Consensus on consensus: a synthesis of consensus estimates on human-caused global warming

John Cook[1,2,3], Naomi Oreskes[4], Peter T. Doran[5], William R. L. Anderegg[6,7], Bart Verheggen[8], Ed W. Maibach[9], J. Stuart Carlton[10], Stephan Lewandowsky[11,2], Andrew G. Skuce[13], Sarah A. Green[12], Dana Nuccitelli[3], Peter Jacobs[9], Mark Richardson[14], Bärbel Winkler[3], Rob Painting[3], Ken Rice[15]

1 Global Change Institute, University of Queensland, Australia
2 School of Psychology, University of Western Australia, Australia
3 Skeptical Science, Brisbane, Queensland, Australia
4 Harvard University, USA
5 Geology and Geophysics, Louisiana State University, USA
6 Department of Biology, University of Utah, USA
7 Princeton Environmental Institute, Princeton University, USA
8 Amsterdam University College, The Netherlands
9 Department of Environmental Science and Policy, George Mason University, USA
10 Texas Sea Grant College Program, Texas A&M University, College Station, TX USA
11 University of Bristol, United Kingdom
12 Department of Chemistry, Michigan Technological University, USA
13 Salt Spring Consulting Ltd, Salt Spring Island, BC, Canada
14 Jet Propulsion Lab, California Institute of Technology, Pasadena, USA
15 Institute for Astronomy, University of Edinburgh, Edinburgh, UK

Abstract

The consensus that humans are causing most of recent global warming is shared by 90-98% of publishing climate scientists according to six independent studies by co-authors of this paper. Cook *et al* (2013) estimated a 97% consensus based on 11,944 abstracts of research papers, of which 4,014 took a position on the cause of recent global warming. This 97% result has been criticised for being both too high (Tol 2015) and too low (Powell 2015). In some cases, Tol assumes that when the cause of global warming is not explicitly stated ("no position"), this represents non-endorsement, while Powell assumes the opposite. Neither assumption is robust: as argued by Powell, Tol's approach would reject the consensus on well-established theories such as plate tectonics. On the other hand, Cook *et al* surveyed authors of the studies considered and some full papers rejected the consensus even when their abstracts were classified as "no position", contradicting Powell's assumption. The author survey (N=2,412 papers) also resulted in a 97% consensus. Tol further asserts that Cook *et al* is "at the high end in the consensus literature" by comparing its results with surveys of non-experts such as

economic geologists and a self-selected group of those who reject the consensus with no requirement for relevant expertise. Tol's selected surveys show that consensus increases with relevant expertise: we conclude that the finding of 97% consensus in published climate research is robust and consistent with other surveys of climate scientists and peer-reviewed studies.

1. Introduction

Scientists overwhelmingly agree that humans are causing global warming. The consensus position is articulated by the Intergovernmental Panel on Climate Change (IPCC) statement that "human influence has been the dominant cause of the observed warming since the mid-20th century" (Qin *et al* 2014, p. 17). The National Academies of Science from 80 countries have issued statements endorsing the consensus position (Table S2). Nevertheless, the existence of the consensus continues to be questioned. Here we summarize studies that quantify expert views and examine common flaws in criticisms of consensus estimates. In particular, we are responding to comments by Tol (2015) and Powell (2015) on Cook *et al* (2013, referred to as C13). We show that contrary to Tol's claim that the results of C13 differ from earlier studies, the consensus of experts is robust across all the studies conducted by coauthors of this correspondence.

Tol's erroneous conclusions stem from conflating the opinions of non-experts with those of publishing climate scientists and assuming that lack of affirmation equals dissent. Powell, in contrast, assumes that lack of dissent equals affirmation, so instead estimates a consensus of 99.9%. This assumption is not obviously invalid, but it is not supported by the data. C13 compared abstract ratings with the ratings of full papers by the papers' authors and found that some papers that reject the consensus have abstracts classified as taking no position, in contradiction to Powell's assumption. The self-rating data support a literature consensus of 97%, an important aspect of C13 that most criticisms fail to consider.

A detailed technical response to Tol is provided in (S1) and to Powell in (S2). The remainder of this paper shows that a high level of scientific consensus, in agreement with our results, is a robust finding in the scientific literature. This is used to illustrate and address the issues raised by Tol and Powell that are relevant to our main conclusion.

2. Assessing Expert Consensus

Efforts to measure scientific consensus need to identify a relevant and representative population of experts, assess their professional opinion in an appropriate manner, and avoid distortions from ambiguous elements in the sample. Approaches that have been employed to assess expert views on anthropogenic global warming (AGW) include analysing peer-reviewed climate papers (Oreskes 2004; C13), surveying members of the relevant scientific community (Bray and von Storch 2007; Doran and Zimmerman 2009; Bray, 2010; Rosenberg *et al* 2010; Farnsworth and Lichter 2012; Verheggen *et al* 2014; Stenhouse *et al* 2014; Carlton *et al* 2015), compiling public statements by scientists (Anderegg *et al* 2010), and mathematical analyses of citation

patterns (Shwed and Bearman 2010). We define domain experts as scientists who have published peer-reviewed climate research. Consensus estimates for these experts are listed in Table 1, with the range of estimates resulting primarily from differences in selection of the expert pool, the definition of what entails the consensus position and differences in treatment of no position responses/papers.

Table 1: Estimates of Consensus on Human-Caused Global Warming among Climate Experts

Source	Year(s)	Total sample (including non-publishing climatologists)			Sub-sample of publishing climatologists			Definition of consensus
		Consensus	N	Description	Consensus	N	Description	
Gallup 1991	1991	66%	400	AMS/AGU members	67%	97	Currently Performing Research in Area Global Warming	Human-induced greenhouse warming is now occurring
Oreskes 2004	1993-2003				100%	928	Peer-reviewed papers on "global climate change"	Earth's climate is being affected by human activities [M]ost of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations
Bray and von Storch 2007	1996	40%	539	1997: 5 countries (US, Canada, Germany, Denmark, Italy)				Climate change is mostly the result of anthropogenic causes
Bray and von Storch 2007	2003	53%	530	2003: 30 countries				Climate change is mostly the result of anthropogenic causes
Doran and Zimmerman 2009	2009	82%	3146	Earth scientists	97%	77	Climatologists who are active publishers of climate research	Human activity is a significant contributing factor in changing mean global temperatures
Anderegg *et al* 2010	2010	66%	1372	Signatories of public statements about climate change	97%	200	Top 200 most published authors (of climate-related papers)	Anthropogenic greenhouse gases have been responsible for "most" of the "unequivocal" warming of the Earth's average global temperature over the second half of the 20th century
Bray 2010	2008				83.5%	370	Authors of climate journals, authors from Oreskes 2004 sample, scientists from relevant institutes (NCAR, AMS, etc)	How convinced are you that most of recent or near future climate change is, or will be, a result of anthropogenic causes?
Rosenberg *et al* 2010	2005				88.5%	433	U.S. climate scientists authoring articles in scientific journals that highlight climate change research	Scientists can say with great certainty that human activities are accelerating global warming
Farnsworth and Lichter 2012	2007	84%	489	AMS/AGU members				In your opinion, is human-induced greenhouse warming now occurring?
Cook *et al* 2013	1991-2011				97.1% 97.2%	4104 abstracts 1381 self-rated	Published peer-reviewed papers on "global climate change" or "global warming" that state a position on AGW	1. Explicitly states that humans are the primary cause of recent global warming 2. Explicitly states humans are causing global warming 3. Implies humans are causing global

						papers		warming. 4a. Does not address or mention the cause of global warming 4b. Expresses position that human's role on recent global warming is uncertain/undefined 5. Implies humans have had a minimal impact on global warming without saying so explicitly 6. Explicitly minimizes or rejects that humans are causing global warming 7. Explicitly states that humans are causing less than half of global warming
Stenhouse *et al* 2014	2013	73%	1821	AMS members	93%	124	Self-reported expertise is climate science, publication focus is mostly climate	Humans are a contributing cause of global warming over the past 150 years
Verheggen *et al* 2014	2012	84% 86%	1461 (Q1) 1682 (Q3)		89% (Q1) 91% (Q3)	623 (Q1) 729 (Q3)	Published more than 10 climate-related papers (self-reported)	Q1. Over half of global warming since the mid-20th century can be attributed to human-induced increases in atmospheric GHG concentrations Q3. Greenhouse gases have made the strongest or tied-strongest contribution (out of different factors considered) to the reported global warming of □ 0.8° C since preindustrial times
Pew Research Center 2015	2015	87%	3748	AAAS members	93%	132	Working Ph.D Earth scientist	Climate change is mostly due to human activity
Powell 2015	2013-2014				99.9%	69,406	Published peer-reviewed papers on "global climate change" or "global warming"	Doesn't explicitly reject AGW in abstract
Carlton *et al* 2015	2014	91.9%	698	Survey of biophysical scientists across disciplines at universities in the Big 10 Conference	96.7%	306	Those who indicated that "The majority of my research concerns climate change or the impacts of climate change."	Response to the following: (1) When compared with pre-1800's levels, do you think that mean global temperatures have generally risen, fallen, or remained relatively constant, and (2) Do you think human activity is a signi cant contributing factor in changing mean global temperatures?

The studies in Table 1 have taken various approaches to selecting and querying pools of experts. Oreskes (2004) identified expressions of views on AGW in the form of peer-reviewed papers on "global climate change". This analysis found no papers rejecting AGW in a sample of 928 papers published from 1993 to 2003, that is, 100% consensus among papers stating a position on AGW.

Following a similar methodology, C13 analysed the abstracts of 11,944 peer-reviewed papers published between 1991 and 2011 that matched the search terms "global climate change" or "global warming" in the ISI Web of Science search engine. Among the 4,014 abstracts stating a position on human-caused global warming, 97.1% were judged as having implicitly or explicitly endorsed the consensus. In addition, the authors of the papers were invited to rate their own papers (N=2,142), based on the full paper, not just the abstract.. Amongst 1,381 papers self-

rated by their authors as stating a position on human-caused global warming, 97.2% endorsed the consensus.

Shwed and Bearman (2010) employed citation analysis of 9,432 papers on global warming and climate published from 1975 to 2008. Unlike surveys or classifications of abstracts, this method is entirely mathematical and blind to the content of the literature being examined. By determining the modularity of citation networks, they concluded, “Our results reject the claim of inconclusive science on climate change and identify the emergence of consensus earlier than previously thought” (p. 831). Although this method does not produce a numerical consensus value, it independently demonstrates the same level of scientific consensus on AGW as exists for the fact that smoking causes cancer.

Anderegg *et al* (2010) identified climate experts as those who had authored at least 20 climate-related publications and chose their sample from those who had signed public statements regarding climate change. By combining published scientific papers and public statements, Anderegg *et al* determined that 97 to 98% of the 200 most published climate scientists endorsed the IPCC conclusions on AGW.

Other studies have directly queried scientists, typically choosing a sample of scientists and identifying subsamples of those who self-identify as climate scientists or actively publish in the field. Doran and Zimmerman (2009) surveyed 3,146 Earth scientists, asking whether “human activity is a significant contributing factor in changing mean global temperatures,” and subsampled those who were actively publishing climate scientists. Overall, they found that 82% of Earth scientists indicated agreement, while among the subset with greatest expertise in climate science, the agreement was 97.4%.

Bray and von Storch (2007) and Bray (2010) repeatedly surveyed different populations of climate scientists in 1996, 2003 and 2008. The questions did not specify a time period for climate change (indeed, in 2008, 36% of the participants defined the term "climate change" to refer to “changes in climate at any time for whatever reason”). Therefore the reported consensus estimates of 40% (1996) and 53% (2003) (which included participants not stating a view on AGW) suffered from both poor control of expert selection and ambiguous questions. Their 2008 study, finding 83% agreement, had a more robust sample selection and a more specific definition of the consensus position on attribution.

Verheggen *et al* (2014) surveyed 1,868 scientists, drawn in part from a public repository of climate scientists (the same source as was used by Anderegg *et al*), and from scientists listed in C13, supplemented by authors of recent climate-related articles and with particular effort expended to include signatories of public statements critical of mainstream climate science. 85% of all respondents (which included a likely overrepresentation of contrarian non-scientists) who stated a position agreed that anthropogenic greenhouse gases (GHGs) are the dominant driver of recent global warming. Among respondents who reported having authored more than 10 peer-reviewed climate-related publications, around 90% agreed that greenhouse gas emissions were causing most of global warming.

Stenhouse *et al* (2014) collected responses from 1,854 members of the American Meteorological Society (AMS). Among members whose area of expertise was climate science, with a publication focus on climate, 78% agreed that the cause of global warming over the past 150 years was mostly human, with an additional 10% (for a total of 88%) indicating the warming was caused equally by human activities and natural causes. An additional 6% answered "I do not believe we know enough to determine the degree of human causation." To make a more precise comparison with the Doran and Zimmerman findings, these respondents were emailed one additional survey question to ascertain if they thought human activity had contributed to the global warming that has occurred over the past 150 years; of the 6% who received this question, 5% indicated there had been some human contribution to the warming. Thus, Stenhouse *et al* (2014) concluded that "93% of actively publishing climate scientists indicated they are convinced that humans have contributed to global warming".

Carlton *et al* (2015) adapted questions from Doran and Zimmerman (2009) to survey 698 scientists across disciplines, finding that 91.9% of them agreed that (1) mean global temperatures have generally risen compared with pre-1800's levels and that (2) human activity is a significant contributing factor in changing mean global temperatures. Among the 306 who indicated that "the majority of my research concerns climate change or the impacts of climate change", there was 96.7% consensus on the existence of AGW.

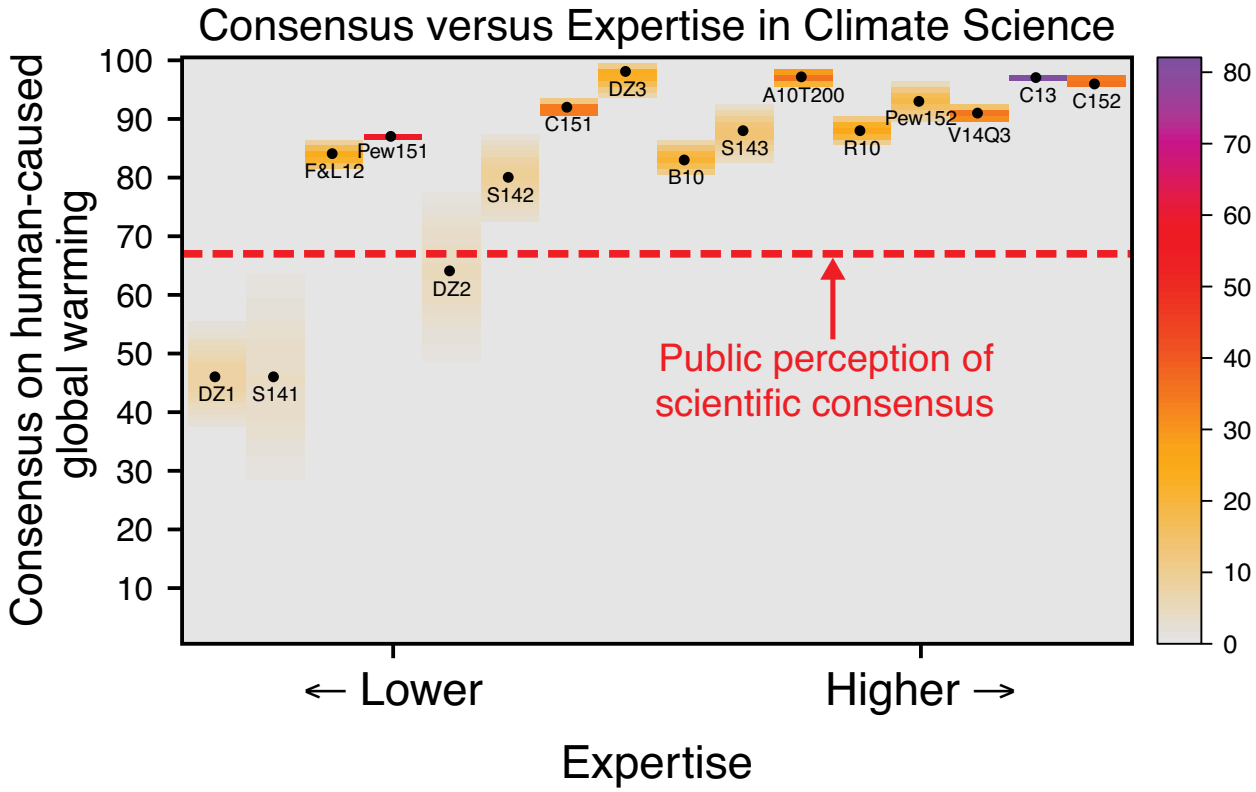

Figure 1: Level of consensus on AGW versus expertise across different studies. Dashed red line represents mean public perception of scientific consensus (67%) from Leiserowitz *et al* (2015).

Right colour bar indicates posterior density of Bayesian 99% credible intervals. Only consensus estimates obtained over the last 10 years are included (see S3 for further details and tabulation of acronyms).

The Pew Research Center (2015) conducted a detailed survey of 3,748 members of the American Association for the Advancement of Science (AAAS) to assess views on several key science topics. Across this group, 87% agreed that “Earth is warming due mostly to human activity”. Among a subset of working Ph.D. Earth scientists, 93% agreed with this statement.

Despite the diversity of sampling techniques and approaches, a consistent picture of an overwhelming consensus among experts on anthropogenic climate change has emerged from these studies. Another recurring finding is that higher scientific agreement is associated with higher levels of expertise in climate science (Anderegg 2010; Doran and Zimmerman 2009; Oreskes, 2004; Verheggen *et al* 2014).

2. Interpreting Consensus Data

How can vastly different interpretations of consensus arise? A significant contributor to variation in consensus estimates is the conflation of *general* scientific opinion with *expert* scientific opinion. Figure 1 demonstrates that consensus estimates are highly sensitive to the expertise of the sampled group. An accurate estimate of scientific consensus reflects the level of agreement among experts in climate science; that is, scientists publishing peer-reviewed research on climate change. As shown in Table 1, low estimates of consensus arise from samples that include non-experts such as scientists (or non-scientists) who are not actively publishing climate research, while samples of experts are consistent in showing overwhelming consensus.

Tol (2015) reports consensus estimates ranging from 7% to 100% from the same studies described above. His broad range is due to sub-groupings of scientists with different levels of expertise. For example, the sub-sample with 7% agreement was selected from those expressing an “unconvinced” position on AGW (Verheggen *et al* 2014). This selection criteria does not provide a valid estimate of consensus for two reasons: firstly, this subsample was selected based on opinion on climate change, predetermining the level of estimated consensus. Secondly, this does not constitute a sample of experts as non-experts were intentionally included. Anderegg (2010) found that nearly a third of the unconvinced group lacked a Ph.D., and only a tiny fraction had a Ph.D. in a climate-relevant discipline. Indeed, eliminating less published scientists from both these samples resulted in consensus values of 90% and 97–98% for Verheggen *et al* (2014) and Anderegg *et al* (2010), respectively. Tol’s (2015) conflation of unrepresentative non-expert sub-samples and samples of climate experts is a misrepresentation of the results of previous studies, including those published by a number of coauthors of this paper.

In addition to varying criteria for expertise, consensus estimates may vary based on their approach to studies or survey responses that do not state an explicit position on AGW. Taking a conservative approach, C13 omitted abstracts that did not state a position on AGW to derive

their consensus estimate of 97%, a value shown to be robust when compared with the subsample of author responses. In contrast, in one analysis, Tol (2015) effectively treats no-position abstracts as rejecting AGW, thereby deriving consensus values less than 35%. Equating no-position papers with rejection or an uncertain position on AGW is inconsistent with the expectation of decreasing reference to a consensual position as that consensus strengthens (Oreskes 2007; Shwed and Bearman 2010). Indeed, Powell (2015) shows that applying Tol's method to the established paradigm of plate tectonics would lead Tol to reject the scientific consensus of that field because nearly all current papers would be classified as taking 'no position'.

Conversely, Powell (2015) assumed that all no-position papers implicitly endorsed AGW. This assumption leads to a 99.9% consensus from essentially the same data as C13. Given the expectation that a strengthening consensus should lead to more no-position papers, this assumption is not unreasonable. However, we consider it an overreach because in the self-rating survey, a small number of no-position abstracts in C13 were rated as rejecting AGW by the papers' authors. Furthermore, some authors published a mixture of "rejection" and "no position" papers and their "no position" papers should not be assumed to be endorsements. Powell (2015) also neglects to consider implicit rejections of AGW, which constitute a larger number of papers than explicit rejections in his analysis. We consider a more robust quantitative measure of the state of scientific debate on AGW is derived from abstracts that explicitly or implicitly stated a position on AGW. However, given that among the no-position abstracts in C13, only a small number were rated as rejecting AGW by the papers' authors, we agree with Powell that many of these papers were written by authors who likely do accept the consensus position. Therefore, it is reasonable to characterise the 97% consensus of C13 as a lower bound estimate of the consensus in the literature.

3. Conclusion

We have shown that the scientific consensus on AGW is robust, with a range of 90-97% depending on the exact question, timing and sampling methodology. This is supported by a number of independent studies despite variations in the study timing, definition of consensus, or differences in methodology including surveys of scientists, analyses of literature or of citation networks. Tol (2015) and Powell (2015) obtain lower and higher consensus estimates, respectively, through inappropriate methodology, such as conflating non-expert and expert views and/or making unsupported assumptions about sources that do not specifically state a position about the consensus view.

An accurate understanding of scientific consensus, and the ability to recognize attempts to undermine it, are important for public climate literacy. Public perception of the scientific consensus has been found to be a gateway belief, affecting other climate beliefs and attitudes including policy support (Ding *et al* 2011, McCright and Dunlap 2013; van der Linden *et al* 2015). However, many in the public, particularly in the US, still believe scientists disagree to a large extent about AGW (Leiserowitz *et al* 2015), and many political leaders, again particularly

in the US, insist that this is so. Leiserowitz et al (2015) found that only 12% of the U.S. public accurately estimate the consensus at 91-100%.

Manufacturing doubt about the scientific consensus on climate change is one of the most effective means of reducing acceptance of climate change and support for mitigation policies (Oreskes 2010; van der Linden *et al* under review). Therefore it should come as no surprise that the most common argument used in contrarian op-eds about climate change from 2007 to 2010 was that there was no consensus (Elsasser and Dunlap 2012; Oreskes and Conway 2011).

Consequently, it is important that scientists communicate the overwhelming expert consensus on AGW to the public (Maibach *et al* 2014; Cook and Jacobs 2014). Explaining the 97% consensus has been observed to increase acceptance of climate change (Lewandowsky *et al* 2012; Cook and Lewandowsky in press) with the greatest change among conservatives (Kotcher *et al* 2014).

From a broader perspective, it doesn't matter if the consensus number is 90%, 97% or 99.9%. The level of scientific agreement on AGW is overwhelmingly high because the evidence is overwhelmingly strong.

Acknowledgements

We thank James Powell and Richard Tol for their comments on C13. Thanks to Neal J. King and Robert Way for helpful comments on this note.

References

Anderegg, W. R. L., Prall, J. W., Harold, J., & Schneider, S. H. (2010). Expert credibility in climate change. *Proceedings of the National Academy of Sciences of the United States of America*, 107, 12107-12109.

Anderegg, W. R. (2010). Moving beyond scientific agreement. *Climatic Change*, *101*(3), 331-337.

Bray, D., & von Storch, H. (2007). The perspectives of climate scientists on global climate change, http://pubman.mpdl.mpg.de/pubman/item/escidoc:2034479/component/escidoc:2034480/gkss_2007_11.pdf, Accessed 21 Sep 2015.

Bray, D (2010) The scientific consensus of climate change revisited. *Environmental Science & Policy, 13*, 340-350. doi: 10.1016/j.envsci.2010.04.001.

Carlton, J. S., Perry-Hill, R., Huber, M., & Prokopy, L. S. (2015). The climate change consensus extends beyond climate scientists. *Environmental Research Letters, 10*(9), 094025.

Cook, J., Nuccitelli, D., Green, S.A., Richardson, M., Winkler, B., Painting, R., Way, R., Jacobs, P., & Skuce, A. (2013). Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters*, 8(2), 024024+.

Cook, J., & Jacobs, P. (2014). Scientists are from Mars, Laypeople are from Venus: An Evidence-Based Rationale for Communicating the Consensus on Climate. *Reports of the National Center for Science Education*, 34(6). http://dx.doi.org/10.6084/m9.figshare.1534562

Cook, J. & Lewandowsky, S. (in press). Rational Irrationality: Modeling Climate Change Belief Polarization Using Bayesian Networks. *Topics in Cognitive Science*.

Ding D, Maibach EW, Zhao X, Roser-Renouf C, Leiserowitz A (2011) Support for climate policy and societal action are linked to perceptions about scientific agreement. *Nat Clim Chang* 1:462–466.

Doran, P., & Zimmerman, M. (2009). Examining the scientific consensus on climate change. *Eos*, Transactions American Geophysical Union, 90, 22.

Elsasser, S. W., & Dunlap, R. E. (2012). Leading voices in the denier choir: Conservative columnists' dismissal of global warming and denigration of climate science. *American Behavioral Scientist*, 0002764212469800.

Farnsworth, S. J., & Lichter, S. R. (2012). The structure of scientific opinion on climate change. *International Journal of Public Opinion Research*, *24*(1), 93-103.

Kotcher, J., Meyers, T., Maibach. E., Leiserowitz, A. (2014). Correcting misperceptions about the scientific consensus on climate change: Exploring the role of providing an explanation for the erroneous belief. Accepted for presentation at the 2014 annual conference of the International Communication Association.

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Rosenthal, S. (2015). Climate Change in the American Mind: October 2015. New Haven, CT: Yale Project on Climate Change Communication. http://climatechangecommunication.org/sites/default/files/reports/Climate-Change-American-Mind-October-2015_0.pdf

Lewandowsky, S., Gilles, G. & Vaughan, S. (2012). The pivotal role of perceived scientific consensus in acceptance of science. *Nature Climate Change*. 10.1038/10.1038/NCLIMATE1720.

Maibach, E., Myers, T., & Leiserowitz, A. (2014). Climate scientists need to set the record straight: There is a scientific consensus that human□caused climate change is happening. *Earth's Future*, 2(5), 295-298.

McCright, A. M., Dunlap, R. E., & Xiao, C. (2013). Perceived scientific agreement and support for government action on climate change in the USA. *Climatic Change*, *119*(2), 511-518.

McGuire, W. J., & Papageorgis, D. (1961). The relative efficacy of various types of prior belief-defense in producing immunity against persuasion. *Public Opinion Quarterly, 26*, 24-34.

Nixon, R. (1995). Limbaughesque Science. *FAIR*. Available at http://fair.org/extra-online-articles/limbaughesque-science/

Oreskes N. (2004) Beyond the ivory tower. The scientific consensus on climate change. *Science*, 306:1686.

Oreskes, N. (2007) The Scientific Consensus on Climate Change: How Do We Know We're Not Wrong? *Climate Change: What It Means for Us, Our Children, and Our Grandchildren*, MIT Press.

Oreskes, N. (2010). "My facts are better than your facts: Spreading good news about global warming." in *How Well Do Facts Travel?* Edited by Mary S. Morgan and Peter Howlett, Cambridge University Press, pp. 135-166.

Oreskes, N., & Conway, E. M. (2011). *Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. Bloomsbury Publishing USA.

Pew Research Center (2015). An elaboration of AAAS Scientists' views. Available at http://www.pewinternet.org/files/2015/07/Report-AAAS-Members-Elaboration_FINAL.pdf

Powell, J. (in press). Comment on "Quantifying the consensus on anthropogenic global warming in the scientific literature". *Environmental Research Letters*.

Rosenberg, S., Vedlitz, A., Cowman, D. F., & Zahran, S. (2010). Climate change: a profile of US climate scientists' perspectives. *Climatic Change*, *101*(3-4), 311-329.

Qin, D., Plattner, G. K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., & Midgley, P. M. (2014). *Climate change 2013: The physical science basis*. T. Stocker (Ed.). Cambridge, UK, and New York: Cambridge University Press.

Shwed, U., & Bearman, P. S. (2010). The temporal structure of scientific consensus formation. *American Sociological Review*, 75(6), 817-840.

Stenhouse, N., Maibach, E., Cobb, S., Ban, R., Bleistein, A., Croft, P., Bierly, E., Seitter, K., Rasmussen, G., & Leiserowitz, A. (2014). Meteorologists' Views About Global Warming: A Survey of American Meteorological Society Professional Members. *Bulletin of the American Meteorological Society, 95*(7), 1029-1040.

Tol, R. (2015). Comment on 'Quantifying the consensus on anthropogenic global warming in the scientific literature'. *Environmental Research Letters*. In press.

Van der Linden, S., Leiserowitz, A. A., Feinberg, G. D., & Maibach, E. W. (2015). The scientific consensus on climate change as a gateway belief: Experimental evidence. *PloS one*, *10*(2), e0118489.

Van der Linden, S. L., Leiserowitz, A. A., Rosenthal, S. A., Feinberg, G. D. & Maibach, E. W. (under review). Inoculating the Public against Misinformation about Climate Change.

Verheggen, B., Strengers, B., Cook, J., van Dorland, R., Vringer, K., Peters, J., Visser, H. & Meyer, L. (2014). Scientists' views about attribution of global warming. *Environmental science & technology*, 48(16), 8963-8971.

Footnotes

1. https://andthentheresphysics.wordpress.com/2013/06/10/richard-tols-fourth-draft/#comment-822

Supplemental Information

S1. Detailed Response to Tol (2015)

S1.1 Contrasting Cook *et al* (2013, or C13) with other consensus estimates

Tol claims that *"[a]s Cook et al. have a sample that is so much larger than in other studies, you would expect its results to lie towards the centre of earlier results."* However, this claim is spurious because the spread of consensus estimates from Tol (2015) are derived from samples with differing levels of expertise. As established in multiple studies, higher levels of consensus on anthropogenic global warming (AGW) are associated with higher levels of expertise in climate science (Doran and Zimmermann 2009; Anderegg *et al* 2010; Verheggen *et al* 2014; Carlton *et al* 2015)

Most of these studies take the approach that the level of consensus is estimated as a fraction of those papers or respondents who actually staked out a position pro or contra the consensus. Tol on the other hand calculated the level of consensus as a fraction of all papers or respondents in the sample, including those who did not take a position. Unsurprisingly, as a fraction of all papers on climate change, those with a stated position in agreement with AGW is low. That doesn't mean that the level of agreement among those papers is similarly low. That is one of the key mistakes made by Richard Tol in his re-analysis of various studies.

Tol also includes many subsamples in his reanalysis, irrespective of how representative they are of the relevant scientific community for which he attempts to quantify the level of consensus. Some of these subsample are not in the least representative of such. For example, both Anderegg *et al* and Verheggen *et al* included a sizeable number of outspoken contrarians in their initial sample, approximately half of whom are not publishing climate scientists. They were included on the basis of having signed public declarations critical of mainstream climate science. Verheggen *et al* reported the results for this particular subgroup, and unsurprisingly the level of consensus among these known contrarians was very low. Surprisingly, a small fraction of them actually agreed with the rather strict definition of the consensus position. However, the low level of agreement amongst this group is not a credible estimate of the scientific consensus on climate change, since the group was selected on the basis of disagreement with mainstream climate science; a form of 'begging the question'. Despite this group's inherent bias, Tol claims that it is a representative estimate and puts it on par with the consensus among the most published climate scientists. This invalidates his argument that C13, with the largest sample, should lie towards the centre of earlier results, since some of what Tol calls "earlier results" are based on samples entirely inconsistent with the sample analysed by C13.

S1.2 Rater independence

Four of the five specific bulleted criticisms of C13 in Tol (2015) concern the rating process. This tactic diverts attention from the abstracts, which are invariant and can be reassessed by anyone at any time (an interactive feature inviting people to replicate the abstract ratings of C13 is available online[1]). Instead Tol focuses on the notion that raters could have colluded with one another or otherwise failed to observe the agreed upon procedures. This argument fails to recognise that C13 was a survey of the abstracts, not a survey of the raters. The raters were simply a mechanism for determining a rating for the abstracts in the survey. Procedures were put in place to try to ensure that individual ratings were independent, and that the final rating was a reasonable representation of an abstract's position with respect to AGW.

Ultimately, however, all the ratings are available online[2] and anyone can check how an abstract was rated. It is also quite possible for anyone to redo the entire analysis in a similar, or a different, way. It is noteworthy that the closest attempt to replicate our analysis has been conducted by Powell (2015).

Tol (2015) claimed that individual ratings could have been released without revealing the identities of raters. However, Tol published instructions on how to identify raters from anonymised data using stolen private correspondence[3] and has publicly identified raters on several occasions[4,5].

Tol (2015) questions what procedures were adopted to prevent communication between raters. Although collusion was technically possible, it was - in practice - virtually impossible. The rating procedure was designed so that each rater was assigned 5 abstracts selected at random from a set of more than 12,000. Consequently, the probability two raters being assigned the same abstract at the same time was infinitesimal making collusion practically impossible. Consequently, the procedure put into place to prevent two raters from colluding on the rating of a single abstract was the infinitesimal probability of both raters being assigned the same abstract at the same time from a pool of 12,000+ abstracts.

Raters had access to a private discussion forum which was used to design the study, distribute rating guidelines and organise analysis and writing of the paper. As stated in C13: "some subjectivity is inherent in the abstract rating process. While criteria for determining ratings were defined prior to the rating period, some clarifications and amendments were required as specific situations presented themselves". These "specific situations" were raised in the forum. A manual search of this forum found content from 32 abstracts consisting of 7 endorsements, 12 no position and 13 rejections, some of which were provided as examples to raters to help with abstract classification. While some discussion may have been missed in this manual search, we are able to identify potential cross-discussion of 0.26% of the sample. Excluding these papers results in an estimated consensus of 97.4%.

After each paper had been rated twice by independent raters, if there was a disagreement in the consensus rating or category of the paper (e.g. mitigation, impacts), then as stated in C13:

"[r]aters were then allowed to compare and justify or update their rating through the web system, while maintaining anonymity". At this stage, raters were able to communicate (which was the entire point of this stage of the rating process). However, we can assess the effect on calculated consensus by comparing the consensus among initial ratings (prior to the comparison step) and among final ratings. Among initial ratings the consensus was 96.7% and among final ratings 97.1%.

For raters who provided more than 500 ratings (N=13), individual rater consensus ranged from 95.7-98.2% in initial ratings and 96.2-97.8% in final ratings. Inter-rater variability could potentially affect reported consensus by up to 1.4%.

Furthermore, rater consistency was assessed by observing the statistics of the time series of ratings. Using moving windows of ratings (N=50, 100 or 500) and calculating consensus within these subsamples, it was previously shown in Cook *et al* (2014) that there was no significant drift in calculated consensus or notable exceedance of bootstrapped confidence intervals in initial ratings. There is no evidence of a significant effect from inter-rater differences or from communication between raters.

S1.3 Additional information

During the rating process of C13, raters were presented only with the paper title and abstract to base their rating on. Tol (2015) queries what steps were taken to prevent raters from gathering additional information. While there was no practical way of preventing such an outcome, raters conducted further investigation by perusing the full paper on only a few occasions, usually to clarify ambiguous abstract language. To mitigate the influence of any single rating, each abstract was rated twice. Given the negligible proportion of original ratings falling under this situation, further mitigated by the process of "double checking" all ratings, this occurrence could have had only a negligible effect on the final consensus estimate.

S1.4. Quantity of abstracts

Tol (2015) claimed that Cook *et al*'s *"supporting data show that there were 12,876 abstracts"*. This claim is false, displaying a misunderstanding of the data. The number is based on the unique identifiers in the database derived from an auto-incrementing MySQL database[6]. As papers were added to the database, each entry was tagged with an identifier where the number itself has no meaning other than to be used as a unique identifier. During the process of importing entries into the database, some papers were accidentally added twice and subsequently duplicate entries were deleted. This explains the "gaps" in the sequence of unique identifiers. The final unique identifiers, and the highest assigned unique identifier (12,876) therefore has no relevance to the number of abstracts in the analysis of C13. The implication in Tol (2015) that abstracts were in some way hidden is based on over-interpretation of essentially meaningless numbers.

Tol (2015) also argues that "[a] later query returned 13,458, only 27 of which were added after Cook ran his query. The paper is silent on these discrepancies." *However, Tol (2014) argues that "[r]estricting the search to the Science Citation Index yields 12,308 papers."* If Tol included the Social Science index in his search, this would result in a larger sample size than that of Cook *et al* (2013). Indeed, these databases and search algorithms are dynamic.

S1.5. Rating accessibility

Tol (2015) argues that *"Cook et al. (2013) do not make clear what steps were taken to ensure that those who rated abstracts in the second and third periods did not have access to the results of the first and second periods"*. The event that separated the first and second rating periods was the hacking of the private website hosting the rating system, which forced relocation to a new web server. Therefore the only thing that distinguished the first and second rating periods was that one was before and the other after the hacking event. The third rating period involved classification of 1000 randomly selected "no position" abstracts into either abstracts stating no position on AGW or stating an uncertain position on AGW – by definition, the raters during the third period had access to the fact that the relevant abstracts had been categorised as "no position". Consequently, this objection has no relevance to the integrity of the abstract ratings.

S2. Detailed Response to Powell (2015)

S2.1. Consensus definition and methodology.

Powell (2015) argues that C13 redefined the meaning of "consensus" and, because of this, their methodology underestimated the degree of consensus in the scientific literature. Broadly speaking, we concur with the various definitions of scientific "consensus" proposed by Powell. Consensus need not require unanimity, nor can it be taken to imply immutable truth. C13 did not attempt to directly evaluate the expert assessment of climate scientists, but rather the judgments expressed in specific abstracts and papers in the peer-reviewed scientific literature. To that end, when evaluating an abstract, only the words on the page were considered. If there was no explicit or implicit linkage to human causes, then the abstract was categorized as expressing "no position" with regard to AGW. Contrary to Powell's claim, this methodology did not involve a redefinition of the word *consensus*, but simply required written evidence that an abstract expressed a position on AGW.

It is true that the sentence: "Among abstracts expressing a position on AGW, 97.1% endorsed the consensus position that humans are causing global warming", has sometimes been simplified to something like "97% of climate scientists agree that humans are causing global warming". This paraphrasing is inexact if referring only to the results of C13. However, in the context of other studies of consensus, for example, Doran and Zimmerman (2009) and Anderegg *et al* (2010), such a statement is well-supported. Certainly, it is not the result of any redefinition of the word *consensus*, as Powell claims.

S2.2. Consensus quantification in plate tectonics

Powell (2015) argues that applying a similar methodology to the one we used to the investigation of the degree of consensus of other well-accepted scientific models, such as plate tectonics, would yield misleading results. We agree with Powell's observation that there are very few papers published in the peer-reviewed geological literature in the past few decades that reject the ruling paradigm of plate tectonics. We also would expect, as Powell found in his investigation of 500 geological abstracts, that modern geologists rarely deem it necessary to endorse the global tectonic model explicitly. This is especially true in the abstract of a paper, where space is limited and is typically reserved for reporting novel results and an outline description of methods used.

Powell's study of recent articles on plate tectonics provides further evidence in favour of the hypothesis that a growing consensus over a specific question results in a reduced emphasis on that question (Oreskes 2007; Shwed and Bearman 2010). C13 found a growing fraction of abstracts took no position on attribution of global warming, consistent with a growing consensus. Indeed, among those that did take a position, they found a continuing increase in the consensus, reaching approximately 98% by 2011.

However, plate tectonics has been uncontroversial since the 1970s (Oreskes, 1999) whereas strengthening attribution statements about climate change have been made since 1990. The C13 study period covers a time during which there was an acceleration in research on the fundamentals of AGW and as such finds a sample size of several thousand examples of abstracts that express an endorsement or rejection, versus the much smaller sample size found by Powell for a theory that has been established for a longer period of time.

We do not accept Powell's assertion that the C13 methodology, if applied to the recent peer-reviewed literature on issues such as plate tectonics, would give a "meaningless 100%" result. Research questions that have been settled for many decades generate a diminishing number of papers that state a position either in favor or opposed to the consensus. We would expect that, applying our method to plate tectonics, we would today find few explicit endorsements of the entire model, although implicit endorsements—in which essential elements of the theory (e.g., seafloor spreading, subduction zones and transform faults) are uncritically referred to as matters of fact—would be more common.

Powell demonstrates decisively that "no position" abstracts do not necessarily mean that there is no consensus, and may well be a sign of an extremely strong consensus. However, the basis of his criticism of our work is that the true distribution of scientists or studies that C13 report as "no position" based on the abstract is significantly different than those that adopt a position in the abstract. The root of the disagreement between the estimates of Powell (2015) and C13 is that Powell assumes a 100% consensus among "no position" abstracts, whereas we make no such assumption. Powell also does not count "implicit rejections"

S2.3. The "no position" abstracts

Powell states: *"…it goes without saying that no climate scientist publishing today could truly have 'no position' on AGW."* This assertion conflicts with survey data. For example, Verheggen *et al* (2014) asked "How would you characterize the contribution of the following factors to the reported global warming of ~0.8 degrees C since pre-industrial times?" (question 3). Out of 1747 respondents 65 (amounting to 3.7%) answered "I do not know" or "it is unknown". All others chose one of the qualitative answer options describing the degree of warming or cooling (the precise answer options were strong cooling - moderate cooling - slight cooling - insignificant - slight warming - moderate warming - strong warming - it is unknown - I do not know). Note that question 1 in this same survey had a highly inflated number of "I don't know" and "unknown" responses, presumably due to the level of specificity that the answer options required (e.g. "51-75% quantitative GHG contribution"). Also in other opinion surveys that allow for an undetermined answer option such as "I'm not sure", such a response is given by a few percent of the scientists asked (e.g. Doran and Zimmermann 2009). It is debatable whether some of these "unsure" or "I don't know" responses indicate that the respondent in question truly does not have a position on AGW, or alternatively that the respondent was not sure how to interpret the question or the answer option provided. The former of these two explanations can not be ruled out however. Based on survey data, it is plausible that a few percent of climate scientists indeed are agnostic regarding AGW.

In any case, C13 was focused on assessing the opinions expressed in specific examples in the scientific literature, not the general opinions of climate scientists. Part of the study involved inviting 8,547 authors of the published papers to categorise their own research. In all, 1,200 authors evaluated 2,412 papers, and 35.5% of these self-reported that their papers expressed no position on AGW, demonstrating that our method of abstract assessment underestimates the proportion of full papers that take a position, as suggested by Powell.

We use the relationship between abstract and full paper ratings determined from the self ratings sample to infer the full paper ratings for the whole sample. Constructing a vector **a** whose 7 elements are the number of abstracts reported with each level of endorsement, and a vector **f** whose 7 elements are the number of full papers with each level of endorsement, we can relate the two via:

$$\mathbf{f} = \mathbf{P}(f|a)\mathbf{a}$$

Where $\mathbf{P}(f|a)$ is a 7x7 matrix whose elements are the conditional probability that a paper has a full paper endorsement score of f and an abstract rating of a. We estimate $\mathbf{P}(f|a)$ from the self-rated subsample and apply this to the full abstract distribution. This implies that the number of full papers that would be assessed as no position is much smaller, consistent with Powell's assertion. The estimated number of full papers that do take a position is 7,580, rather than the 4,014 abstracts we identified. This consists of 7,348 endorsements and 232 rejections. The number of rejections is greater than the abstract sample primarily because, according to the authors of the studies considered, some full papers should be categorized as "rejection" when

we identified them as “no position.” This is further evidence against Powell’s assumption of 100% consensus among the no position papers.

Powell writes:

> *If we are to claim that AGW is the ruling paradigm of climate science, in the same way that plate tectonics is for geology and evolution is for biology, then in the absence of any evidence or statements to the contrary, we must assume that virtually all of the “no position” authors accept AGW. This reasoning justifies adding the 7970 “no position” articles to the 3896 which endorse AGW, to calculate that 11866 of 11944, or 99.3% of publishing climate scientists, accept AGW. This would be the average over the twenty years covered in the CEA survey.*

To claim that “no position” articles endorse AGW (leading to the conclusion that AGW *is* the ruling paradigm) because of the assumption that AGW is the ruling paradigm is a circular argument. Further, the assumption that *all* “no position” articles endorse AGW is falsified not just by the author self ratings, but by the fact that some scientists who authored “rejection” papers also authored “no position” papers. It is erroneous to insist that their “no position” papers be included as endorsements and underscores the problematic exercise of making ungrounded assumptions about the position of papers that express no position. By excluding “no position” papers from the calculation of the consensus, C13 reduced the risk of bias in either direction.

S2.4. 97% versus 99.9%

Powell writes:

> *The true scientific consensus, i.e. the consensus of acceptance based on the peer-reviewed literature, is not 97%, as it is widely assumed that CEA found, but in my estimation is at least 99.9%. That is why, to find a single article that explicitly rejects AGW, one has to search through not the few dozen that the “97% consensus” would imply, but thousands of articles.*

It is not merely “widely assumed” that C13 found a 97% consensus in the literature. That figure is what was found using the ratings of 11,944 abstracts as well as the ratings of 2,142 papers by their own authors. C13 counted not only explicit endorsements and rejections but also implicit ratings. Powell arrives at his 99.9% consensus figure by taking into account only explicit rejections of AGW and by assuming that the rest of the literature (including implicit rejections) endorses AGW. In the results of C13, 24 explicit rejection abstracts were found out of a total of 11,944. Adopting the methodology of Powell, i.e., assuming that all the other abstracts, including the implicit rejection abstracts and the “no position” are endorsements, would yield a consensus of 99.8%. The difference between the two assessments does not therefore hinge on how the explicit rejection abstracts are assessed and counted, but on what assumptions are made in the case of implicit positions and cases where no position is expressed at all.

Powell makes a valid point about the current level of scientific consensus versus the average level of consensus over the 21 years considered in C13 which quantifies the average level of

consensus. The paper also finds that the level of agreement in 2011 among relevant climate papers approaches 98%.

C13 was conservative in identifying the total number of studies or scientists involved in the consensus, and that the level of consensus has grown with time. Nevertheless, the original conclusion in C13 about the average level of consensus from 1991 to 2011 stands: Among abstracts and papers in the peer-reviewed literature that express an opinion on AGW, 97% endorse it.

S3. Plotting expertise versus consensus

Figure 1 uses Bayesian credible intervals to visualise the degree of confidence of each consensus estimate (largely a function of the sample size). The coloring refers to the density of the Bayesian posterior, with anything that isn't gray representing the 99% credible interval around the estimated proportions (using a uniform prior). Expertise for each consensus estimate was assigned qualitatively, using ordinal values from 1 to 5. Only consensus estimates obtained over the last 10 years are included.

Table S1. Assigning expert levels to sub-groups in consensus studies

Study	Code	Group	Expert level	Consensus	Sample Size
Doran & Zimmerman 2009	DZ1	Economic Geologists	1	46.6%	103
Doran & Zimmerman 2009	DZ2	Meteorologists	3	63.9%	36
Doran & Zimmerman 2009	DZ3	Publishing climate scientists	5	97.4%	77
Stenhouse *et al* 2014	S141	Non-publishers (climate science)	1	46.2%	26
Stenhouse *et al* 2014	S142	Publishing (other)	3	80.5%	82
Stenhouse *et al* 2014	S143	Publishing climate	5	87.9%	124
F&L 2012	F&L12	AMS/AGU members	2	84.0%	489
Pew 2015	Pew151	AAAS members	2	87.0%	3748
Pew 2015	Pew152	Working Ph.D Earth scientist	5	93.2%	132
Carlton *et al* 2015	C151	Survey of biophysical scientists at Big 10 universities	3	641	698
Carlton *et al* 2015	C152	Majority of research concerns climate change or the impacts of climate	5	96.7%	306

		change			
Bray 2010	B10	Authors of climate journals, authors from Oreskes 2004 sample, scientists from relevant institutes	5	83.5%	370
Anderegg *et al* 2010	A10T200	Top 200 publishing climate research	5	97.5%	200
Rosenberg *et al* 2010	R10	U.S. climate scientists authoring articles in scientific journals that highlight climate change research	5	88.5%	433
Verheggen *et al* 2014	V14Q3	Published more than 10 climate-related papers (self-reported)	5	90.9%	729
Cook *et al* 2013	C13	Publishers of global climate change papers stating a position on AGW	5	97.2%	1381

Table S2: 80 National Academies of Science

National Academy of Science Statements on Climate Change

	Country	Statement	Type
1	Albania	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
2	Argentina	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
3	Armenia	IAP Statement on Tropical Forests and Climate Change	Implicit
4	Australia	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
5	Austria	Statement by European Academies Science Advisory Council	Explicit
6	Bangladesh	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
7	Belgium	Statement by European Academies Science Advisory Council The Science of Climate Change	Explicit
8	Bolivia	IAP Statement on Tropical Forests and Climate Change	Implicit

9	Brazil	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
10	Bulgaria	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
11	Cameroon	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change IAP Statement on Ocean Acidification	Explicit
12	Canada	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
13	Chile	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
14	China	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
15	Colombia	IAP Statement on Ocean Acidification	Explicit
16	Croatia	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
17	Cuba	IAP Statement on Ocean Acidification	Explicit
18	Czechoslovakia	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
19	Denmark	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
20	Dominica	IAP Statement on Ocean Acidification	Explicit
21	Egypt	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
22	Estonia	Statement by European Academies Science Advisory Council	Explicit
23	Finland	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit

24	France	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
25	Georgia	IAP Statement on Ocean Acidification	Explicit
26	Germany	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change Statement by European Academies Science Advisory Council	Explicit
27	Ghana	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change	Explicit
28	Greece	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
29	Guatemala	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
30	Hungary	Statement by European Academies Science Advisory Council	Explicit
31	India	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
32	Indonesia	The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
33	Iran	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
34	Ireland	Statement by European Academies Science Advisory Council The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
35	Israel	IAP Statement on Ocean Acidification	Explicit
36	Italy	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change Statement by European Academies Science Advisory Council	Explicit

		IAP Statement on Ocean Acidification	
37	Japan	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society IAP Statement on Ocean Acidification	Explicit
38	Jordan	IAP Statement on Ocean Acidification	Explicit
39	Korea, Republic of	IAP Statement on Ocean Acidification	Explicit
40	Kosovo	IAP Statement on Ocean Acidification	Explicit
41	Kenya	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change IAP Statement on Ocean Acidification	Explicit
42	Kyrgyz Republic	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
43	Latvia	Statement by European Academies Science Advisory Council	Explicit
44	Lithuania	Statement by European Academies Science Advisory Council	Explicit
45	Madagascar	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change	Explicit
46	Malaysia	The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
47	Mauritius	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
48	Mexico	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society IAP Statement on Ocean Acidification	Explicit
49	Moldova	IAP Statement on Tropical Forests and Climate Change	Implicit
50	Montenegrins	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
51	Mozambique	IAP Statement on Tropical Forests and Climate Change	Implicit
52	Netherlands	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
53	New Zealand	The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
54	Nicaragua	IAP Statement on Ocean Acidification	Explicit

		IAP Statement on Tropical Forests and Climate Change	
55	Nigeria	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change	Explicit
56	Norway	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
57	Pakistan	IAP Statement on Ocean Acidification	Explicit
58	Peru	IAP Statement on Ocean Acidification	Explicit
59	Poland	Statement by European Academies Science Advisory Council	Explicit
60	Portugal	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
61	Romania	IAP Statement on Tropical Forests and Climate Change	Implicit
62	Russia	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society	Explicit
63	Sénégal	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change IAP Statement on Ocean Acidification	Explicit
64	Serbia	IAP Statement on Ocean Acidification IAP Statement on Tropical Forests and Climate Change	Explicit
65	Slovakia	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
66	Slovenia	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
67	South Africa	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change Joint science academies' statement: Climate change adaptation and the transition to a low carbon society IAP Statement on Ocean Acidification	Explicit
68	Spain	Statement by European Academies Science Advisory Council IAP Statement on Ocean Acidification	Explicit
69	Sri Lanka	IAP Statement on Ocean Acidification	Explicit
70	Sudan	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change IAP Statement on Ocean Acidification	Explicit

71	Sweden	Statement by European Academies Science Advisory Council The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
72	Switzerland	Statement by European Academies Science Advisory Council	Explicit
73	Tanzania	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change IAP Statement on Ocean Acidification	Explicit
74	Turkey	IAP Statement on Ocean Acidification	Explicit
75	Uganda	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change IAP Statement on Ocean Acidification	Explicit
76	United Kingdom	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society The Science of Climate Change IAP Statement on Ocean Acidification	Explicit
77	USA	Joint science academies' statement: Climate change adaptation and the transition to a low carbon society IAP Statement on Ocean Acidification	Explicit
78	Venezuela	IAP Statement on Ocean Acidification	Explicit
79	Zambia	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change	Explicit
80	Zimbabwe	Joint statement by the Network of African Science Academies (NASAC) to the G8 on sustainability, energy efficiency and climate change IAP Statement on Ocean Acidification	Explicit

References

Anderegg, W. R. L., Prall, J. W., Harold, J., & Schneider, S. H. (2010). Expert credibility in climate change. *Proceedings of the National Academy of Sciences of the United States of America*, 107, 12107-12109.

Cook, J., Nuccitelli, D., Green, S.A., Richardson, M., Winkler, B., Painting, R., Way, R., Jacobs, P., & Skuce, A. (2013). Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters*, 8(2), 024024+.

Cook, J., Nuccitelli, D., Skuce, A., Way, R., Jacobs, P., Painting, R., Honeycutt, R., Green, S.A. (2014). Reply to Comment on 'Quantifying the consensus on anthropogenic global warming in the scientific literature: a Reanalysis'. *Energy Policy*. DOI: 10.1016/j.enpol.2014.06.002

Doran, P., & Zimmerman, M. (2009). Examining the scientific consensus on climate change. *Eos*, Transactions American Geophysical Union, 90, 22.

Oreskes, N., & Wegener, A. (1999). *The rejection of continental drift: Theory and method in American earth science* (p. 420). New York: Oxford University Press.

Pew Research Center (2015). An elaboration of AAAS Scientists' views. Available at http://www.pewinternet.org/files/2015/07/Report-AAAS-Members-Elaboration_FINAL.pdf

Powell, J. (2015). Comment on "Quantifying the consensus on anthropogenic global warming in the scientific literature". *Environmental Research Letters*. In press.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M. & Miller, H. L. (ed). (2007). *Climate change 2007: The Physical Science Basis: Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Vol. 4). Cambridge University Press. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg1_report_the_physical_science_basis.htm

Stenhouse, N., Maibach, E., Cobb, S., Ban, R., Bleistein, A., Croft, P., Bierly, E., Seitter, K., Rasmussen, G., & Leiserowitz, A. (2014). Meteorologists' Views About Global Warming: A Survey of American Meteorological Society Professional Members. *Bulletin of the American Meteorological Society, 95*(7), 1029-1040.

Tol, R. S. (2014). Quantifying the consensus on anthropogenic global warming in the literature: A re-analysis. *Energy Policy*, 73, 701-705.

Tol, R. (2015). Comment on 'Quantifying the consensus on anthropogenic global warming in the scientific literature'. *Environmental Research Letters*. In press.

Verheggen, B., Strengers, B., Cook, J., van Dorland, R., Vringer, K., Peters, J., Visser, H. & Meyer, L. (2014). Scientists' views about attribution of global warming. *Environmental science & technology*, 48(16), 8963-8971.

Footnotes

1. http://skepticalscience.com/tcp.php
2. http://iopscience.iop.org/1748-9326/8/2/024024/media/erl460291datafile.txt
3. http://wattsupwiththat.com/2013/08/28/cooks-97-climate-consensus-paper-crumbles-upon-examination/#comment-1401967
4. http://joannenova.com.au/2013/08/richard-tol-half-cooks-data-still-hidden-rest-shows-result-is-incorrect-invalid-unrepresentative/#comment-1311465
5. http://joannenova.com.au/2013/08/richard-tol-half-cooks-data-still-hidden-rest-shows-result-is-incorrect-invalid-unrepresentative/#comment-1311489
6. http://blog.hotwhopper.com/2015/03/deconstructing-97-self-destructed.html?showComment=1427562092205#c3347699341286854954