Supplemental Information

S1. Detailed Response to Tol (2016)

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 (2016) 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 Zimmerman 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: Consensual knowledge is no longer reiterated in the scientific literature but taken for granted. 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 (2016) concern the rating process. This 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. The abstract rating results are further validated by comparison of the abstract ratings with the results of the author survey where the scientists who produced the studies were invited to rate their full papers, resulting in a 97% consensus.

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.

Tol (2016) 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 multiple occasions[4,5].

Tol (2016) 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 of two raters being assigned the same abstract at the same time was infinitesimal, making collusion practically impossible.

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. In addition, several non-reviewed or non-climate-related abstracts were identified and raised in the forum, although these are irrelevant for the results. 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.

Lastly, the 97.1% consensus derived from abstract ratings was independently confirmed by the 97.2% consensus derived from the self-rating survey of authors of the climate papers. None of the criticisms of the abstract rating process are relevant to the self-rating survey.

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 (2016) queries what steps were taken to prevent raters from gathering additional information. While there was no practical way to hinder raters from fuller investigation of each of thousands of abstracts they viewed, raters affirm that this occurred in very few instances, mainly 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 (2016) 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 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.

Tol (2016) 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 (2016) 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 has no relevance to the integrity of the abstract ratings.

S2. 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 Jeffreys 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
Farnsworth and Lichter 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	91.8%	698
Carlton *et al* 2015	C152	Majority of research concerns climate change or the impacts of climate change	5	96.7%	306
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 IAP Statement on Ocean Acidification	Explicit
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 IAP Statement on Tropical Forests and Climate Change	Explicit
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

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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