

## Climate Denial 101

*A User's Guide to the arguments of global warming skeptics*

By Scott Church – Updated July 31, 2023

**No reasonable doubt** remains that human activities, particularly greenhouse gas emissions, have significantly altered global climate. Over the last two centuries global land, sea, and atmospheric temperatures have increased to a degree that cannot be accounted for by historical natural variability alone, and the world's climate scientists are in general agreement that this warming may already have passed a point of no return. At a bare minimum, there is at least another century of warming "in the pipe" so to speak, even if we implement draconian mitigation measures today. But of course, this has done little to dampen climate change skepticism among anti-environmental special interests and the lawmakers beholden to them. Since the early 90's the fossil fuel, coal-fired power, and automobile industries, and various Far-Right foundations have sunk millions into front organizations advertised to the public as "think tanks" or "research" institutions, but whose express behind-the-scene purpose is to lobby against climate change mitigation efforts on behalf of their benefactors. Originally these groups focused on denying the reality of global warming, but in recent years that approach has all but become a lost cause, so the emphasis has been shifting toward denying that we have anything to do with it.

It must be remembered that these organizations aren't merely lobbyists, they're *fronts* that employ some of the best public relations people in the game. No matter how unreasonable their claims may seem to many, they know how to sell themselves to lawmakers and the public as "science-based," and they're anything but stupid. Anti-environmental special interests funnel millions to these folks because they're the undisputed masters of *spin*, and with the evidence for human-cause global warming mounting daily, the need for spin has become increasingly central to their activities.

Now, every masterful spin job has at two key components;

- a) A compelling, and slickly presented straw man.
- b) An emotionally charged scapegoat to pin it on that can be used to push the target audience's buttons.

The latter is easy enough. As the 2016 presidential campaign demonstrated all too well, if people are angry enough you can all but throw an election with made-up fake news stories, tweets, and other red meat. The real art of spin lies in crafting a good straw man, which in turn achieves two primary goals of its own;

- c) An argument that's as impressive and compelling as possible, without reveal the underlying errors and omissions.
- d) A conclusion that tars and feathers the intended scapegoat with maximal apparent idiocy.

If the apparent idiocy fruit is low-hanging and juicy enough one can go straight to d). Case in point, religious extremists, who routinely provide anti-religion secularists with so much dry tinder that a thimble's worth of dog-whistle revisionist history is usually enough to ignite a continent-wide prairie fire. For global warming skeptics however, the task is not so easy. Respected climate scientists are far worthier opponents than Pat Robertson or ISIS, so the emphasis must be on c). In this they are favored by the fact that climate science is complex, and more than subtle enough to give them plenty of grist for the mill. But even so, there are recurring conceptual errors that underlie all their arguments, and once these are revealed the entire climate denial platform collapses.

**Before** jumping into these errors, let's start with a few climate science fundamentals that will give us the bricks and mortar we'll need to evaluate them.

1) 1) *Climate is not the same thing as weather.*

Weather (or *meteorology*) deals with short-term local atmospheric conditions—what’s happening now in the county where you live, and what the evening forecast says you can expect when planning your weekend getaways. *Climate* on the other hand, is the sum of all *long-term* patterns and trends exhibited by weather on a *regional or global* basis, where by regional we mean continental or subcontinental (e.g. West Coast, Midwest, etc.), and by long-term we mean at least 30 years, and more commonly, centuries. The factors which drive the latter have little to do with the former.

Think of taking a canoe down a river. Many factors will impact whether the river will rise or drop during your trip, and how the canoe maneuvers and responds to obstacles while travelling downstream. But these are very different from the ones that shape the watershed’s long-term environmental and hydrological formation. The subtleties of your listless drift through a long pool and the way you’re carried through the riffle at its tailout have little to do with the environmental factors that shaped both, and the river’s journey from mountaintop glaciers to the ocean surf throughout history. Media commentators and activists on both sides of the issue are fond of relating extreme weather events to global warming. But as understandable as these reactions may be in the moment, such comparisons are like trying to answer questions about the river’s evolution from the way your canoe maneuvers in a riffle. The latter have certainly been influenced by the former, but comparing the two is category error.

2) 2) *The earth’s climate is a system.*

Most people think of climate change as a warming of the atmosphere. This is not surprising given that it’s the most visible symptom of it, and greenhouse gas emissions are the most commonly publicized culprit. But in fact, there are five main components to the earth’s global climate. In addition to the atmosphere, climate is also driven by the world’s oceans (the *hydrosphere*), continental land masses (the *lithosphere*), global ice coverage in glaciers and polar ice caps (the *cryosphere*), and the biological ecosystems that interact with, and depend on them (the *biosphere*). These are all interconnected, and together they comprise what we call a *second-order system*—which is just a fancy way of saying shock absorber.

There are many kinds of shock absorbers, but all are a combination of three generalized components: A “weight,” a “spring,” and a “damper,” and the overall response of the system to some “force” is determined by all three. The clearest example is the mechanical one (like the shock absorbers on your car) in which the combination of a weight and spring (in the usual sense of those terms) with a friction damper (or dashpot) is subjected to a mechanical force (like a bumpy road). Figure 1 shows a schematic of this.

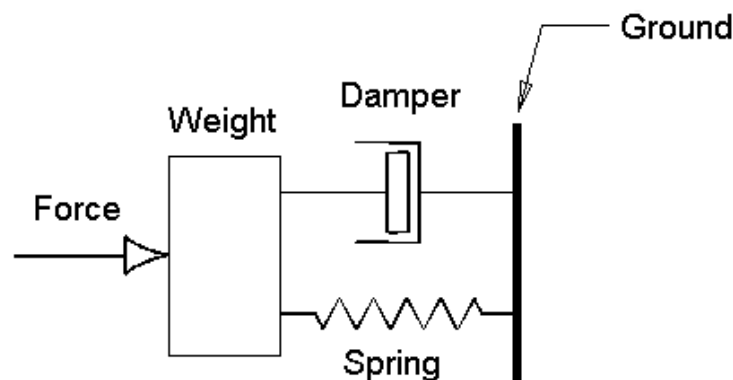


Figure 1 – An idealized shock absorber

One of the more interesting things about systems like these is that there's a time delay (or *phase lag*) between when they're kicked and when/how they react. The larger the ratio of their weight to the stiffness of the spring, the longer that delay is, and the smaller the response will be over any shorter timeframe. This is how your car's shock absorbers keep you from feeling all those quick, hard bumps in the road. They respond to the ongoing weight of the vehicle by holding it up off the road. But the bumps you hit while driving load them over a much shorter timespan than they can respond to, so they absorb them by deflecting rather than transmitting them to the vehicle (you may have noticed that driving very slowly over speed bumps is often more jarring than hitting them at a few miles per hour).

Though far more complicated, global climate is essentially a thermal equivalent of this. In the climate system, the "weight" is the heat absorption capacity of the world's lakes, rivers, and oceans (their capacity to store *latent heat*). Chemical and thermal properties of the atmosphere, land surface, and global ice cover function as the "spring" and "damper," and the "force" delivered to all this comes from incoming solar radiation, and various natural and anthropogenic inputs that change the system's ability to retain it. The figure below shows how all of this works together (Stocker, 2014).

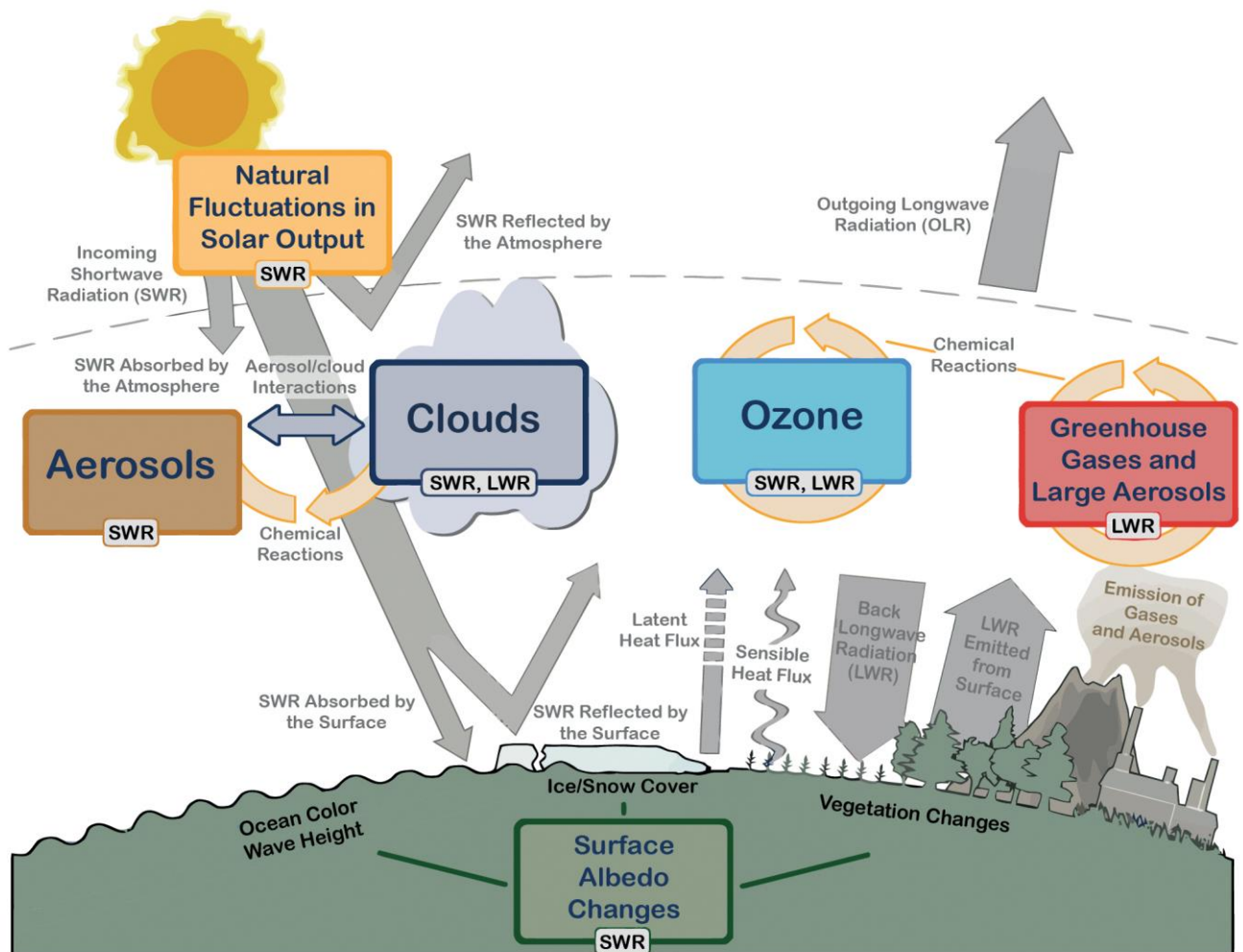


Figure 2 – The Global Climate System

3) 3) *Changes in climate depend on how it is forced.*

Climate change is a system response to various inputs. Any input that alters one or more climate trends is referred to as a *forcing*. As already noted, the clearest example is variation in the amount of solar radiation the earth receives. But not all the energy the sun sends our way ends up here, or stays around for any length of time if it does. Some is reflected by clouds and/or surface ice before it can be absorbed. Some is absorbed, but re-radiated back to space (by warm ground on cloudless nights for instance) before it can affect much. Any input to the climate system that impacts how efficiently it retains the solar energy it receives will have the same impact as changes in direct solar energy input, and are considered forcings as well. Anthropogenic (man-made) greenhouse gas emissions are one case in point.

4) 4) *There are many kinds of forcings and climate responds differently to each.*

How quickly and strongly the climate responds to any given forcing is referred to as its *sensitivity* to that forcing. Climate sensitivities may be positive, or negative, short-term or long-term. With some forcings, the response is immediate and dramatic—like an excitable kid who can't go to sleep and has just been pricked with a sewing needle. Immediately he vaults out of bed ("OOOOOW...!") and races to the upstairs bathroom for a Power Rangers band-aid, ricocheting off the walls the whole way. In other cases, the response is more like that of the kid's listless overweight dad—stab him in the leg with an icepick and he'll slowly sit up... grumble a little... scratch his head and stare for a few minutes... ("Aw, for the love of...") and eventually drag himself out of bed and plod off in the general direction of the bathroom. Greenhouse gases emissions are more like Dad. They accumulate in the atmosphere over extended periods, gradually, but inexorably warming global climate in the process. On the other hand, increases in aerosols (e.g. smoke, or volcanic emissions) are more like the excitable kid. They do not remain suspended in the atmosphere for extended periods, but lead to temporary changes in cloud cover that often produce dramatic effects while they do.

Putting it all together

In the real world, all this is happening continuously. Short and long-term forcings impact the climate system on an ongoing basis, and it responds to each input with widely varying sensitivities. Furthermore, even during lulls in these forcings the climate system can, and often does respond by redistributing the energy it already has from one part of the system to another. Deep ocean currents continuously move their latent heat back and forth in "oscillations," exchanging some of that heat with the atmosphere in the process (El Nino's and the corresponding La Nina events are the best-known examples, but there are others). This leads to temporary spikes and dips in global *atmospheric* temperatures that have little to do with ongoing climate change in the entire system. Daddy is shuffling slowly but surely toward the bathroom, while Junior is bouncing on his shoulders, shifting his weight from side to side, screaming bloody murder, and putting dents in the ceiling every 18 inches.

**Why** does all this matter...? Because at least 95% of climate skeptic arguments depend on misunderstanding, or carefully misrepresenting every one of these concepts. Once we understand where this is being done and how, the errors and omissions they've so carefully hidden are out in the open, and the futility of denying anthropogenic climate change is apparent. So, without further ado, let's have a closer look at these errors and how they're being wielded by anti-climate change lobbies. In what follows I'll be drawing from multiple skeptic sources, but for the most part I'll concentrate on a recent Forbes editorial that manages to stumble into most of them in one fell swoop (Ferrara, 2012). The author is a lawyer for the Heartland Institute who clearly has no science background at all, much less any in climate science.

*Error #1) Skeptics do not understand system responses.*

Climate deniers believe global land, sea, and atmospheric temperatures respond to being forced the way a golf ball responds to a line drive—immediately, and dramatically. They are forever equating trends in *one* of these components with real-time contemporary greenhouse gas emissions alone. To wit, Peter Ferrara tells us to,

"Check out the 20th century temperature record, and you will find that its up and down pattern does not follow the industrial revolution's upward march of atmospheric carbon dioxide (CO<sub>2</sub>), which is the supposed central culprit for man caused global warming (and has been much, much higher in the past). It follows instead the up and down pattern of naturally caused climate cycles... For example, temperatures dropped steadily from the late 1940s to the late 1970s..." (Ferrara, 2012)

This is hardly surprising. We don't expect 20th Century temperatures to follow CO<sub>2</sub> emissions in lock-step—if they did they'd be violating the laws of physics.

Let's have another look at our climate thermal shock absorber. As we've seen, its response to CO<sub>2</sub> emissions will lag them by a time delay that will be proportional to the ratio, in thermal terms, of its effective "mass" to the stiffness of its atmospheric "spring." The mass in this case is the latent heat storage capacity of the world's oceans, which as my daughter would say, is *gi-normous*. If you've ever had to warm up a hot tub or swimming pool you know that it takes an obscene amount of heat to do so, and a correspondingly high power bill. Now imagine what it would take to warm the world's oceans... Daddy is a gigantic, corn-fed sumo wrestler. On the other hand, the forcing associated with gradually building up a few hundred parts-per-million concentrations of greenhouse gases is a very soft thermal spring. Put the two together, and what you have is like towing a wagon full of bowling balls with a slinky, or heating a swimming pool with a cigarette lighter. *Hell* yes it's going to be a while before we see the corresponding temperature rise! On the other hand, the "naturally caused" forcings associated with solar fluctuations, atmospheric aerosols, changes in sea-ice and the like, are immediate. They're the excitable kid kicking the front and rear of the wagon along the way.

Figures 3 and 4 respectively show global mean surface temperature anomalies<sup>1</sup> relative to a 1961–1990 baseline with least squares trend fits for 1901–2012, 1901–1950 and 1951–2012 (Stocker, 2014 Chap. 2), and the relative strengths of various forcings contributing to these trends for most of the same period (Rohde, 2014).

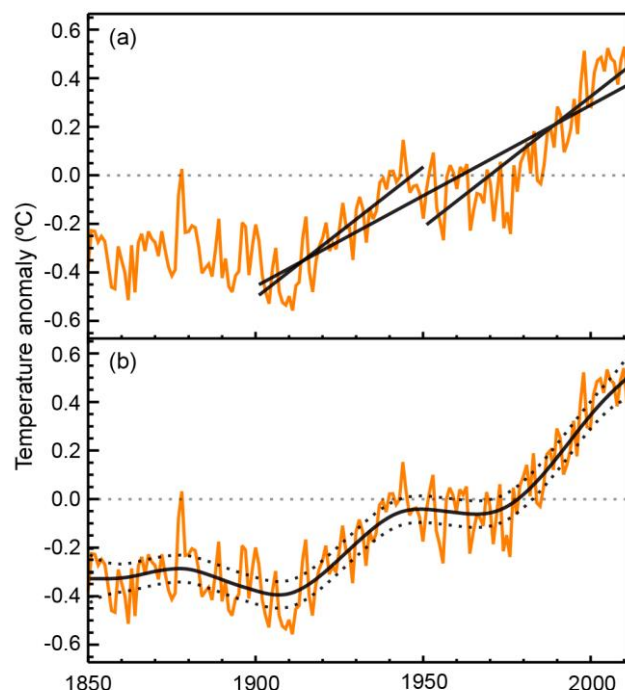


Figure 3 – 20th Century Global Average Surface Temperatures

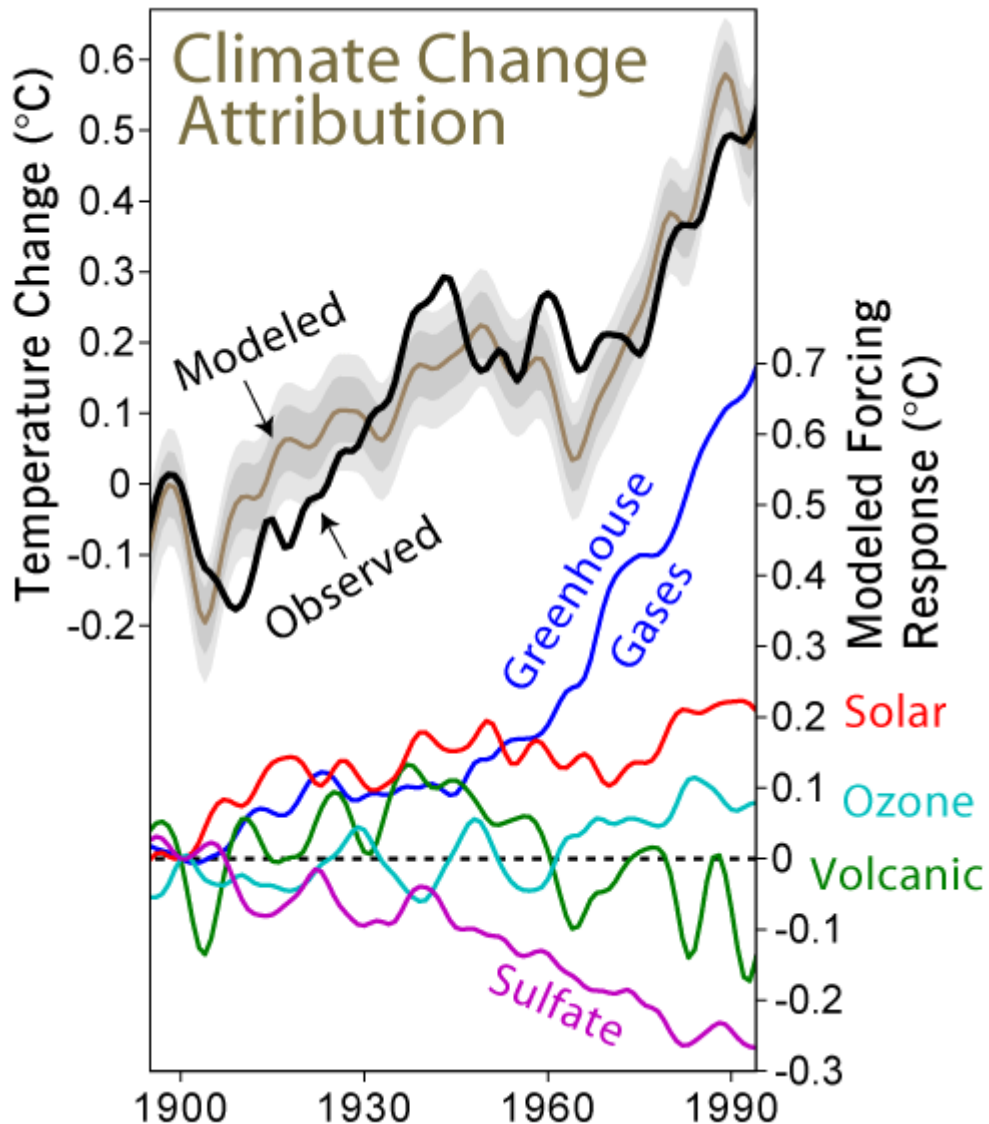


Figure 4 – 20th Century Climate Forcings and Surface Temperature Responses

The blue line in Figure 4 is the slinky towing the wagon, and the rest are the excitable kid kicking it on both ends. Comparing the two reveals that 20th Century climate change comes in three somewhat distinct chunks. Early on we see warming for which the strongest forcing was an increase in solar radiation output. Then, around 1940 or so the solar kick flattens out, and until the late 70's or so, other negative forcings like volcanic aerosols yank things back a bit. Thus, Ferrara's 1940's to 1970's cooling. Then, according to him,

"In the late 1970s, the natural cycles turned warm and temperatures rose until the late 1990s..." (Ferrara, 2012)

Nonsense! Compare those two figures again for the latter 20th Century. Prior to the 70's greenhouse gases clearly weren't a major contributor—the slinky hadn't had enough time to stretch out. But by the late 70's positive and negative natural forcings had slacked off to the point of cancelling each other out while the slinky was tightening. By the 80's or so, two centuries of post-Industrial Revolution stretching finally tightened it enough to overrun the other forcings... and surprise, surprise, the wagon picks up speed. Since then "natural cycles" have had nothing to do with it.



It's also worth noting that the same physics which makes the wagon of bowling balls take so long to respond also makes it that much harder to *stop*, even if we quit yanking the slinky altogether. A freight train still takes many miles to slow down, even when the engineer is standing on the brakes. Hence recent announcements that we've passed a "point of no return" with greenhouse gas emissions.

*Error #2) Skeptics confuse short-term trends with long-term ones.*

Ferrara tells us that,

"In 2000, the UN's IPCC predicted that global temperatures would rise by 1 degree Celsius by 2010... Don Easterbrook, Professor Emeritus of Geology at Western Washington University, knew the answer. He publicly predicted in 2000 that global temperatures would decline by 2010. He made that prediction because he knew the PDO had turned cold in 1999, something the political scientists at the UN's IPCC did not know or did not think significant... Easterbrook shows that by 2010 the 2000 prediction of the IPCC was wrong by well over a degree, and the gap was widening. That's a big miss for a forecast just 10 years away, when the same folks expect us to take seriously their predictions for 100 years in the future...." (Ferrara, 2012)

Now we're getting to the real meat and potatoes of most skeptic spin. Climate deniers are forever confusing the excitable kid's cavorting with his sumo-wrestler dad's slow forward march—typically based on one or more gross exaggerations of "predictions" they've misattributed to the Intergovernmental Panel on Climate Change (IPCC), the world's leading climate science authority. The mere fact that Ferrara thinks "just 10 years" should be a much easier trend to determine than one for "100 years in the future" proves that he has absolutely no clue how this sort of thing even works.

Right out of the gate, he compounds his misunderstanding with outright carelessness. The skeptic he's referring to (Easterbrook, 2012) said the IPCC predicted a 1 deg. *F* rise by 2010, not 1 deg. C. He's misquoting a skeptic who in turn, is misrepresenting them. Naturally the IPCC said no such thing. What they've predicted is roughly 1.5 degs. C warming over the next 80+ years or so—a long-term average of around 0.2 deg. C per decade with progressively higher uncertainties on the short term. In 2000, their next-decade confidence interval on that 0.2 degs. C was +/- 0.24 degs. C, so there was even a chance it could go negative during that period (Colose, 2008).

No citations were provided either by either Ferrara or Easterbrook, but in this case the alleged IPCC "predictions" appear to have been taken from the work of Lord Christopher Monckton (Monckton, 2009), a British hereditary peer and policy advisor for another Astroturf front called the Science and Public Policy Institute.<sup>2</sup> The IPCC's actual predicted trends were, and continue to be clearly stated in the Working Group I Assessment Reports and the corresponding Summaries for Policy Makers (Stocker, 2014). Like most skeptics, Ferrara and Monckton were both careful not to look there. Instead, Monckton started with what he called an IPCC "forecast" of future greenhouse gas emissions. The IPCC makes no such forecasts—they provide *scenarios* for which a range of outcomes are generated (e.g. - if we generate this much greenhouse gas, this is what will happen). He then ran it through an equation the IPCC uses to calculate climate model steady-state temperatures (Bickmore, 2010). Climate models need be "spun up" to a stable modeled climate *before* being forced by various scenarios to see how they'll response. The equations used for the former have nothing whatsoever to do with the latter.

So, climate denier #1 takes an imaginary worst-case greenhouse gas scenario, plugs it into an equation he doesn't understand, and ends up with a warming "prediction" five times the size of the actual one predicted by climate models... climate denier #2 repeats that figure uncritically... and climate denier #3 manages to almost *double* the original error by misquoting him in turn...

*This just keeps getting better and better.*

As for the PDO (Pacific Decadal Oscillation), the "political" scientists at the IPCC didn't consider significant because it *isn't*. As we saw earlier, the climate system routinely shuffles energy from one component to another, El Nino events being a case in point. The PDO is another such oscillation that redistributes what the system has already absorbed (there's a North Atlantic Oscillation as well). These redistributions are short-term events—the excitable kid shifting his weight on daddy's shoulders. They have nothing whatsoever to do with long-term climate change.

But what about all that "cooling" that we're told has happened since 2000...?

Let's return to the lower graph in Figure 1. The black curve is sumo-wrestler Daddy, and the jagged orange one is the excitable kid. See that big spike at around 1998 or so—the 3rd highest one to the left of the right-hand side of the figure? That was the Mother of all El Nino's... the screaming kid flew off daddy's shoulders and took out the chandelier with his head. Compare that chandelier-breaker not only to the underlying black curve, but to the orange curve in 2011 as well. Notice how far it deviates from both, and how quickly it returned to long-term trend.

Figures 5 and 6 below show the 10 and 30-year trends Easterbrook (2012) bases his "cooling" claims on. Both were taken from a presentation he gave at the Heartland Institute's 7<sup>th</sup> International Conference on Climate Change, or ICC3<sup>3</sup> (linked from the 3rd paragraph of Ferrara's editorial).

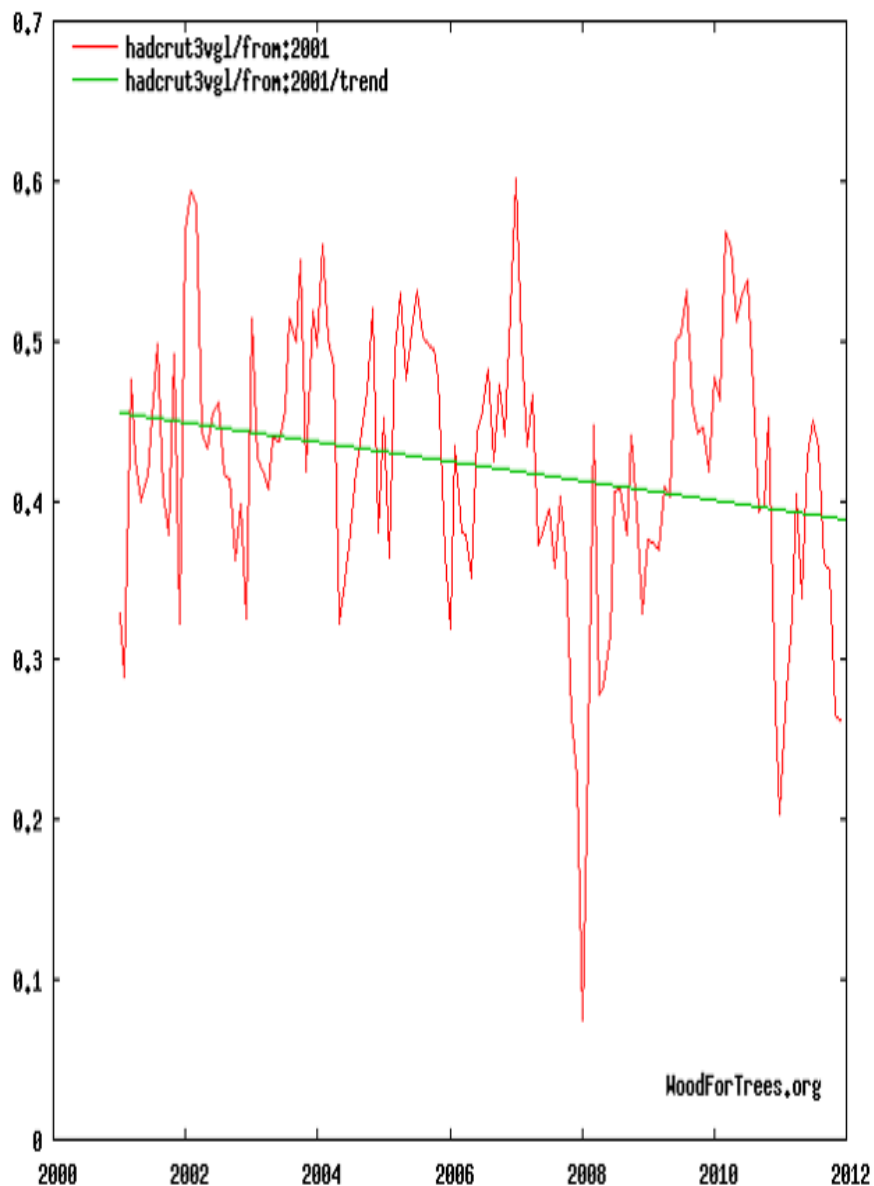


Figure 5 – Surface Temperature Anomalies for 2000-2012 (as reported by the Heartland Institute)



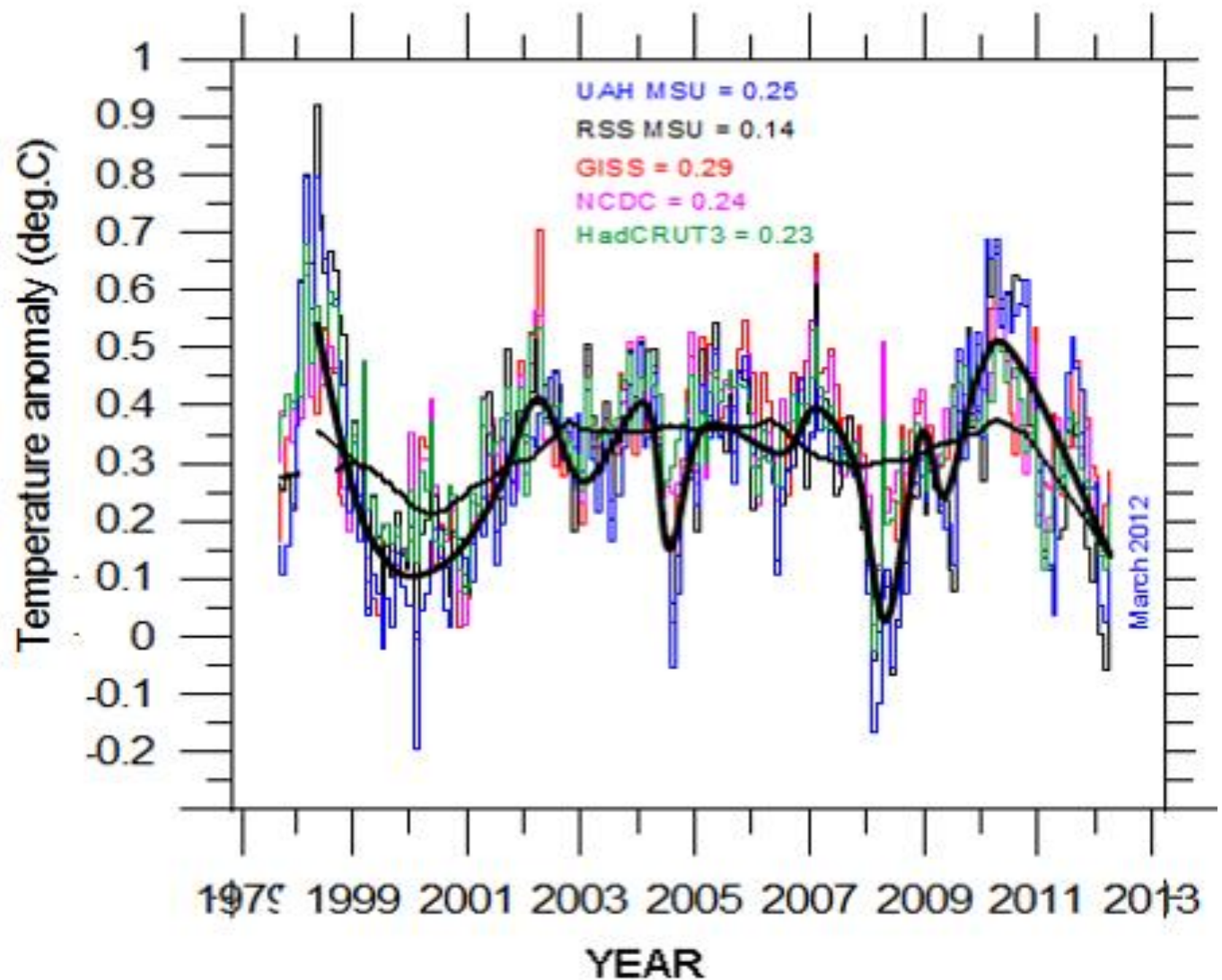


Figure 6 – Multiple Dataset Temperature Anomalies for 1979-2013 (as reported by the Heartland Institute)

Compare Easterbrook's curves to the same period in Figure 3. Different data averaging and reporting methods are used by each of these curves so their numbers and shapes may not line up exactly. But apart from that, the similarities are obvious. Figure 7 gives an even clearer picture.

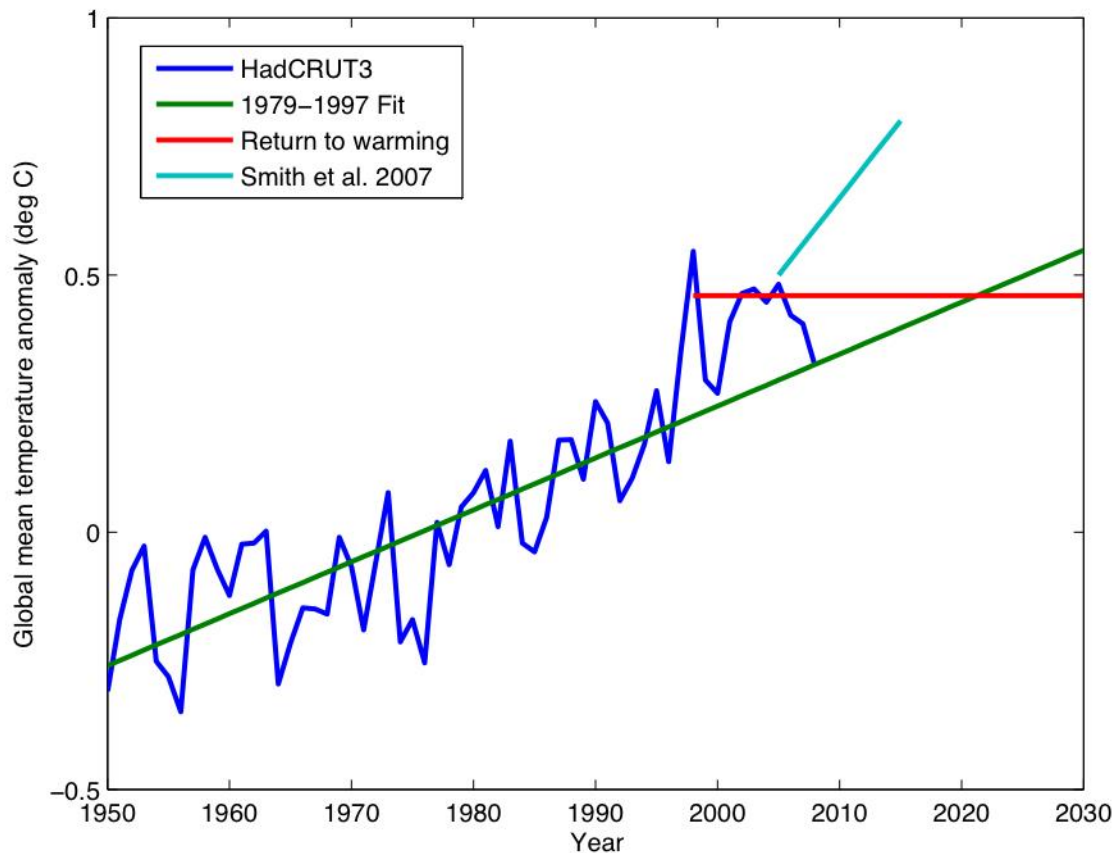


Figure 7 – Long and Short-Term Surface Temperature Trends

This figure is taken from an article by Kyle Swanson of the University of Wisconsin-Milwaukee (Swanson, 2009) in which he discusses at length how climate deniers have distorted (or more properly *butchered*) his own research in support of their claims of global cooling. The blue curve is the same surface temperature dataset presented by Easterbrook (Figure 5, and in the green curve in Figure 6) which was taken from the U.K. Met Office's HadCRUT3 dataset. Here that data is set against a 1979 to 1997 averaged fit (the green curve) for context. The red line labeled *Return to warming* is the portion Ferrara and Easterbrook want you to dwell on.

*Take moment to ponder this figure...* It may be the clearest example you'll ever see of how nearly all skeptic spin works.

What's happening of course, is that climate deniers treat the *red* curve (or one drawn from the top of the El Nino peak it starts from to the bottom of whatever is current today) as though it were the blue or green one. According to them trends between one of Junior's chandelier-breaking bounces and some carefully chosen low point 10 to 20 years later are conclusive proof that a long-term anthropogenic warming trend doesn't exist. The fallacy is obvious, yet this sort of thing turns up again and again in their arguments.

*Error #3) Skeptics cherry-pick their arguments, often deliberately.*

This should come as no surprise--we've seen how selective they can be with temperature datasets. But it doesn't end there. Climate deniers routinely spin context and history as well. In a few cases, they've even been caught deliberately falsifying records. Let's review three particularly egregious examples.

1) Satellite-measured atmospheric temperatures

Ferrara may have mangled the surface temperature record, but not to worry. There's a better source of data, he tells us, and it doesn't show much warming either!

"The incorruptible satellite measured global atmospheric temperatures show less warming during this period than the heavily manipulated land surface temperatures..." (Ferrara, 2012)

The "incorruptible" satellite record he refers to is the one collected by the Microwave Sounding Unit (MSU) and Advanced MSU (AMSU) packages that have flown on NASA's Television Infrared Observation Satellite (TIROS-N) series of spacecraft since 1979. These packages detect microwave radiation emitted by the lower and upper atmosphere from which average temperatures for each are calculated. The lion's share of research on these records is maintained in two trended products--one generated by the University of Alabama, Huntsville (UAH), and the other by Remote Sensing Systems of Santa Rosa, CA (RSS). At the time the former team, then led by two well-known climate skeptics (one of whom has since retired), was getting significantly lower numbers and trends than the latter--enough that they disagreed with the predictions of the best extant climate models. Needless to say, this was (and to this day still is) the only product being quoted by skeptics.

In 2005, with gracious assistance and peer-review from the IPCC I produced two research papers on this record (Church, 2005; 2005b). Among other things, I discussed how climate models have always predicted less atmospheric warming than the allegedly "heavily manipulated" land surface record (a fact Ferrara appears to be completely ignorant of). I also analyzed both satellite products in depth and showed why they were neither incorruptible, nor in disagreement with the surface record. It ended up being passed around the IPCC, the U.S. Climate Change Commission, and a few universities as well. Eventually someone gave copies of both to the leader of the UAH team. He reached out to me with an extended and thoughtful response, and even provided me with more data and a preprint copy of a paper his team was preparing on the relationship of the tropospheric record to the stratospheric one before it was published (with the understanding that I would, of course, keep quiet about it until it was... which I did). But when he saw a comment I made in the second paper about a statement he'd made before Congress (which was highly misleading) he was infuriated and responded with a diatribe that bordered on outright hysteria (it seems I hit a nerve...)<sup>4</sup>

All that aside, many of the issues I raised in my paper got some folks thinking (or at least pushing harder in directions they were already headed). Six months later the RSS team published a paper (Mears & Wentz, 2005) that uncovered the reason for those surprisingly low trends (it's probably wishful thinking or grandiosity on my part, but I like to think that I contributed something to that). The TIROS-N satellites that collect this data are operated in polar orbits that allow them to cover the entire earth in a few passes as it rotates beneath them (this isn't possible with an equatorial orbit as the earth is rotating about the same axis as the satellite's orbit, so the equator is all it will ever see). A consistent temperature record can only be maintained if these satellites overfly each point on earth at the same time every day (it's a lot warmer in Albuquerque at high noon than it is at 9am). However, a satellite in polar orbit about the earth doesn't know about its journey around the sun. Its plane will remain fixed with respect to the background space instead, as depicted by the red orbit in the upper left corner of Figure 8 below.

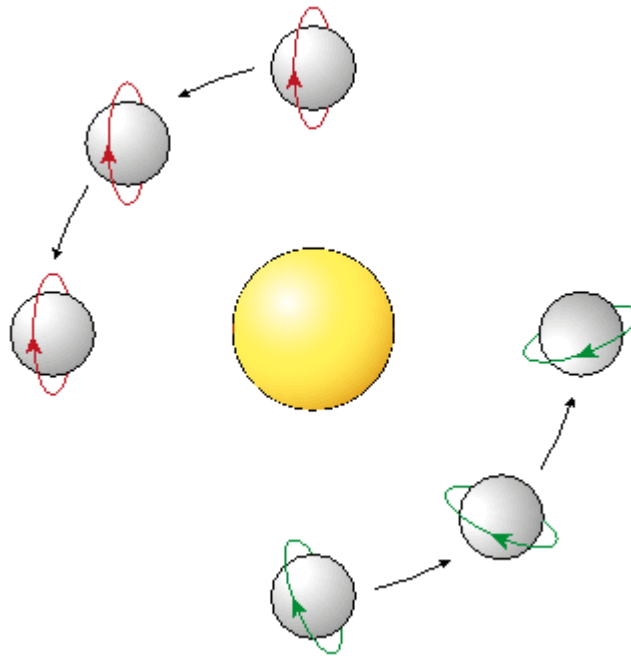


Figure 8 – Normal and Sun-Synchronous Polar Orbits

But if the satellite can be induced to orbit in a polar plane that rotates at a rate of once annually (the green orbit in the lower right) it will preserve its angle with the earth-sun axis throughout the year and overfly Albuquerque (or wherever) at the same time daily throughout its service life. This is known as a *sun-synchronous* orbit, and all TIROS-N satellites have flown in one for daily consistency of data.

But alas, satellites are machines... and like all machines they have problems. Rocket launches are never perfect, and neither is the sun-synchronicity of orbits of their payloads end up in. With respect to the sun, every one of the TIROS-N satellites experiences some east-west drift in their daily orbital paths over the course of their service lives. This is known as *diurnal drift*, and depending on its direction it will show up in a satellite's record as a spurious warming or cooling. Fortunately, it's straightforward to measure these errors and adjust the data to correct for them, and both the UAH and RSS teams do.

Now as it happens, one of the satellites in the series that operated between 1986 and 1993 (NOAA-9) had a particularly bad diurnal drift, and I'd spent some time addressing it in my papers. Well, what the RSS team discovered was that the climate deniers' beloved UAH team had inadvertently gotten a minus sign out of place in their correction for this error. As a result, they ended up adjusting their temperature trends by subtracting from them what they thought was a spurious warming. What they needed to do was *add* to them what was in fact a spurious *cooling*. Correcting the error resulted in a 40% increase in their figures resulting in trends that were still low compared to RSS trends and those of other analysis products, but well within the range of the best climate model predictions (Mears & Wentz, 2005).

In other words, the only reason Ferrara's "incorruptible" satellite record showed "less warming during this period" was because... [wait for it...] *the skeptic-led team screwed up their arithmetic! Ooops...!*

The skeptic team leader I corresponded with ended up having to publicly retract more than 8 years of his team's analysis products, and the climate skeptic community was dealt what may be their worst narcissistic injury to date. They scrambled for months to cover their tracks and have been licking their wounds ever since. One or two of the more outspoken climate skeptics at the time (most notably Ron Bailey of the Cato Institute) even reversed their positions on global warming.

That was 17 years ago... and apparently, Ferrara and many other skeptics still think this little detail isn't worth mentioning.

To this day, climate skeptics continue to tout UAH analysis products because even after correction, they are still artificially low. Enough so, that when compared to a suitably cherry-picked subset of climate models (for which details of the forcing scenarios are carefully suppressed, of course) they're still useful for some spin—provided, of course, that no one looks too closely. Since their inception, UAH products use a different analysis method to merge

the overlapping records of satellites as they reach the end of their service lives and are replaced with newer ones. Specifically, they leave out those they deem to be outliers in the series (needless to say, the “outliers” tend to be those with higher trends). In addition to UAH, there are at least four independent lower and mid troposphere analysis products covering all, or part of the period from 1979 to 2017 using varying methodologies (Mears & Wentz, 2017; Prabhakara et. al., 2000; Vinnikov et. al., 2006; Zou et. al., 2006; Housfather, 2017). For comparable periods and products, these all agree with each other to within measurement noise, and show anywhere from 1.5 times to *twice* the corresponding UAH trends, and they are in full agreement with the best climate models under the most realistic forcing scenarios—so much so that by 2007, the IPCC Fourth Assessment Report concluded that,

"New analyses of balloon-borne and satellite measurements of lower- and mid-tropospheric temperature show warming rates that are similar to those of the surface temperature record and are consistent within their respective uncertainties, largely reconciling a discrepancy noted in the TAR." (Wigley et. al., 2006)

Don't expect to hear about any of this from astroturf lobbyists though. Their industry and Far-Right benefactors aren't paying for that kind of publicity.

## 2) The coming “ice age”

But wait...! According to Ferrara and other skeptics it gets even worse. Not only is the earth not warming, not long ago those global warming alarmists were even predicting a catastrophic ice age!

"For example, temperatures dropped steadily from the late 1940s to the late 1970s. The popular press was even talking about a coming ice age. Ice ages have cyclically occurred roughly every 10,000 years, with a new one actually due around now..." (Ferrara, 2012)

This is an urban legend that's been rattling around Far-Right forums for decades, and just won't die. Its origin goes back to media claims regarding two papers published during the '70s; one of which is now thoroughly anachronistic, and the other based on a non-sequitur that an honest two minutes' worth of due diligence would've uncovered. That's right, papers published *six decades ago*. I literally have co-workers whose *parents* weren't born when the events Ferrara is referring to took place. Yet somehow, we're supposed to believe they're still relevant to climate science today.

The first was an early '70s modeling study that examined various forcing scenarios involving greenhouse gas emissions and aerosols (Rasool & Schneider, 1971). At the time, climate modeling was in its infancy and there wasn't much data yet on greenhouse gas or aerosol levels in the atmosphere. It wasn't known whether industrial pollution was producing more of one or the other. The dominant climate forcing then was solar and the sun had been in a waning phase since WWII so naturally, the earth had been cooling since then—a fact that was well-known at the time and to be expected from the prevailing oceanic and atmospheric physics (see Error #1 and Figure 4 above). Everyone knew that eventually the greenhouse forcing “spring” would start to tighten, but it hadn't done so yet to a noticeable degree yet, and in the absence of better greenhouse gas concentration data we couldn't tell with any confidence when that was going to happen, or when the sun was going to enter a waxing phase. Climate scientists couldn't say with any confidence exactly when the cooling trend of the period was going to reverse—only that if business as usual continued, it eventually would.

Against this backdrop, the authors (one of whom was a PhD student) conducted some crude model runs using various *hypothetical* scenarios intended to test a wide range of emissions scenarios, some of them extreme, see what would happen under each. One of the extreme scenarios they tested involved flooding the entire atmosphere with a thick uniform cover of particulate aerosols not unlike a nuclear winter. As it happened, that one led to a global 3–5-degree cooling and a potential ice age. Neither the authors nor anyone else believed this was likely to happen. It was just one of the more extreme “kick the tires” runs among several. It was *not* a serious prediction of expected near-term climate change, and the study was never intended to be released as a consensus stance. But unfortunately, someone carelessly misrepresented it as such and leaked news of it to journalists before a conference in Stockholm, and the authors found themselves in the awkward position of having to discuss it publicly and explain their work to a reactionary press with little grasp of how development of climate models or science work.

Again, this was *60 years ago*. And to this day, climate deniers still insist not only that scientists were *predicting* an ice age then, but that science has made virtually *no* progress of any kind since. They literally expect us to believe that climate scientists today don't know one single thing about the earth's climate that wasn't known then and have no way of telling whether the coming century is more likely to bring warming or an ice age.

The second paper dates to the mid '70s when the National Academy of Sciences published a study on the impact of Milankovitch cycles on past ice ages and the prospects for another one in the future (Hays et al., 1976). Milankovitch cycles are changes in global climate resulting from gravitationally induced perturbations to the earth's orbit and/or axis of rotation caused by near-misses with large asteroids and the like. They occur over millennial timescales and have nothing whatsoever to do with climate change on a decadal/century scale, man-made or otherwise. The myth survives because climate deniers rarely bother to read the papers they cite, and they tend to assume their readers won't either. One of the guys who collaborated with me on my 2005 papers has [a nice write-up about this issue](#) including links to other resources.

Apparently, the difference between *millennial* scale astronomical events that might happen in coming ages and greenhouse gas-induced warming over the coming century is also not worth mentioning.

### 3) "Over-predictions" of global warming in 1988

Giving skeptics the benefit of a doubt, the omissions and distortions we've seen so far might be attributed to careless oversight. Particularly those like Ferrara who have little if any science training, and as such, a limited awareness of the errors they propagate. Unfortunately, this is not always the case. A few skeptics have been caught deliberately falsifying data. One of the most notorious incidents was committed by Patrick Michaels, a senior fellow in environmental studies at the Cato Institute and former professor of environmental studies at the University of Virginia. For years Michaels has been a bread-and-butter consultant for industry-funded Astroturf lobbies, and a favorite of ultra-conservative climate deniers in Congress. In 1998, he was called on by some of his industry friends there to testify on global warming before the House Committee on Small Business. During his testimony, he made the following statement,

"Ten years ago, on June 23, 1988, NASA scientist James Hansen testified before the House of Representatives that there was a strong "cause and effect relationship" between observed temperatures and human emissions into the atmosphere...

At that time, Hansen also produced a model of the future behavior of the globe's temperature, which he had turned into a video movie that was heavily shopped in Congress. That model was one of many similar calculations that were used in the First Scientific Assessment of the United Nations Intergovernmental Panel on Climate Change ("IPCC", 1990), which stated that 'when the latest atmospheric models are run with the present concentrations of greenhouse gases, their simulation of climate is generally realistic on large scales.'

That model predicted that global temperature between 1988 and 1997 would rise by 0.45°C... Ground-based temperatures from the IPCC show a rise of 0.11°C, or more than four times less than Hansen predicted...

The forecast made in 1988 was an astounding failure, and IPCC's 1990 statement about the realistic nature of these projections was simply wrong." (Michaels, 1998)



Figures 9 and 10 respectively show the slide Michaels used to illustrate the 1988 to 1997 warming prediction he attributed to Hansen's team, and the original its temperature curve was borrowed from (Hansen et al., 1988, Figure 3) superimposed with the observed temperature record at the time of his testimony (the black curve).

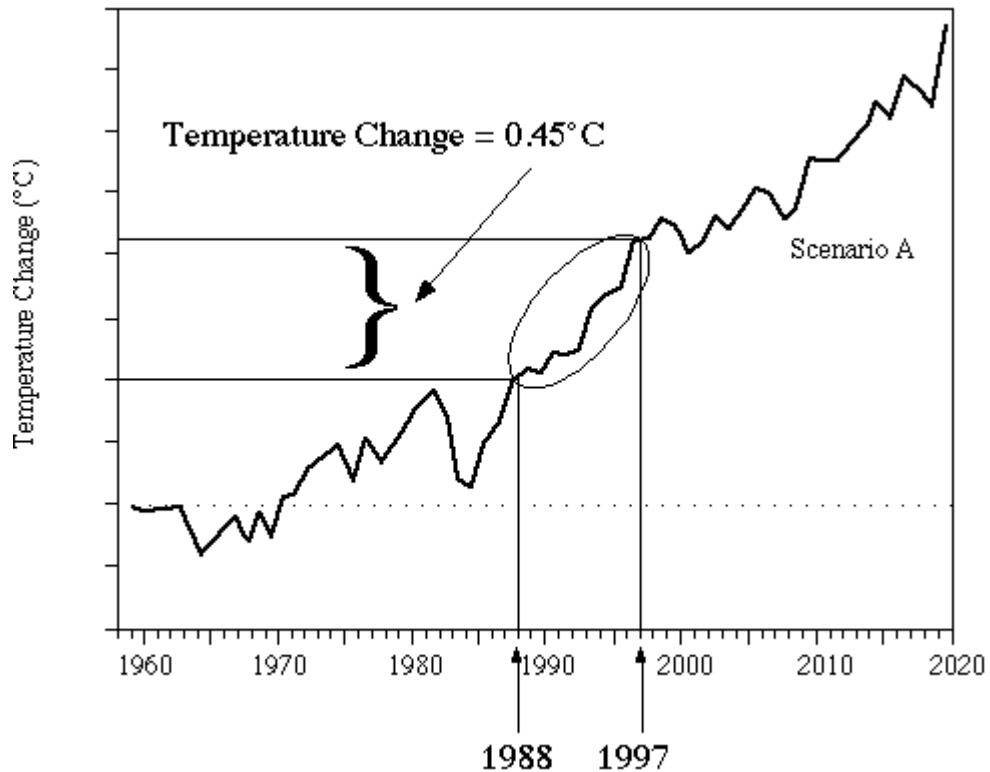


Figure 9 – Patrick Michael's Slide Showing Hansen's 1988 Model Predictions

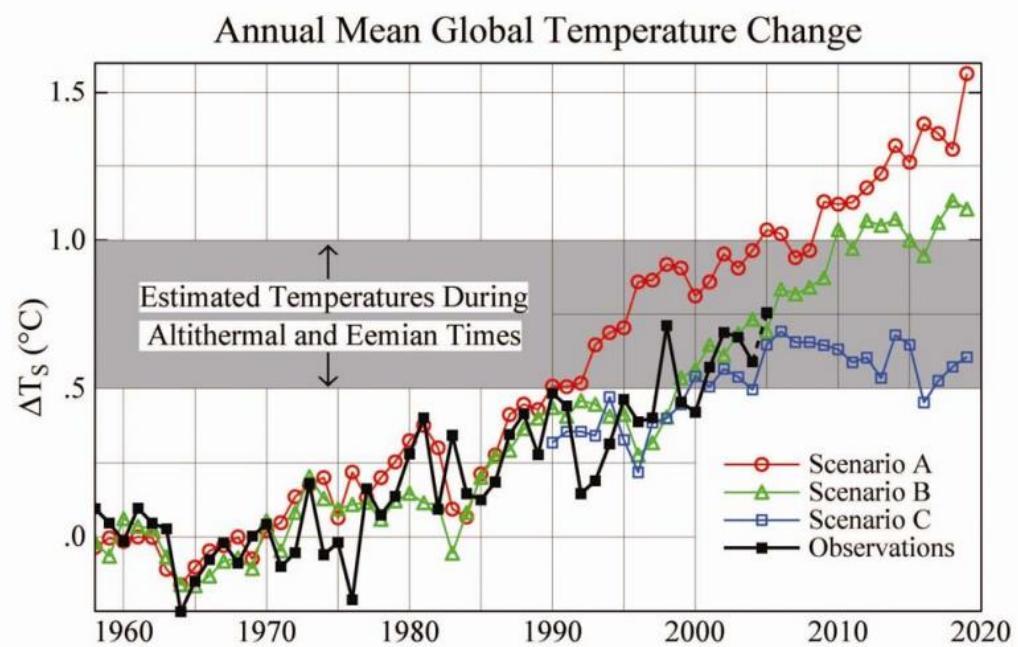


Figure 10 – The original slide Michaels borrowed Figure 9 from (with observed temperatures overlaid)

Notice anything...? (82)

As can be seen, Hansen's team ran their climate model against three greenhouse gas emissions scenarios. Scenario C (the blue curve) was their low-end case that could be expected to prevail if the world stopped listening to people like Michaels and drastically reduced emissions, even beyond the Kyoto guidelines and other proposed restrictions. Scenario B (the green curve) was their baseline "business-as-usual" estimate that presumed current emissions and the reductions that could be realistically expected for the 90's and beyond, given mitigation efforts that were under way. Scenario A (the red curve) was their worst-case—Michaels et al. have their way, the gloves come off, and polluting industries gleefully flood the atmosphere with exponentially increasing greenhouse gas emissions.

The agreement between the green Scenario B curve and the black observed one speaks for itself. The only significant differences correspond to aerosol cooling from the 1991 eruption of Mt. Pinatubo, and the record-breaking 1998 El Nino discussed earlier, neither of which could've been taken specifically into account in any forecast and were transient events that have little to do with long-term climate change anyway. Hansen presented all three scenarios during his 1988 Congressional testimony to give lawmakers a sense of the range of potential outcomes. But the bulk of his data and slides concentrated on this scenario because it was deemed to be far closer to what could be realistically expected in the coming decade...

And it's *missing* from Michaels' Figure 9 slide, as is Scenario C.

That's right folks... Michaels *erased* Hansen's baseline and low-end results from his slide, and *deliberately misrepresented the worst-case scenario as his baseline instead!* This isn't just spin or careless oversight... it's outright *fraud*.

Short of violence, knowingly falsifying data is the most negligent offense a scientist can commit—especially when he/she has been trusted to provide expert testimony to Congressional lawmakers. If Michaels had pulled a stunt like this at a scientific symposium or in a paper submitted to a peer-reviewed journal, he would've been fired with malice and stripped of his titles. But since he was testifying on behalf of industry-funded Astroturf fronts outside the scientific community he was immune from academic disciplinary action.

The scientific community was understandably horrified. Michaels was widely condemned for his fraudulent behavior in the media and scientific forums (Hansen, 2005; Krugman, 2006; Lambert, 2006; 2008; etc.), but not surprisingly, the skeptic community had a ready string of excuses for him. Michaels himself bristled at being labeled a fraud and defended his actions by claiming that (get this...) in *his* opinion, "business-as-usual" means baseline—regardless of what the authors meant by either term.

"my purpose was to demonstrate that commonly held assumptions about climate change can be violated in a very few short years.

One of those is that greenhouse gas concentrations, mainly carbon dioxide, would continue on a constant exponential growth curve. NASA scientist James Hansen had a model that did just this, published in 1988, and referred to in his June 23, 1988 Senate testimony as a 'Business as Usual' (BAU) scenario.

BAU generally assumes no significant legislation and no major technological changes. It's pretty safe to say that this was what happened in the succeeding ten years." (Michaels, 2006)

Other skeptics echoed similar rationalizations. One even went so far as to claim that Scenario A was Hansen's real baseline because it was "arguably more prominent graphically" in his figure (McIntyre, 2008; Lambert, 2008) ... again, in *his* opinion.

The problem with all this of course, is that it wasn't his own work, nor that of any other skeptic that Michaels was representing in his testimony—it was *Hansen's*. And the only definition of "baseline" that's germane to *his* work is the one he clearly presented in his publications and 1988 Congressional testimony as his team's most plausible case (Hansen, 2005). The scenarios they modeled are specifically spelled out, not only in the body of their published research, but in the paper's abstract where even a minimal attempt at due diligence would've made them evident (Hansen et al., 1998). The responsible thing to do (not to mention, the *ethical* one) would've been to present all three transparently with a justification for why one thinks the exponentially increasing emissions case should be treated as the baseline rather than the most plausible one. Unfortunately for Michaels, it was 1998. Had he done that it would've been clear that the actual greenhouse gas emissions that had taken place since Hansen's testimony were much closer to Scenario B than the one that was more favorable to his agenda, and the

spectacular agreement between the green and black curves in Figure 10 would've stood out like a sore thumb. The Committee would've put two and two together and drawn the obvious, but politically inconvenient conclusion... and we certainly can't have *that*, now can we? ☹️

So, he did the only thing he could've done to serve his deep-pocketed industry benefactors... he erased everything but the worst-case scenario lest the Committee be allowed to judge for themselves.

*Error #4) Skeptics assume regional weather events apply to climate change.*

As we've seen, climate change is the global system response of the earth's oceans, continental land mass, ice sheets, and atmosphere to various long-term forcings. Individual weather events such as storms or temperature records cannot be tied to it, although a clear upward (or downward) trend in their frequency and/or intensity can be. For the most part, professional climate deniers with official-sounding think-tank titles and big industry paychecks are aware of this and rely on errors of the previous sort. But in the popular press and blogosphere, a veritable legion of talking heads and wannabe climate commentators regularly show up to feed at this trough. Now to be fair, climate activists are often as guilty of this as any skeptic (how often have we heard someone from Greenpeace, or the Sierra Club blame global warming for Hurricane Katrina or a nasty heat wave in Palm Springs?). But unlike their environmental counterparts, skeptics routinely compound the error with a glaring ignorance of basic high-school science.

To wit, in a 2015 Forbes editorial one James Taylor (not the singer) tells us that,

"Yet another bitterly cold, snowy winter is destroying alarmist global warming claims, proving once again that over-the-top global warming predictions are proving no more scientifically credible than snake oil... blizzard after blizzard is burying much of the nation with record winter snow totals, with winter snowfall records being set from Boston to Denver. Global warming activists are in full-throttle damage control, desperately claiming global warming causes record snow and cold." (Taylor, 2015)

Sentiments like these are hardly new. As far back as 2003, conservative polemicist Ann Coulter (her chosen label BTW, not mine) echoed similar thoughts.

"[this] year, Washington, D.C., had the coldest February in a quarter-century. What are the scientific conclusions of Ms. Carlson's neighbors now? In a single day in February, New York got its fourth-deepest snowfall since 1869. Baltimore got more snow in February than in any other month in recorded history. I wish there were global warming." (Coulter, 2003)

The weather/climate confusion in both screeds speaks for itself. But the real irony here is that "global warming activists" aren't the only ones who claim that global warming causes record snowfalls. High school chemistry teachers do as well. Had Taylor or Coulter taken one of their classes (and paid enough attention to actually pass), one of the first things they would've learned is the *ideal gas law*. According to the ideal gas law, the ratio of pressure to density in any pure gas is proportional to its temperature. Extending this law to gaseous mixtures like moist air results in what's known as the *Clausius Clapyron* relationship, which tells us that dew point is also a function of temperature and pressure. Increasing the temperature and/or pressure of air increases the amount of moisture it can hold before becoming saturated (this BTW, is why relative humidity is (ahem...) *relative*). If a parcel of air is wet enough, and a change in pressure or temperature lowers its dew point below its ability to carry the amount of water it has, and the excess moisture must go somewhere. This is why your mirror fogs up with dew after a hot shower. It's also why a falling barometer tends to bring rain... or, if it's cold enough, snow.

As global average temperatures increase, so does the amount of moisture the atmosphere can carry. This translates directly into larger water bombs available to be dropped when the barometer falls, or when the excitable kid delivers an unseasonable cold snap. In other words, ... [wait for it] ... *record snowfalls*.

This isn't "full-throttle damage control" folks... it's high school chemistry.

**The four classes** of error we've covered are a recurring theme in virtually every argument the climate skeptic community has ever made. Having followed their writings for over 20 years, I can honestly say that I have yet to see them make a single claim that isn't a textbook fit to one or more parts of this four-point template. Use it long enough and a pattern begins to emerge—a pattern of chronic spin, that when traced to its financiers is found to have little to do with science, and everything to do with the short-term gain of special interests. That is a problem... because the real world is beholden to the laws of physics, which care little for anyone's profit or loss.

Nobel laureate physicist Richard Feynmann was one of the scientists who served on the Rogers Commission that investigated the 1986 Challenger disaster. Speaking of the events that led up to that tragedy he said,

"For a successful technology reality must take precedence over public relations, for nature cannot be fooled."

He was right. I realize that climate mitigation efforts will be costly. I understand all too well why industries and consumers who will be impacted (including me) find them alarming. But we don't have the luxury of misleading ourselves. Nature couldn't care less about the pretty, majestically turreted sandcastles we've built for ourselves, or how much trouble it will be to move them to higher ground. It doesn't care about our petty agendas and prevarications, nor our need to be appeased with easy populist answers and scapegoats. If our children and grandchildren are to inherit a livable world, we *cannot* afford to kid ourselves about the incoming tide.

Period.

### **Footnotes**

- 1) In climate science publications temperature trends are generally presented as deviations from a baseline average to make the actual magnitude of the changes more apparent. These are referred to as *anomalies* from the referenced datum.
- 2) There are literally dozens of these fronts, all well-funded by industry and Far-Right foundations, and with official-sounding names carefully crafted to give the appearance of neutral science.
- 3) Astroturf fronts routinely give their publications, websites, and events names that closely mimic those of legitimate institutions to superficially leech their respectability with audiences that don't pay close attention (which sadly, is all too often true of the general public). In this case "ICCC" is a thinly-veiled attempt to mimic the IPCC—an international organization of the world's most respected scientists in climate-relevant fields, and the world's leading climate change authority. Likewise, [realclimate.org](http://realclimate.org) is an informative, and widely respected blog run by some of the world's leading climate scientists (a few of whom I know). But [realclimatescience.com](http://realclimatescience.com) is a blog run by anti-environmental activist Tony Heller who until recently hid behind the online [sockpuppet](http://sockpuppet) "Steven Goddard," no doubt to hide the fact that he has no formal training whatsoever in any climate-relevant field (Heller still uses this sockpuppet in many forums, even after admitting to it in 2014). He is well-known for recklessness with climate facts and bizarre conspiracy theories (including his 2019 claim that NASA has been deliberately falsifying global surface temperature records from as long ago as the mid-1800's, originally published in the John Birch Society publication the *New American*). These and other claims of Heller's have been repeatedly debunked (Johnson, 2019; Boyer, 2016; Greenburg, 2014), and his track record has gone far enough off the rails that even prominent climate skeptics have begun to distance themselves from him (Bailey, 2014).
- 4) Interestingly, he was (and still is) part of the IPCC and as such, a Nobel recipient with Al Gore. So... for better or worse, I now have the dubious distinction of being the only guy I know ever to have received hate mail from a Nobel Laureate. ☹

### **References**

Bailey, R. 2014. Did NASA/NOAA Dramatically Alter U.S. Temperatures After 2000? Reason, June 23, 2014. Online

at <https://reason.com/2014/06/23/did-nasanoaa-dramatically-alter-us-tempe/>. Accessed July 31, 2023.

Bickmore, B.R. (2010). Monckton makes it up. *RealClimate*, Aug. 7, 2010. Available online at [www.realclimate.org/index.php/archives/2010/08/monckton-makes-it-up/](http://www.realclimate.org/index.php/archives/2010/08/monckton-makes-it-up/). Accessed Apr. 17, 2010.

Boyer, P. 2016. Talking Point: Laughable conspiracy theory set to be peddled in Parliament. *Mercury News*, Aug. 23, 2016. Available online at <https://www.themercury.com.au/news/opinion/talking-point-laughable-conspiracy-theory-set-to-be-peddled-in-parliament/news-story/8b175133651c5c460b88325dc915df38>. Accessed July 31, 2023.

Church, S. (2005). Climate Change & Tropospheric Temperature Trends: Part I - What do we know today and where is it taking us? *ScottChurchDirect*, Feb. 10, 2005. Available online at [www.scottchurchdirect.com/docs/MSU-Troposphere-Review01.pdf](http://www.scottchurchdirect.com/docs/MSU-Troposphere-Review01.pdf). Accessed Apr. 13, 2017.

Church, S. (2005b). Climate Change & Tropospheric Temperature Trends: Part II - A Critical Examination of Skeptic Claims. *ScottChurchDirect*, Feb. 10, 2005. Available online at [www.scottchurchdirect.com/docs/MSU-Troposphere-Skeptic01.pdf](http://www.scottchurchdirect.com/docs/MSU-Troposphere-Skeptic01.pdf). Accessed Apr. 13, 2017.

Colose, C. (2008). Easterbrook and the coming 'Global Cooling.' *Chris Colose WordPress Blog*, Nov. 11, 2008. Available online at <https://chriscolose.wordpress.com/2008/11/11/easterbrook-and-the-coming-global-cooling/>. Accessed Apr. 17, 2017.

Easterbrook, D. (2012). Are Forecasts of a 20-Year Cooling Trend Credible? *Heartland Institute*. Presented at the 7<sup>th</sup> annual International Conference on Climate Change. May 2012. Video available at <http://climateconferences.heartland.org/don-easterbrook-iccc7/>. PowerPoint slides at [http://climateconferences.heartland.org/wp-content/uploads/Powerpoints/ICCC7/Easterbrook\\_Don.ppt](http://climateconferences.heartland.org/wp-content/uploads/Powerpoints/ICCC7/Easterbrook_Don.ppt). Accessed Apr. 12, 2017.

Ferrara, P. (2012). Sorry Global Warming Alarmists, The Earth Is Cooling. *Forbes*. May 31, 2012. Available online at [www.forbes.com/sites/peterferrara/2012/05/31/sorry-global-warming-alarmists-the-earth-is-cooling/](http://www.forbes.com/sites/peterferrara/2012/05/31/sorry-global-warming-alarmists-the-earth-is-cooling/). Accessed Apr. 6, 2017.

Greenburg, J. 2014. Fox's Doocy: NASA fudged data to make the case for global warming. *PolitiFact*, June 25, 2014. Available online at <https://www.politifact.com/factchecks/2014/jun/25/steve-doocy/foxs-doocy-nasa-fudged-data-make-case-global-warmi/>. Accessed July 31, 2023.

Hansen, J., I. Fun, A. Lacis, D. Rind, S. Lebedeff, R. Ruedy, G. Russell, and P. Stone. (1988). Global climate changes as forecast by Goddard Institute for Space Studies three-dimensional model. *J. Geophys. Res.*, **93**, pp. 9341-9364, doi:10.1029/JD093iD08p09341. Available online at [https://pubs.giss.nasa.gov/docs/1988/1988\\_Hansen\\_ha02700w.pdf](https://pubs.giss.nasa.gov/docs/1988/1988_Hansen_ha02700w.pdf). Accessed Apr. 14, 2017.

Hansen, J. (2005). Michael Crichton's "Scientific Method." *Columbia University*, J. Hansen Communications, Sept. 27, 2005. Available online at [www.mediafire.com/view/2mobtu52t0tk58k/20050927\\_Crichton.pdf](http://www.mediafire.com/view/2mobtu52t0tk58k/20050927_Crichton.pdf). Accessed Apr. 14, 2017.

Hays, J.D., J. Imbrie, & N.J. Shackleton. (1976). Variations in the Earth's Orbit: Pacemaker of the Ice Ages. *Science*, **194** (4270), pp. 1121-1132. Available online at [www.researchgate.net/profile/J\\_Hays/publication/301325552\\_Variations\\_in\\_the\\_Earth\\_pacemaker\\_of\\_the\\_ice\\_ages/links/573cca0c08ae9ace840fe240.pdf](http://www.researchgate.net/profile/J_Hays/publication/301325552_Variations_in_the_Earth_pacemaker_of_the_ice_ages/links/573cca0c08ae9ace840fe240.pdf). Accessed Apr. 13, 2017.

Housfather, Z. 2017. Major correction to satellite data shows 140% faster warming since 1998. *CarbonBrief*, June 30, 2017. Available online at <https://www.carbonbrief.org/major-correction-to-satellite-data-shows-140-faster-warming-since-1998/>.

Accessed July 31, 2023.

Johnson, S. 2019. NASA did not create global warming by manipulating data. *Climate Feedback*, June 26, 2019. Available online at <https://climatefeedback.org/claimreview/nasa-did-not-create-global-warming-by-manipulating-data-tony-heller-steven-goddard/>. Accessed July 31, 2023.

Lambert, T. (2006). Pat Michaels: "fraud, pure and simple." *Deltoid*, June 5, 2006. Available online at <http://scienceblogs.com/deltoid/2006/06/05/pat-michaels-fraud-pure-and-si/>. Accessed Apr. 14, 2017.

Lambert, T. (2008). Steve McIntyre defends Pat Michaels' fraud. *Deltoid*, Jan. 17, 2008. Available online at <http://scienceblogs.com/deltoid/2008/01/17/steve-mcintyre-defends-pat-mic/>. Accessed Apr. 14, 2017.

Krugman, P. (2006). Swift Boating the Planet. *New York Times*, May 29, 2006. Available online at <http://select.nytimes.com/2006/05/29/opinion/29krugman.html?n=Top%2fOpinion%2fEditorials%20and%20Op-Ed%2fOp-Ed%2fColumnists%2fPaul%20Krugman&pagewanted=print>. Accessed Apr. 14, 2017.

Mears, C. A., & Wentz, F. J. (2005). The effect of diurnal correction on satellite-derived lower tropospheric temperature. *Science*, **309** (5740), pp. 1548-1551. Available online at [http://images.remss.com/papers/rsspubs/Mears\\_Science\\_2005\\_Diurnal.pdf](http://images.remss.com/papers/rsspubs/Mears_Science_2005_Diurnal.pdf). Accessed July 31, 2023.

Mears, C.A. and Wentz, F.J., 2017. A satellite-derived lower-tropospheric atmospheric temperature dataset using an optimized adjustment for diurnal effects. *Journal of Climate*, **30** (19), pp.7695-7718. Available online at <https://journals.ametsoc.org/view/journals/clim/30/19/jcli-d-16-0768.1.xml>. Accessed July 31, 2023.

Michaels, P.J. (1998). Kyoto Protocol: A Useless Appendage to an Irrelevant Treaty. Testimony of Patrick J. Michaels, Professor of Environmental Sciences, University of Virginia, and Senior Fellow in Environmental Studies at Cato Institute before the Committee on Small Business, United States House of Representatives, Washington, DC. Available online at [www.cato.org/publications/congressional-testimony/kyoto-protocol-useless-appendage-irrelevant-treaty](http://www.cato.org/publications/congressional-testimony/kyoto-protocol-useless-appendage-irrelevant-treaty). Accessed Apr. 13, 2017.

Michaels, P.J. (2006). Smeared by Krugman. *Cato Institute*, June 1, 2006. Available online at [www.cato.org/blog/smeared-krugman](http://www.cato.org/blog/smeared-krugman). Accessed Apr. 14, 2017.

Monckton, C. (2009). SPPI Monthly CO2 Report. *Science & Public Policy Institute*, Feb. 2009. Available online at [http://scienceandpublicpolicy.org/images/stories/papers/originals/feb\\_co2\\_report.pdf](http://scienceandpublicpolicy.org/images/stories/papers/originals/feb_co2_report.pdf). Accessed Apr. 12, 2017.

Prabhakara, C., J.R. Iacovozzi, J.M. Yoo and G. Dalu. 2000: Global Warming: Evidence from satellite observations. *Geophys. Res. Lett.*, **27** (21), 3517-3520. Available online at <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2000GL011719>. Accessed July 31, 2023.

Rasool, S.I. and Schneider, S.H., 1971. Atmospheric carbon dioxide and aerosols: Effects of large increases on global climate. *Science*, **173** (3992), pp.138-141. Available online at <https://www.science.org/doi/10.1126/science.173.3992.138>. Accessed July 31, 2023.

Rohde, R.A. (2014). File:Climate Change Attribution.png. *Wikipedia*, updated July 16, 2014. Available online at [https://en.wikipedia.org/wiki/File:Climate\\_Change\\_Attribution.png](https://en.wikipedia.org/wiki/File:Climate_Change_Attribution.png). Accessed Apr. 6, 2017.

Stocker, T. (Ed.). (2014). Climate change 2013: the physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change. *Cambridge University Press*. Available online at [www.ipcc.ch/report/ar5/wg1/](http://www.ipcc.ch/report/ar5/wg1/). Accessed Apr. 4, 2017.



Swanson, K. (2009). Warming, interrupted: Much ado about natural variability. *RealClimate*, July 12, 2009. Available online at [www.realclimate.org/index.php/archives/2009/07/warminginterrupted-much-ado-about-natural-variability/](http://www.realclimate.org/index.php/archives/2009/07/warminginterrupted-much-ado-about-natural-variability/). Accessed Apr. 12, 2017.

Taylor, J. (2015). Record Cold and Snow Destroy Global Warming Claims. *Forbes*, Feb. 25, 2015. Available online at [www.forbes.com/sites/jamestaylor/2015/02/25/cold-and-snow-destroy-global-warming-claims/#701ceb384c22](http://www.forbes.com/sites/jamestaylor/2015/02/25/cold-and-snow-destroy-global-warming-claims/#701ceb384c22). Accessed Apr. 15, 2017.

Vinnikov, K.Y., Grody, N.C., Robock, A., Stouffer, R.J., Jones, P.D. and Goldberg, M.D., 2006. Temperature trends at the surface and in the troposphere. *Journal of Geophysical Research: Atmospheres*, **111** (D3). Available online at <https://www2.atmos.umd.edu/~kostya/Pdf/VinnikovEtAlTempTrends2005JD006392.pdf>. Accessed July 31, 2023.

Wigley, T., Ramaswamy, V., Christy, J., Lanzante, J., Mears, C.A., Santer, B.D., & C.K. Folland. 2006. Executive Summary: Temperature Trends in the Lower Atmosphere – Understanding and Reconciling Differences. United States Global Climate Change Research Program. Available online at [https://www.gfdl.noaa.gov/bibliography/related\\_files/tmlw0602.pdf](https://www.gfdl.noaa.gov/bibliography/related_files/tmlw0602.pdf). Accessed July 31, 2023.

Zou, C.Z., Goldberg, M.D., Cheng, Z., Grody, N.C., Sullivan, J.T., Cao, C. and Tarpley, D., 2006. Recalibration of microwave sounding unit for climate studies using simultaneous nadir overpasses. *Journal of Geophysical Research: Atmospheres*, **111** (D19). Available online at <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2005JD006798>. Accessed July 31, 2023.