnitude of "noise," including errors in the measurements and chaotic (unforced) variability in the model and real-world climate changes.

If Michaels had examined the noise question he would have realized that a nine-year change is insufficient to determine the real-world temperature trend or distinguish among the model runs. Even the period 1988–2005 is too brief for most purposes. Within several years the differences among scenarios A, B, and C, and comparisons with the real world, will become more meaningful.

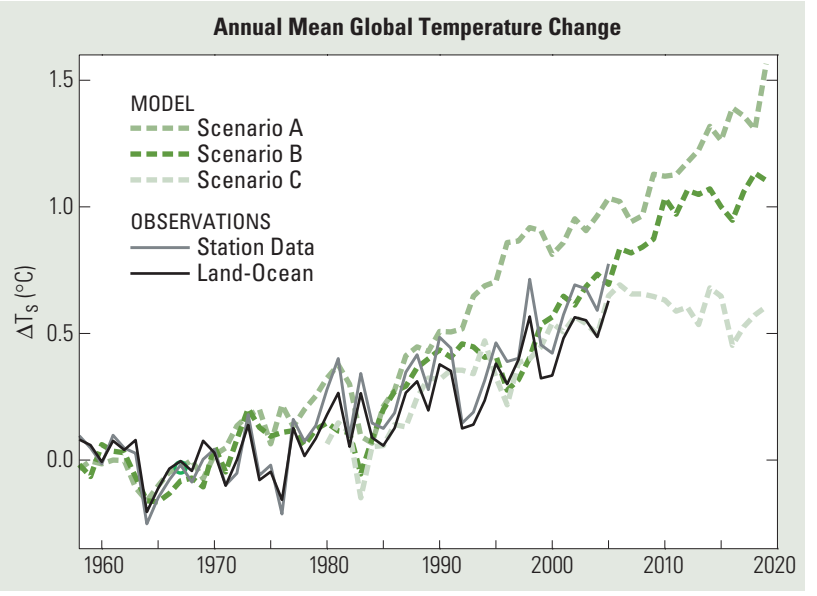
Michaels' latest tomfoolery, repeated on several occasions, is the charge that I approve of exaggeration of potential consequences of future global warming. This is more unadulterated hogwash. Michaels quotes me as saying, "Emphasis on extreme scenarios may have been appropriate at one time, when the public and decision-makers were relatively unaware of the global warming issue."

What trick did Michaels use to create the impression that I advocate exaggeration? He took the above sentence out of context from a paragraph in which I was being gently critical of a tendency of Intergovernmental Panel on Climate Change climate simulations to emphasize only cases with very large increases of climate forcings. My entire paragraph (from a June 2003 presentation to the Council on Environmental Quality) read as follows:

> *Summary opinion re scenarios. Emphasis on extreme scenarios may have been appropriate at one time, when the public and decision-makers were relatively unaware of the global warming issue, and energy sources such as "synfuels," shale oil, and tar sands were receiving strong consideration. Now, however, the need is for demonstrably objective climate forcing scenarios consistent with what is realistic under current conditions. Scenarios that accurately fit recent and near-future observations have the best chance of bringing all of the important players into the discussion, and they also are what is needed for the purpose of providing policy-makers the most effective and efficient options to stop global warming.*

Would an intelligent reader who read the entire paragraph (or even the entire sentence; by chopping off half of the sentence Michaels brings quoting-out-of-context to a new low) infer that I was advocating exaggeration? On the contrary. Perhaps I should take it as a compliment that anyone would search my writing so hard to find something that can be quoted out of context.

Having taken this trouble to refute Michaels' claims, I still wonder about the wisdom of arguing with contrarians as a strategy. Many of them, including Michaels, receive support from special interests such as fossil fuel and automotive companies. It is understandable that special interests gravitated, early on, to scientists who had a message they preferred to hear. But now that global warming and its impacts are clearer, it is time for business people to reconsider their position—and scientists, rather than debating contrarians, may do better to communicate with business leaders. The latter did not attain their positions without being astute and capable of changing. We need to make clear to them the legal and moral liabilities that accrue with continued denial of global warming. It is time for business leaders to chuck contrarians and focus on the business challenges and opportunities.



Stealth Budgets & Unitary Executives

The second incident involved NASA's budget. Many people are aware that something bad happened to the NASA Earth Science budget this year, yet the severity of the cuts and their long-term implications are not universally recognized. In part this is because of a stealth budgeting maneuver.

When annual budgets for the coming fiscal year are announced, the differences in growth from the previous year, for agencies and their divisions, are typically a few percent. An agency with +3 percent growth may crow happily, in comparison to agencies receiving +1 percent. Small differences are important because every agency has fixed costs (civil service salaries, buildings, other infrastructure), so new programs or initiatives are strongly dependent upon any budget growth and how that growth compares with inflation.

When the administration announced its planned fiscal

2007 budget, NASA science was listed as having typical changes of 1 percent or so. However, Earth Science research actually had a staggering reduction of about 20 percent from the 2006 budget. How could that be accomplished? Simple enough: reduce the 2006 research budget retroactively by 20 percent! One-third of the way into fiscal year 2006, NASA Earth Science was told to go figure out how to live with a 20-percent loss of the current year's funds.

The Earth Science budget is almost a going-out-of-business budget. From the taxpayers' point of view it makes no sense. An 80-percent budget must be used mainly to support infrastructure (practically speaking, you cannot fire civil servants; buildings at large facilities such as Goddard Space Flight Center will not be bulldozed to the ground; and the grass at the centers must continue to be cut). But the budget cuts wipe off the books most planned new satellite missions (some may be kept on the books, but only with a date so far in the future that no money needs to be spent now), and support for contractors, young scientists, and students disappears, with dire implications for future capabilities.

Bizarrely, this is happening just when NASA data are yielding spectacular and startling results. Two small satellites that measure the Earth's gravitational field with remarkable precision found that the mass of Greenland decreased by the equivalent of 200 cubic kilometers of ice in 2005. The area on Greenland with summer melting has increased 50 percent, the major ice streams on Greenland (portions of the ice sheet moving most rapidly toward the ocean and discharging icebergs) have doubled in flow speed, and the area in the Arctic Ocean with summer sea ice has decreased 20 percent in the last 25 years.

One way to avoid bad news: stop the measurements! Only hitch: the first line of the NASA mission is "to understand and protect our home planet." Maybe that can be changed to "…protect special interests' backside."

I should say that the mission statement *used* to read "to understand and protect our home planet." That part has been deleted—a shocking loss to me, as I had been using the phrase since December 2005 to justify speaking out about the dangers of global warming. The quoted mission statement had been constructed in 2001 and 2002 via an inclusive procedure involving representatives from the NASA Centers and e-mail interactions with NASA employees. In contrast, elimination of the "home planet" phrase occurred in a spending report delivered to Congress in February 2006, the same report that retroactively slashed the Earth Science research budget. In July 2006 I asked dozens of NASA employees and management people (including my boss) if they were aware of the change. Not one of them was. Several expressed concern that such management changes by fiat would have a bad effect on organization morale.

The budgetary goings-on in Washington have been noted, e.g., in editorials of *The Boston Globe*: "Earth to NASA: Help!" (June 15, 2006) and "Don't ask; don't ask" (June 22), both decrying the near-termination of Earth measurements. Of course, the *Globe* might be considered "liberal media," so their editorials may not raise many eyebrows.

But it is conservatives and moderates who should be most upset, and I consider myself a moderate conservative. When I was in school we learned that Congress controlled the purse strings; it is in the Constitution. But it does not really seem to work that way, not if the Bush administration can jerk the science budget the way they have, in the middle of a fiscal year no less. It seems more like David Baltimore's "Theory of the Unitary Executive" (the legal theory that the president can do pretty much whatever he wants) is being practiced successfully. My impression is that conservatives and moderates would prefer that the government work as described in the Constitution, and that they prefer to obtain their information on how the Earth is doing from real observations, not from convenient science fiction.

Congress is putting up some resistance to the budget manipulation. The House restored a fraction of the fiscal year 2007 cuts to science and is attempting to restore planning for some planetary missions. But the corrective changes are moderate. You may want to check your children's textbooks for the way the U.S. government works. If their books still say that Congress controls the purse strings, some updating is needed.

The NASA Mission

To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
…as only NASA can.

But may it be that this is all a bad dream? I will stand accused of being as wistful as the boy who cried out, "Joe, say it ain't so!" to the fallen Shoeless Joe Jackson of the 1919 Chicago Black Sox, yet I maintain the hope that NASA's dismissal of "home planet" is not a case of either shooting the messenger or a too-small growth of the total NASA budget, but simply an error of transcription. Those who have labored in the humid, murky environs of Washington are aware of the unappetizing forms of life that abound there. Perhaps the NASA playbook was left open late one day, and by chance the line "to understand and protect our home planet" was erased by the slimy belly of a slug crawling in the night. For the sake of our children and grandchildren, let us pray that this is the true explanation for the devious loss, and that our home planet's rightful place in NASA's mission will be restored.

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