

The Consensus on Anthropogenic Global Warming Matters

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Abstract

Skuce et al., responding to Powell, title their article, “Does It Matter if the Consensus on Anthropogenic Global Warming Is 97% or 99.99%?” I argue that the extent of the consensus does matter, most of all because scholars have shown that the stronger the public believe the consensus to be, the more they support the action on global warming that human society so desperately needs. Moreover, anyone who knows that scientists once thought that the continents are fixed in place, or that the craters of the Moon are volcanic, or that the Earth cannot be more than 100 million years old, understands that a small minority has sometimes turned out to be right. But it is hard to think of a case in the modern era in which scientists have been virtually unanimous and wrong. Moreover, as I show, the consensus among publishing scientists is demonstrably *not* 97%. Instead, five surveys of the peer-reviewed literature from 1991 to 2015 combine to 54,195 articles with an average consensus of 99.94%.

Keywords

global warming, climate change, consensus, peer review, history of science

Introduction

Skuce et al. (2016, henceforth S16), responding to Powell (2016), ask, “Does it matter if the consensus on anthropogenic global warming is 97% or 99.99%?”

Of course it matters.

It matters because the consensus cannot be both 97% *and* virtual unanimity.

It matters because in science, when confronted with differing results for the same quantity, we do not shrug our shoulders and say that one is as good as the other: We try to determine which is correct.

It matters because to allow the public to believe that 3% of climate authors reject anthropogenic global warming (AGW), when virtually none do, is to give the deniers an undeserved and dangerous foothold.

It matters because the stronger the public believe the consensus on AGW to be, the more likely they are to support action:

Increasing public perceptions of the scientific consensus is significantly and causally associated with an increase in the belief that climate change is happening, human-caused and a worrisome threat. In turn, changes in these key beliefs are predictive of increased support for public action. (van der Linden, Leiserowitz, Feinberg, & Maibach, 2015)

Finally, it surely matters if one of the two percentages is simply wrong.

Consensus

What does consensus in science mean and how can it best be measured? The Oxford English Dictionary (2016) defines consensus as “Agreement in opinion; the collective unanimous opinion of a number of persons.” According to Wikipedia (2016), “Scientific consensus is the collective judgment, position, and opinion of the community of scientists in a particular field of study. Consensus implies general agreement, though not necessarily unanimity.”

Common understanding and our experience as scientists jibe with the Wikipedia definition. When we say that biologists have reached consensus on Darwinian evolution, for example, we mean that a large majority, though not necessarily 100%, accept, believe, or agree with the theory. We refer to their state of mind, to what they believe to be true. We do *not* mean that to be part of a consensus, scientists must formally put their acceptance in writing.

To gauge the consensus on AGW, scholars have used opinion polls and literature surveys.

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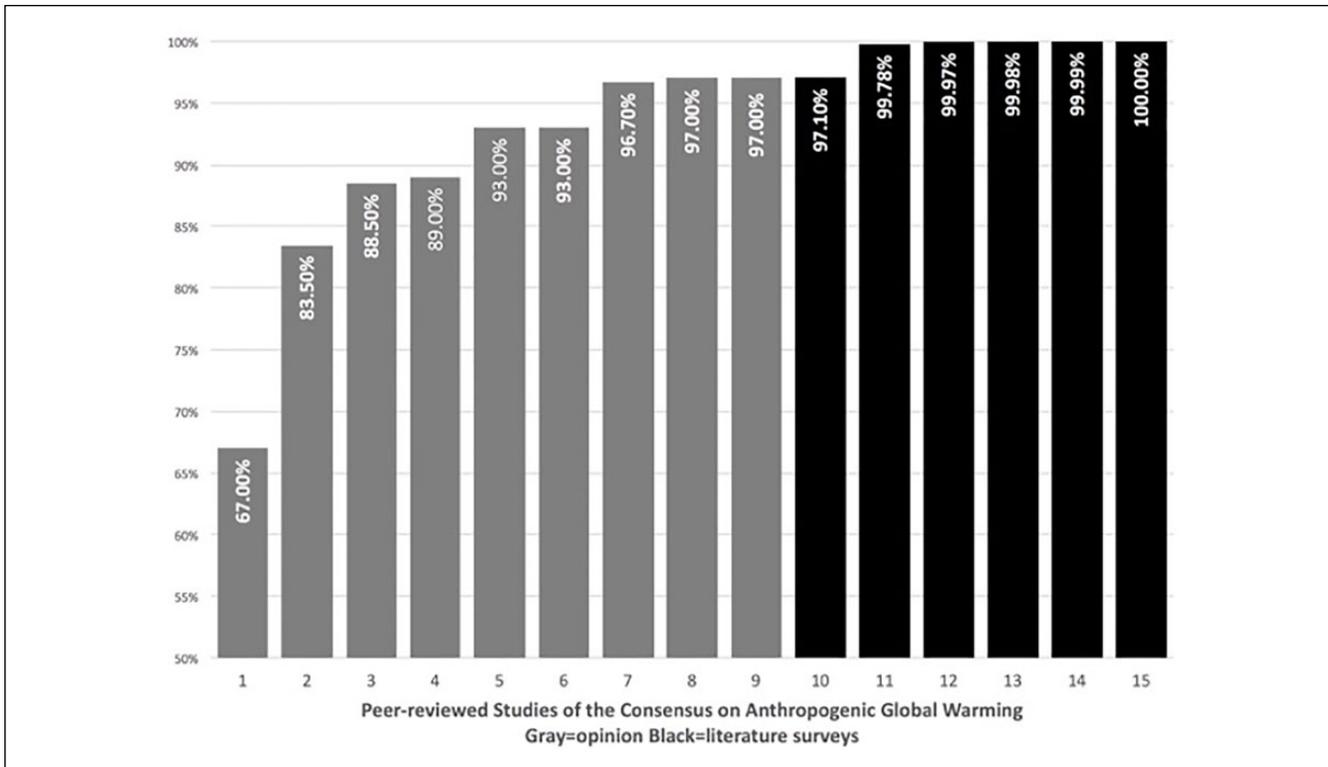


Figure 1. The consensus on consensus: Surveys of the consensus on anthropogenic global warming.

Gray = opinion, surveys of “publishing climatologists” from C16; Black = literature surveys from Table 1 and C13. The vertical scale begins at 50%. 1. Gallup (1991). 2. Bray (2010). 3. Rosenberg et al. (2010). 4. Verheggen et al. (2014). 5. Pew Research Center (2015). 6. Stenhouse et al. (2014). 7. Carlton et al. (2015). 8. Doran and Zimmerman (2009). 9. Anderegg et al. (2010).¹ 10. Cook et al. (2013) as reported. 11. Cook et al. (2013) using only rejections. 12. Powell unpublished for 2012. 13. Powell (2016). 14. Powell unpublished for 2015. 15. Oreskes (2004).

Opinion Polls

We scientists tend to be cautious and not to accept a claim unless and until we have good reason. If asked whether we accept a theory about which we have little direct knowledge, we are as likely to respond no as yes, perhaps really meaning, “not yet” or “it’s not my field.” We err on the side of caution, sometimes to the point of not answering at all, lowering the response rate of an opinion poll.

The result of an opinion poll depends on the precise way the question is framed and on the group polled. Cook et al. (2016, henceforth C16) list the peer-reviewed opinion polls that scholars have conducted on AGW. Each asks at least a slightly different question of a different audience. The results are shown in Figure 1.

Opinion polls provide useful information, but a more reliable and informative way to gauge a consensus among scientists is to survey the peer-reviewed literature, the gold standard of science.

Literature Surveys²

- A peer-reviewed article must provide evidence for its conclusions and pass the scrutiny of editors and experts.

- Authors have carefully considered the statements they make in peer-reviewed articles.
- A survey of the peer-reviewed literature not only can quantify the consensus, but being evidence-based can directly reveal how likely a given theory is to be true.
- If scientists have evidence that a theory may be false, they will report it.
- The response rate for a literature survey is 100% of the articles surveyed.
- Opinions change, but the peer-reviewed evidence stands.

Cook et al. (2013)

The claim of a 97% consensus comes from Cook et al. (2013, henceforth C13), who used the Web of Science to review the titles and abstracts of peer-reviewed articles from 1991 to 2011 with the keywords “global climate change” and “global warming.” C13 reported that “Among abstracts *expressing a position* on AGW, 97.1% endorsed the consensus position that humans are causing global warming.” (p. 1, italics added). The phrase “expressing a position” has often been overlooked, sometimes by the C13 authors themselves, and their result widely promulgated and accepted without qualification.

But the three words “expressing a position” expose *the first danger signal*: C13 did *not* measure the consensus as defined above and as commonly understood. They did not count *all* the articles in their search that might have been part of the consensus but only those that “endorsed” AGW by “Explicitly stat[ing] that humans are the primary cause of recent global warming.” C13 redefined consensus to mean not what scientists accept but what they put in writing.

Before calculating the consensus, C13 threw out 7,930 articles by an estimated 21,000 climate authors because those authors failed directly to endorse AGW. These articles, C13 said, took “no position” on AGW. If there *is* a strong consensus on AGW, which we know from other evidence there is, C13 first ruled out two thirds of its members then calculated the consensus to three significant figures.

Of those 7,930 “no position” articles, 4,528 were on the “impacts” of AGW.³ To say these articles took no position is equivalent to saying that although thousands of scientists viewed the potential consequences of AGW as a serious matter deserving of their time and resources, we can have no idea whether they accept AGW. This is at best illogical and at worst belies the very concept of consensus in science.

Is it not self-evident that one cannot throw out the majority and still calculate what the majority accept? Or look at it this way: If two thirds of authors truly have no position on AGW, then it cannot be the consensus position. Conversely, if AGW *is* the consensus position, which we know from other evidence it is, then C13 have demonstrated that most authors accept the theory but do not “express an opinion.” But that falsifies the C13 method.

A *second danger signal* arises with the phrase, “Explicitly states that humans are the primary cause of recent global warming.” Climate scientists refer to this as “attribution.”

Some articles on AGW are directly about attribution. The authors of such articles are likely to cite human activities as the cause of observed global warming and thus meet the C13 criterion. But authors writing about other aspects of AGW, such as impacts, measurement, mitigation, and paleoclimates, for example, have no reason to make an attributing statement and they seldom do. C13 mistook attribution for endorsement.

Of the 11,944 articles in their database, C13 ranked only 64, or 0.5%, as “endorsing” the position that humans are the principal cause of global warming (C13, Category 1). But if direct endorsement is alleged to be the criterion of consensus, yet only 0.5% of publishing scientists meet that criterion, then either there is no consensus or direct endorsement fails to measure it.

I reviewed the abstracts of those 64 articles, assigning them to categories by subject matter. I judge 35 to be mostly about attribution and modeling, 25 about mitigation, and 4 about impacts. The exact topic is not important, but what is important is that in nearly every case the authors made a statement of attribution either because their subject matter and results required it or because they found it a useful

device to emphasize the human role and set the stage for their article.

Given that C13 used endorsement as the criterion of consensus, finding that they sometimes deny their own yardstick presents a *third danger signal*: “Of note is the large proportion of abstracts that state no position on AGW. This result is expected in consensus situations” (C13, p. 5). Does this not say that when there is a strong consensus, a “large proportion” of authors will not directly endorse the theory in question? How then can endorsement be the criterion of consensus?

On his website, John Cook goes further:

That so many studies on climate change don’t bother to endorse the consensus position is significant because scientists have largely moved from what’s causing global warming onto discussing details of the problem. (Cook, 2016b)

In the scientific field of climate studies—which is informed by many different disciplines—the consensus is demonstrated by the number of scientists who have stopped arguing about what is causing climate change—and that’s nearly all of them. (Cook, 2016c)

If C13 deny their own starting assumption, can their result be right?

Does James Hansen Accept AGW?

C13 categorized articles into seven different levels from explicit endorsement to explicit rejection. Here is a *fourth danger signal*: Since climate authors who write about attribution often write about other topics, articles by a single author often wind up in different C13 categories, as exemplified by these passages:

In “How Sensitive Is the World’s Climate?” Hansen, Lacic, Ruedy, Sato, and Wilson (1993) sought to quantify the effect of rising CO₂ on global temperature: to establish the climate sensitivity. Unsurprisingly, they made an attributing statement: that anthropogenic greenhouse gases are the dominant climate-forcing agent. C13 ruled this article and its authors *into* the consensus.

In “Potential Climate Impact of Mount Pinatubo” Hansen, Andrew, and Sato (1992) reported the effect on global temperature of aerosols emitted during the 1991 eruption of Mount Pinatubo. Since they were writing about a natural event, a volcanic eruption, Hansen and colleagues had no need to “express a position” on the role of human activities and did not. C13 ruled this article and its authors *out* of the consensus.

Hansen has 4 articles in C13 Category 1 (Explicit Endorsement with Quantification), 6 in Category 2 (Explicit Endorsement without Quantification), and 6 in Category 3 (Implicit Endorsement), as well as 6 in Category 4 (No Position). Although I sometimes have trouble believing it, Jim Hansen is only one man: he does not have four different positions on AGW.

C13 also ruled out many other distinguished climate scientists, assigning them to the “no position” category. These included (with the number of articles ruled out) R. Bradley (3), K. Briffa (2), E. Cook (5), M. Hughes (2), P. Jones (3), T. Karl (5), M. Mann (2), M. Oppenheimer (3), B. Santer (2), G. Schmidt (3), the late S. Schneider (3), S. Solomon (5), K. Trenberth (7), and T. Wigley (3).

As far as we know, during the period of the C13 survey each of these authors accepted AGW. That an author can show up in several different C13 categories is further evidence that the C13 method is not about what climate scientists accept—the consensus as defined and commonly understood—but about the subject matter of their articles and the language they happened to use.

Endorsement in the Scientific Literature

As reported in Powell (2016), a review of the literature on other widely accepted theories falsifies the use of endorsement as the criterion of consensus, giving rise to a *fifth danger signal*. Consider Darwinian evolution and impact cratering. By analogy with the C13 requirement of attribution, for its authors to be part of the consensus on evolution, an article would have to make a direct statement about natural selection as the cause or perhaps directly affirm the modern evolutionary synthesis. An article on impact cratering on the Moon would have to say in effect that “meteorite impact is the cause of lunar craters.”

I reviewed 261 abstracts in the *Journal of Evolutionary Biology* from 2000 through 2014. None directly endorsed Darwinian evolution nor did any reject it.

Of 100 recent articles on “lunar craters,” none explicitly attributed those craters to meteorite impact nor did any reject the theory.

To come at the question from a different angle, I reviewed abstracts from a single journal, *Environmental Research Letters*, for 2013 and 2014, searching for “global warming” and “climate change,” the search terms used by C13. I found 283 unique articles. None rejected AGW and only one might be said to endorse it, an article titled, “The Role of Reduced Aerosol Precursor Emissions in Driving Near-Term Warming” (Gillett & Salzen, 2013). The authors concluded: “In the near-term, as in the long-term, GHG [greenhouse gas] increases are the dominant driver of warming.” This wording meets the C13 requirement, but because this article is *about* attribution, it was natural for the authors to make such a statement. There is no reason to believe that this pair of authors accepts AGW, while we cannot know whether the authors of the other 282 articles do.

C13 were among the ERL authors who failed to endorse AGW, thus taking “no position” and, using their own criterion, ruling themselves out of the consensus.

I also reviewed 500 recent articles on plate tectonics, again finding no rejections and no endorsements. C16 agree

that “Nearly all current papers [on plate tectonics] would be classified as taking ‘no position.’” But using the C13 method, one would then conclude that there is no consensus on plate tectonics, even though it has been the ruling paradigm of geology for the past half-century.

Dividing Zero by Zero

C13 decided that 7,930 articles, two thirds of the total, neither endorsed nor rejected AGW. These were the articles they labelled as taking “no position” and ruled out of the consensus. But these authors were writing about “global warming” or “global climate change,” else the articles would not have come up in the C13 search. It must be a rare climate scientist today—a scientific Rip Van Winkle—who truly has “no position” on AGW. The *articles* may take “no position” according to the C13 criterion, but we know that their *authors* have one, otherwise they would not be writing about global warming.

C13 classified 2,910 articles as “implicit endorsements,” leading to a *sixth danger signal*. As the plate tectonics articles exemplify, to attempt to separate implicit endorsements from abstracts that take no position is to seek a distinction without a difference, one entirely in the eye of the beholder. When a theory is the ruling paradigm of its discipline, virtually all workers in the field accept it at least implicitly and few say so explicitly. This is evidently the way of science.

As an example of the difficulty, see Appendix A. Again, we use articles by James Hansen and colleagues. One of the two articles C13 rated “implicit endorsement,” the other “no position.”

Moreover, science authors never expected that their words would be scrutinized at the level of detail of Talmudic scholarship. They certainly did not realize that if they failed explicitly to attribute global warming to human activities, someone would come along and cast them out of the consensus. Had they known, surely some would have used different language and C13 would have gotten a different result.

To derive their 97.1% consensus, C13 divided the number of endorsements by the number of endorsements plus rejections, giving rise to a *seventh danger signal*. For the articles on evolution, impact cratering, and plate tectonics, their method would leave us dividing zero by zero. For the articles from *Environmental Research Letters* that I reviewed, where there might have been one endorsement, we might divide 1 by 1 and calculate a 100% consensus, while leaving out every article but that one.

Skuce et al. (2016)

In their comment on Powell (2016), S16 cite two arguments made by C16 which, despite the evidence to the contrary, S16 claim validate the C13 method and result.

Table 1. Literature Reviews That Used Rejection as the Criterion of Consensus.

Source	Years covered	Number of articles	Expected rejections if consensus = 97.1%	Number of rejecting articles	Consensus, %
Oreskes (2004)	1993-2003	928	27	0	100.00
Cook et al. (2013)	1991-2011	11,016 ⁴	319	24	99.78
Powell ^a	2012	3,517	102	1	99.97
Powell (2016)	2013-2014	24,210	702	5	99.98
Powell ^a	2015	14,524	421	1	99.99
Total/average	1991-2015	54,195	1,572	31	99.94

^aMy reviews of articles from 2012 and 2015 listed were previously unpublished.

All Studies Agree. The opening lines of C16 read, “The consensus that humans are causing recent global warming is shared by 90%–100% of publishing climate scientists according to *six independent studies by co-authors of this paper*. Those results are consistent with the 97% consensus reported by [C13]” (italics added). But note that C16 also show the results of three other opinion surveys *not* written by coauthors of the article: Bray (2010), consensus = 83.5%; Rosenberg et al. (2010), 88.5%; and Pew Research Center (2015), 93%.

In an article in *Skeptical Inquirer*, Cook makes the point more bluntly: “Powell’s approach is similar to that of Senator [Ted] Cruz’s, dismissing the wide range of surveys all arriving at the same 97 percent conclusion” (Cook, 2016a).

Figure 1 shows nine surveys of expert opinion as listed by C16. The consensus among all nine, not just the subset of C16 coauthors, ranges from 67% to 100% or, if the low outlier is omitted, from 83.5% to 100%. The average of the eight surveys of expert opinion listed by C16, omitting the low outlier, is 92.2%. It is evident from this and from Figure 1 that these studies do not “all arrive at the same 97% conclusion.” Moreover, even to say that they are “consistent with the 97% consensus” stretches the meaning of consistent beyond common usage.

To sum up this alleged confirmation, S16 ask us to believe that when the results of a literature survey in which nearly 8,000 articles by an estimated 21,000 authors have been thrown away happens to agree with an opinion survey with a response rate of 31% and a sample size of under 80 (Doran & Zimmerman, 2009), each validates the other.

C13 Author Survey. As a second confirmation, C16 reported that “A survey of authors [by C13] also supported a 97% consensus.”

When I first learned that C13 had surveyed authors directly, I assumed they had asked those authors whether they accept AGW. That would have provided valuable information. Instead, C13 went out of their way to *avoid* learning whether these authors accept AGW:

We are not asking about your personal opinion but whether each specific paper endorses or rejects (whether explicitly or implicitly) that humans cause global warming.

As a result, the C13 author survey suffers the same flaw as their literature survey: it asked authors what they believe they *wrote*, not what, based on the scientific evidence, they *believe*. Moreover, the C13 survey drew only a 14% response rate.

Thus, neither of the two confirmations offered by S16 and C16—that all methods including the author survey converge on 97%—survive scrutiny.

Rejection as the Criterion of Consensus

The reasoning presented so far shows that publishing scientists only rarely endorse their ruling paradigm. But the history of science tells us that those who have evidence against a theory are highly likely to say so. This means that a better method for measuring the consensus on AGW is to derive it from the number of articles that reject the theory.

The first to use this method was Oreskes (2004). She used the ISI database to search for articles on “global climate change” between 1993 and 2003, finding 928. She summed up, “Remarkably, none of the papers disagreed with the consensus position.”⁵

Oreskes (2004) did not quantify the magnitude of the consensus. However, C16, of which Oreskes is a coauthor, write, “This analysis [Oreskes, 2004] found no papers rejecting AGW . . . that is, 100% consensus *among papers stating a position on AGW*” (italics added). The italicized phrase employs the same terminology as C13, giving the reader the impression that Oreskes used the same method: dividing endorsements by endorsements plus rejections. But she did nothing of the kind: instead of restricting her analysis to articles that “state a position,” Oreskes based her finding on “all the papers” and the lack of a single rejection.

Would the C13 method work if applied to Oreskes’s (2004) search results? I repeated her survey and compared the result with the C13 rankings and found only three articles that attribute observed global warming to human activities. Thus, 99.7% do *not* meet the C13 criterion of consensus. If Oreskes *had* used the C13 method, she would have divided 3 by 3 to obtain the same 100% that she found using only rejections, while leaving out 925 articles.

The Consensus on Anthropogenic Global Warming

As summarized in Table 1 and shown in Figure 1, five surveys of the peer-reviewed literature on AGW have, or could have, used rejection as the criterion of consensus. The average consensus among the resulting 54,195 articles is 99.94%. In the 25-year period, there were 31 rejecting articles, about 1.2 articles per year. Not only is the number vanishingly small in the vast scientific literature on AGW, most of the rejecting articles have been cited only rarely, even by other rejecting authors. Several have never been cited.⁶

The C16 authors title their article, “Consensus on Consensus.” Indeed, there is one: the one plainly shown in Figure 1 by the literature surveys that use rejection as the criterion: virtual unanimity.

In an interview on March 9, 2017, incoming EPA Administrator Scott Pruitt repeated a standard denier talking point, a blatant “false fact”: “There’s tremendous disagreement about the degree of impact [of climate change]” (DiChristopher, 2017). Mr. Pruitt used this claim to justify the “need to continue the debate and continue the review and the analysis.” Is it not time that, for the sake of our grandchildren’s future, scientists and those who support science respond with one voice to say that on AGW, publishing scientists are virtually in unanimous agreement?

Appendix A

C13 ranked one of the Hansen abstracts below as “implicit endorsement” and the other as “no position.”

Global surface temperature has increased ≈ 0.2 °C per decade in the past 30 years, similar to the warming rate predicted in the 1980s in initial global climate model simulations with transient greenhouse gas changes. Warming is larger in the Western Equatorial Pacific than in the Eastern Equatorial Pacific over the past century, and we suggest that the increased West-East temperature gradient may have increased the likelihood of strong El Niños, such as those of 1983 and 1998. Comparison of measured sea surface temperatures in the Western Pacific with paleoclimate data suggests that this critical ocean region, and probably the planet as a whole, is approximately as warm now as at the Holocene maximum and within ≈ 1 °C of the maximum temperature of the past million years. We conclude that global warming of more than ≈ 1 °C, relative to 2000, will constitute “dangerous” climate change as judged from likely effects on sea level and extermination of species (Hansen et al., 2006, rated implicit endorsement by C13).

Global surface air temperature has increased about 0.5 °C from the minimum of mid-1992, a year after the Mt. Pinatubo eruption. Both a land-based surface air temperature record and a land-marine temperature index place the meteorological year 1995 at approximately the same level as 1990, previously the warmest year in the period of instrumental data. As El Niño warming was small in 1995, the solar cycle near a minimum,

and ozone depletion near record levels, the observed high temperature supports the contention of an underlying global warming trend. The pattern of Northern Hemisphere temperature change in recent decades appears to reflect a change of atmospheric dynamics (Hansen, Ruedy, Sato, & Reynolds, 1996, rated no position by C13).

Appendix B

S16 identify one potential flaw in my reasoning:

Powell assumes that making no statement is equivalent to endorsement, yet evidence from C13 contradicts this assumption: for example, Spencer et al. (2007) was rated as rejection, but five other papers by the same lead author were rated as “no position”. It is illogical to assume, as Powell does, that those papers represent endorsements.

S16 are correct that Roy Spencer has published articles on global warming that take “no position.” But I submit that he may be something of a special case in that he, together with his co-author John Christy, maintain one of the several satellite temperature records, yet both are known from ample other evidence to deny AGW. There cannot be many other authors, if indeed there are any, who provide critical data affirming AGW yet deny its existence.

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Notes

1. Anderegg et al. (2010) did not conduct an opinion poll per se, but reviewed scientific assessment reports and multisignatory statements, dividing the signatories into two groups: those “convinced by the evidence (CE) of [AGW] and those unconvinced by the evidence (UE).” I include their result in the calculation of the average consensus as determined by opinion polls. Verheggen et al. (2014) listed two results; I include only the one from Q1.
2. Literature surveys require the reviewer to make a judgment, but different reviewers can achieve similar results. C13 found 24 abstracts that explicitly reject AGW. Using the same time period and keywords, in an unpublished study (not shown), I identified 23 such abstracts. The two lists are not identical but show considerable overlap.
3. Information from the C13 study that is not directly cited comes from their Supplemental Materials: <http://iopscience.iop.org/1748-9326/8/2/024024/media>
4. C13 read the same 928 articles as Oreskes (2004) and confirmed that they contain no rejections. The figure of 11,016 for

- C13 in Table 1 is the difference between 11,944, C13's total, and those 928 articles. This avoids double counting.
- Oreskes (2004) searched for "global climate change." C13 searched for "global climate change" and "global warming." Powell (2016) and my unpublished search for 2015 added the search topic "climate change" to the C13 topics, greatly increasing the total number of articles found.
 - Reading thousands of titles and abstracts can become tiring, leading the reviewer possibly to miss or misinterpret some articles that reject AGW. But if the reviewers listed in Table 1 had missed as many rejections as they found, instead of 99.94%, the consensus would be 99.89%.

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