Climate Change Consensus Only Achieved with Filtering and Selection Bias

A Review of Secondary Consensus Claim Papers

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Abstract

Based on the premises that there is a high rate of agreement among the scientific community concerning the key factors driving climate change, there have been growing calls from the public to 'unite behind science'. However, a careful assessment of the so-called climate research 'consensus', raises serious questions about the validity of this claim.

This work analyses key peer reviewed publications supposedly documenting a climate 'consensus', focusing on 'consensus' publications that are not based on the analysis of data, but rather of the subjective positioning and beliefs of scientists, obtained mainly from surveys.

We have used a 90 % agreement rate as a reasonable threshold for indicating consensus, and found that, in fact, an above 90 % consensus agreement rate is only achieved by filtering and selection bias. The same pattern was observed in the different studies analyzed, and we show that no 'consensus' has actually been documented.

The work further substantiates that the central anthropogenic global warming hypothesis of scientific consensus has not only not been documented, but in fact does not exist in the analyzed material.

Despite the obvious weaknesses observed in these climate consensus publications, the climate science community is yet to refute these claims which might lead to misinformation on the public scene. Hence, the objective of this study is to change this, as well as to shed light on potential data analysis issues in economic style surveys on climate change.

Keywords: *Climate Ch*ange, *Consensus*, *Systematic Review*, *Sample Selection Bias*

Introduction

Current climate science is at the forefront of a large portion of political discussions and debates. Hence, a phalanx of public voices from within as well as from outside the scientific community are demanding to 'unite behind the science'. One of the key implicit and often explicit assumptions for this political demand, is that 'science is settled' or 'science is united' on the questions of the main factors driving climate change, i. e. uniting behind an IPCC endorsed anthropogenic global warming (AGW)–view on climate science, specifically pinpointing to a dominant key factor, i. e. anthropogenic greenhouse gas (GHG) emissions, especially CO_2. This GHG-AGW-hypothesis is also at the fore and center of most political mitigation measures, as laid down in the Paris climate accord.

There is a seemingly credible scientific justification for the notion that 'science is united' on the GHG-AGW-hypothesis. This is the so-called *climate consensus*, which is postulated in a number of widely cited manuscripts (Cook et al. (2016), Cook et al. (2013), Doran & Zimmerman (2009),

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Oreskes (2004), Verheggen et al. (2014)), of which the most prominent one is the 97 % agreement notion created by Cook et al (2013). However, careful scientific scrutiny reveals that the so-called climate research consensus claim might actually be unfounded.

This work details a systematic review and debunking of peer-review published climate-consensus assertions, concentrating on those papers which claim to support a climate consensus based on a methodology which goes beyond the one employed by Cook et al. (2013). These papers are based on measuring the level of agreement in climate science, by analyzing the convictions of scientists with surveys. The pioneering work following this type of methodology is Doran and Zimmerman (2009), following in their footsteps, some of the key papers include works from Verheggen et al. (2014), Stenhouse et al. (2014), and Carlton et al. (2015). Lastly, in a similar fashion Anderegg et al. (2010) studied the publicly stated opinions of scientists in a database.

Material and Method

We scrutinized the peer-reviewed scientific literature for claims of having confirmed or documented a climate consensus, starting with the key paper of Cook et al. (2013) and working both backwards and forward. We are certain that we have captured the key works. We evaluated all papers for what they actually did and organized the results in categories as well as discussing key findings individually. We concentrated on the question of a documented agreement rate or 'consensus' for the key question of the GHG-AGW-hypothesis being the key climate factor to explain today's climate patterns. We used 90 % agreement as a threshold for indicating a consensus.

While we cannot fully exclude that there may be additional work claiming to support a climate consensus, we are certain that we have captured the key ones, and thus covered the key methods to arrive at a consensus claim notion in the peer-reviewed literature.

Results and Discussion

1 Background on Climate Change Consensus Studies

Investigations trying to gauge and quantify the level of agreement in climate science, typically conducted in the attempt to prove a 'climate consensus', can be categorized into two main categories as shown in Figure 1. In the first main category, the analyses are based on the positioning and beliefs of active scientists. This main category comprises subcategories. In the first subcategory, the analysis is centered around the positioning of scientists, in the abstracts of published works. The pioneering work here is from Oreskes (2004), while the key reference is the 97.1 % claim from Cook et al. (2013).

The second subcategory comprises works which employ a different methodology, i. e. gauging the beliefs and convictions of scientists with surveys. Here the pioneering work was published by Doran and Zimmermann (2009), while the key reference is Verheggen et al. (2014).

The third subcategory contains other scientist-centered methodologies, such as the work of Anderegg et al. (2010), which created and analyzed a database of scientists, which were categorized according to their publicly stated positions on climate change either supporting or criticizing the International Panel on Climate Change (IPCC).

In the other main category, the views and statements of the scientists are not being gauged, but the actual published data are input to the analysis. Thus, the analysis is based on what the published study presented in terms of results, investigations, modelling, scenarios, reviews, etc., which actually contributes to the underlying scientific question, and the GHG-AGW hypothesis.

In Figure 1, the current situation for climate research is summarized. There is a number of publications in the first main category, both as abstract analysis, survey investigations, or other scientist-centered analysis, while as of today no data-centered investigation has been conducted and reported in the scientific literature thus far.

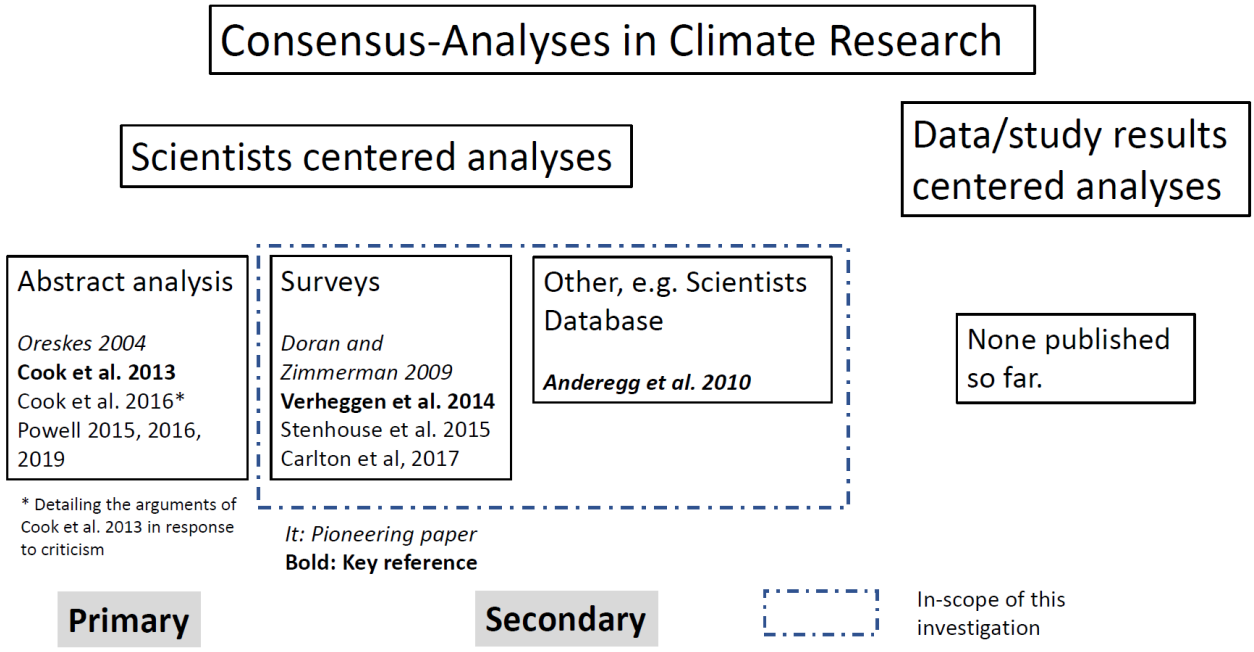

Figure 1. A visual representation of the main categories and sub-categories of the type of consensus analysis in climate research (categories of re:look climate).

We consider this to be the key finding of this systematic evaluation: The climate consensus claim is only based on investigations of the stated beliefs and positionings of scientists, be it via abstract analysis, survey, or other methodology. What the vast amount of data published actually tells the community, in an attempt to present a consensus-type agreement rate, has not yet been investigated.

However, this analysis will show that even within this narrowed scope of only focusing on the beliefs and convictions of scientists, no 'consensus' has actually been documented. We have previously documented by reanalyzing and refuting the lighthouse 97.1 % consensus claim published by Cook et al. (2013) that the abstract analysis type of consensus claims are in fact not showing anything resembling a 'scientific consensus'. This analysis is currently submitted elsewhere and waiting to be published (Lengsfeld et al., 2021).

The analysis presented here will concentrate on the consensus works centering around the analysis of beliefs and statements of scientists by surveys or scientist database analysis. On Figure 1, this is shown in the blocks 'Surveys' and 'Scientists Database'.

In conjunction with the authors themselves, we would consider survey or database categorization investigations to be supportive evidence for a consensus at best. However, the analysis is still worth pursuing as it will both show why all works in fact do not support the notion of a climate consensus, and moreover give a strong hint on how the climate consensus notion has in fact been constructed.

Firstly, three consensus-survey works were analyzed: Verheggen et al. (2014), Stenhouse et al. (2014) and Carlton et al. (2015), all of which followed in the footsteps of the 97.1 %-publication of Cook et al. (2013). Secondly, we were drawing on some of the key findings and connections to the pioneering work of Doran and Zimmerman (2009), and finally we conclude with the analysis of the key work on the scientist categorization by Anderegg et al. (2010).

2 Analysis of Verheggen et al.

Verheggen et al. (2014), a paper which has John Cook as a co-author, can be considered as a 'consensus' survey gold standard work (similar to Cook et al. (2013)) in the abstract analysis subcategory. The survey was conducted among climate scientists identified by a literature search. Verheggen et al. (2014) contacted 6,550 scientists, of which 1,868 (29 %) responded. The survey

contained two questions, which are directly relevant for the GHG-AGW-consensus hypothesis, i. e. on the qualitative and quantitative attribution of GHG (dominant influence) for global warming since industrialization began.

The answers to these questions clearly fell below a consensus threshold: an 82 % agreement on qualitative and a 66 % agreement of quantitative attribution. However, the authors drove these numbers by means of filtering, albeit at the cost of a significantly reduced base. Using filtering according to the number of publications which each respondent has in this field, the authors managed to considerably rise the agreement rates.

However, only in the subgroup with the strongest filtering, i. e. the IPCC AR (assessment report) 4 WG (working group) 1 authors group, the 90 % agreement threshold was passed, at least on the qualitative attribution, while notably even this select group did not pass a consensus threshold on the quantitative attribution question (agreement rate being still slightly below 80 %). This filtering considerably drove down the base number of scientists. The strongest filter, AR4 WG1, necessary to achieve the consensus threshold agreement rate of 90 percent, reduces the number of responses to Q3 from 1747 scientists to 165.

The effect of the filtering driving up the agreement rate while significantly lowering the base is envisaged in Figure 2, using the data for Q3 of Verheggen et al. (2014). It should be noted that the filtering not only significantly reduces the base, but also shifts the evaluation.

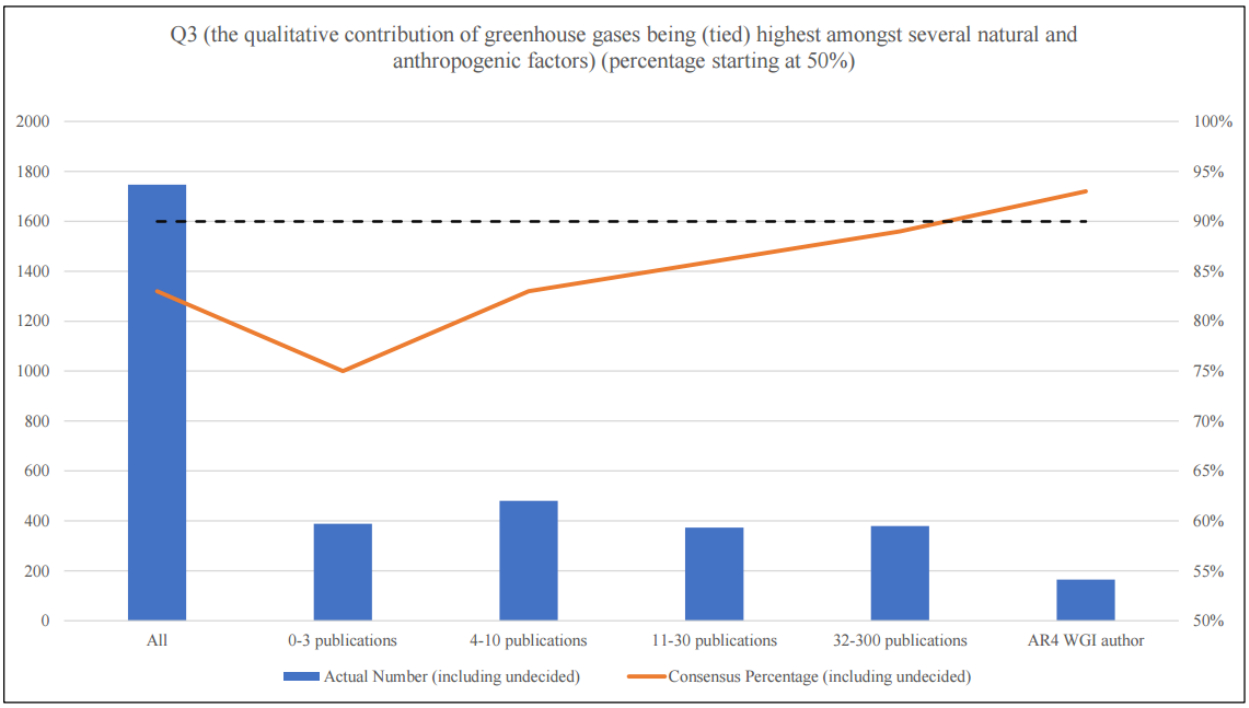

Figure 2. A graphical representation of the key results from Verheggen et al. (2014). (Question 3: The qualitative contribution of greenhouse gases being (tied) highest amongst several natural and anthropogenic factors. Data and exact phrasing taken from Verheggen et al. (2014), Figure 3 left side, and Table S3 from SI, Q3 (data including undecided)).

The figure shows both the actual numbers of scientists and the percentage agreement. The consensus threshold of 90 % (indicated in the figure with a dotted line) is only achieved for the group with the lowest number of scientists (AR 4 WG1 authors), i.e. after strongest filtering.

While originally any active climate scientists were surveyed, broadly identified by a literature search, the catchy consensus threshold level agreement rate is only achieved in the highly selected

group of the IPCC AR4 WG1 of 165 scientists representing less than 10 % of the respondents, and less than 3 % of the scientists originally contacted.

Just as a side note: It seems highly likely, although not analyzed by Verheggen et al. (2014), that the response rate of the IPCC AR4 WG1 authors was considerably higher than that of the overall group (which was 29 %), and it seems probable that IPCC AR4 WG1 authors supportive of the IPCC positions had a higher interest in responding, to further reinforce the already evident selection bias.

3 Analysis of Stenhouse et al.

Very similar patterns are seen in the investigations by Stenhouse et al. (2014). Stenhouse et al. (2014) surveyed 7062 members of the American Meteorological Society: In the group of the 'all respondents' (n=1821, response rate 26 %) the answers fall significantly short of the 90 % consensus threshold. The question "Is global warming happening? If so, what is the cause?" was answered with 52 % "yes: mostly human" and 10 % "yes: equally human and natural".

Filtering again changed the numbers: Setting a filter which only looks at those members of the American Meteorological Society (AMS) who are active in climate research, drove the numbers up in the direction of 90 %. To the above quoted question "Is Global Warming happening? If so, what is its cause?" the highest agreement rate, 78 % to the answer: "Yes: mostly human" was achieved in the group of AMS members with the area of expertise "climate science" and the publication focus "mostly climate". Again, the filtering significantly reduced the base, in this case from 1821 to 124 scientists. And, a clear selection was introduced, while from the original AMS members now only those with a self-declared "climate science" expertise and a publication focus "mostly climate" contributed to the judgment call. Evidently, this reduction in base from 1821 to 124 has increased the percentage to the question from 52 % to 78 %, however, even with this filtering Stenhouse et al. (2014) are still not close to the 90 % threshold for a consensus.

4 Analysis of Carlton et al.

We now move on to Carlton et al. (2015), who surveyed scientists beyond the core field of climate and meteorology. The survey went to scientists of the 10 biggest American universities active in life and technical science in the broader sense. The group survey comprised a sample of 1868 scientists and received 698 responses (37.4 % response rate). The core results in this survey are not easily digestible as the questioning was in a cascade form. The answer relevant to the GHG-AGW-hypothesis is the following combination: Q3 "When compared with pre-1800's levels, do you think that mean global temperatures have generally risen, fallen, or remained relatively constant?", if answered with "Risen" the following question was presented Q4 "Do you think human activity is a significant contributing factor in changing mean global temperatures?". Finally, if that answer was "yes" the following question was presented: Q12 "How sure are you that human activity is a significant contributing factor in changing mean global temperatures?".

When looking solely at Q12 and combining the percentages from "Extremely sure" and "Very sure", you get: 53.23 % + 35. 32 % = 88.55 %, which is still shy of a 90 % agreement rate. However, it is also important to note that progressing from Q3 to Q12 reduces the base size, as this 88.55% is not based on the original 698 responses. Given that Q3 was given to all 698 scientists and the percentage of those who replied "Risen" is 93.48 %, this would equate to 653 scientist which would also be the base value for Q4. Therefore, the number of replies to "Yes" on Q4 is: 96.66 % * 653 = 631. This 631 is the actual base value in Q12, this means that the 88.55 % is from 631 which yields a value of 559 scientists. If this is compared to the original 698, that would give only a percentage of 80 % of the original sample who say that either they are "Extremely sure" or "Very sure" that human activity is a significant contributing factor in changing global temperatures (Figure 3).

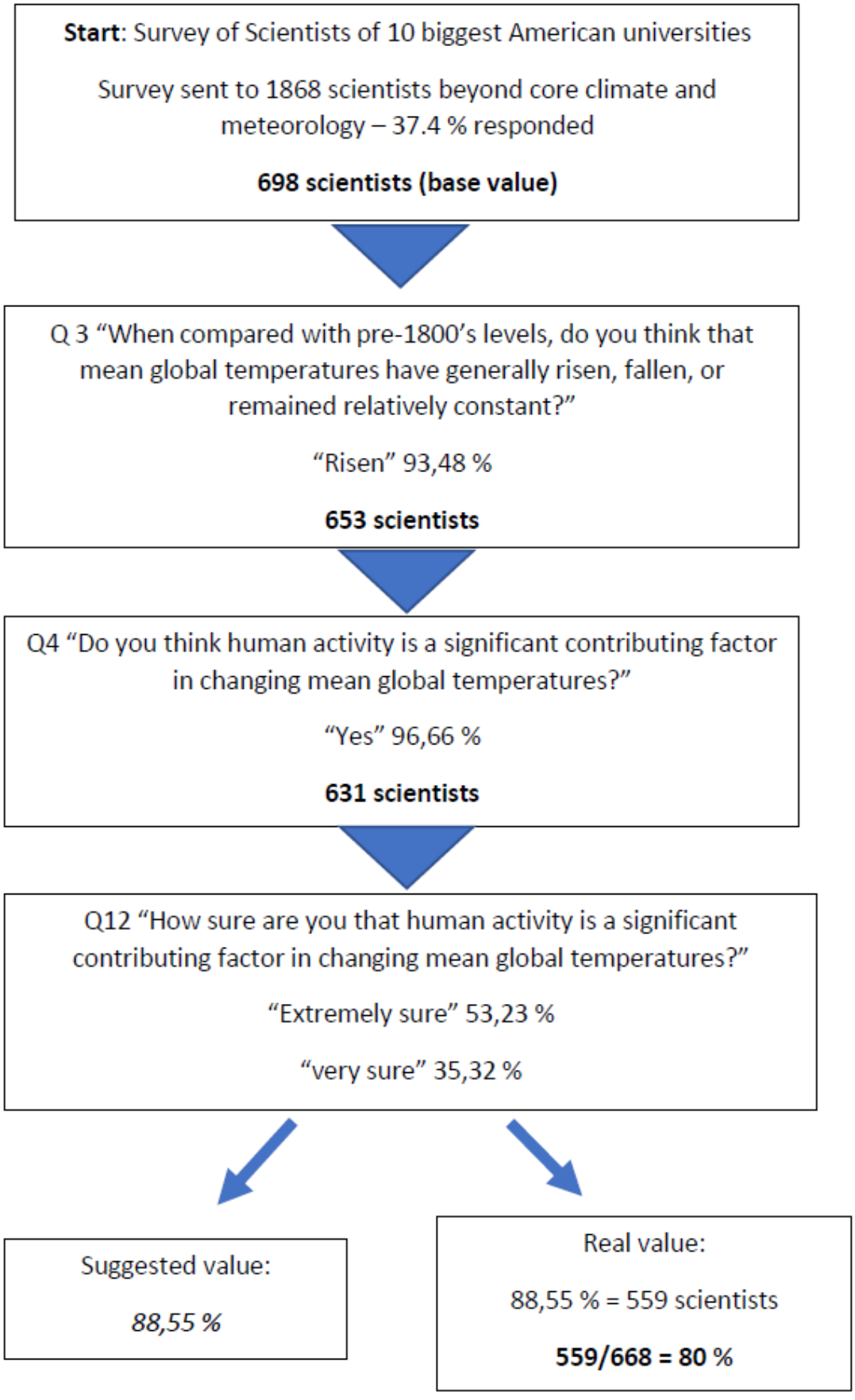

Figure 3: Illustration of the filtering/cascading performed in Carlton et al. (2015) analysis to achieve a higher agreement.

Carlton et al. (2015) did not necessarily employ filtering to increase this 86 % agreement rate, nonetheless it is important to note that the value is not based on the whole sample. Additionally, they did display in the text a conclusionary sentence; by only combining the answers of Q3 and Q4, omitting Q12: "Together, these two facts reveal that 91.9 % of scientists surveyed believed in anthropogenic climate change".

We would clearly state that omitting answers to Q12 ("How sure are you that human activity is a significant contributing factor in changing mean global temperatures?") such as "somewhat sure" and "not sure at all" and thus presenting the beyond 90 % result consensus-threshold passing level in the text, is not justified.

5 Analysis of Doran and Zimmerman.

It should be noted that there emerged criticism against the original pioneering work of Doran and Zimmerman (2009), from which Carlton et al. (2015) copied their question Q3 and Q4. The critics questioned the validity of the survey regarding how imprecisely the key questions were phrased (Granqvist, 2009; Helsdon, 2009). However, the imprecise questions may in fact not be the key weakness in the pioneering work of Doran and Zimmerman (2009).

The key weakness, again, is the use of filtering, which was already employed in this pioneer work, and also resulting in a clear selection bias. The survey was sent out to 10,257 earth scientists, of which 3146 scientists responded (response rate 31 %). In the overall response, 82 % answered the key question of "Do you think human activity is a significant contributing factor in changing mean global temperatures?", with "yes". This is the key result to look at, as it is the only question that is directly relating to the GHG-AGW hypothesis. This result clearly falls flat of a 90 % consensus threshold. The agreement rate goes up with filtering, albeit at the expense of a significantly reduced base.

The 90 % agreement rate threshold is touched in the subgroup 'Active publishers - Climate change', and passed with a 95 % agreement in the subgroup of "Climatologists, who are active publishers on climate change" (defined as more than 50 % of their publications). What is the key here, is the shift of base: Doran and Zimmerman (2009) only mentioned the number for the subgroup with the highest agreement rate: The 95 % agreement rate was reached only in an elite subset of 79 scientists: "Climatologists, who are active publishers on climate change", which is less than 3 % of the respondents and less than 1 % of the scientists who received the survey.

6 Analysis of Anderegg et al.

The final work to be considered is Anderegg et al. (2010), which is not a survey, but a database analysis of active scientists categorized according to their position on climate change. Anderegg et al. (2010) assembled a database of 1,372 active climate researchers and classified these scientists in two categories: 'convinced of the evidence' and 'unconvinced of the evidence' based on publicly signed statements relating to the IPCC. The results are striking, especially if one compares them with a 90 % consensus notion: 903 (66 %) were categorized as 'convinced of the evidence', while a sizable 472 scientists (34 %) were categorized as 'unconvinced of the evidence' (note that 3 scientists are found in both categories). Thus, this detailed analysis is in fact the first peer-reviewed documentation that, at least till 2010, there was nothing resembling a scientific consensus in the climate research community.

Only when using a filtering according to the number of publications did Anderegg et al. (2010) arrive at 90 % and above 'convinced' scientists. By creating top ranking groups, the authors report to have found a 97 % 'convinced' rate in the top 100 group – note again the shift of base. The top 100 of course only represents just about 7 % of the original 1,372 scientists. Note again, as the original group only comprises climate researchers, the publication filter results in the selection of those scientists who dominated the peer-reviewed literature on climate research.

Conclusion: Key Learnings

This is one of the key learnings from this analysis: The agreement rate to the GHG-AGW-hypothesis is clearly well below a consensus threshold rate of 90 % in any survey analysis. In every case the agreement numbers only increase via filtering, which significantly reduces the base, and narrows the field to those scientists who dominate the peer-reviewed climate research discussion. Please refer again to Figure 2, demonstrating the effect of the filtering, i. e. driving support up, while significantly reducing the base, taking data from Verheggen et al. (2014).

However, the filtering employed not only significantly reduces the base, but obviously introduces a selection bias, as suddenly not the overall groups' beliefs or convictions are in the center of attention, but only those of the scientists dominating the peer-reviewed scientific literature and the IPCC working groups on the topic in question.

So overall, we found a consistent pattern across the 'consensus' publications. The actual analysis does not support a consensus notion, sometimes quite the opposite, but by employing additional measures, i. e. filtering according to publication efforts a 'consensus claim' confirmation can be stated, and is actually being claimed. The cost of this 'consensus' claim is a significantly reduced base and a strong selection bias, completely devaluing the original notion of a 'consensus'. As it's widely known in the science community and explicitly stated by Winship and Mare (1992), "Sample selection bias occurs when observations are selected so that they are not independent of the outcome variables in the study; this sample selection leads to biased inferences about social processes". This is the phenomenon that we have observed and discussed in this paper, and which has led to the conclusion that the climate research consensus claim might actually be unfounded.

A further problem with the publication filtering is a possible mechanism of self-citation or clique citation. Anderegg et al. (2010) mentioned this issue at the end of their work; however, then explained that this is a tendency in climate change research and that this should be less of a problem with increased sample size. However, this may not be the case as shown above, even with a large sample; if the observations are not independent of the outcome, there will be bias in the results. Nonetheless, this issue may not be limited to this field of research alone, but also to the peer-review process in general. Work done by Siler et al. (2015), on publications in general showed that the peer-review process might be making "gate keeping mistakes", in that they are "Rejecting seminal contributions and accepting mediocre submissions", leading to statistics such as 12 of 14 most cited articles being desk rejected and overall suggesting that the peer-review process has issues with exceptional or unconventional submissions (Siler, Lee, & Bero, 2015).

We also want to point to a dangerous mechanism: while the original papers do contain the data discussed here, secondary quotations and especially media reports often shorten the respective findings to a 'consensus' confirmation. We would not only argue that this is a classical case of a confirmation bias mechanism, but also that the authors of all the works analyzed here in fact were hoping to achieve exactly that effect. In fact, Tony Leiserowitz, the last author of Stenhouse et al. (2014) in 2017 posted the following spin on YouTube-platform ("the five key beliefs (sic) in ten words: "It's real", "It's us", "Experts agree", "It's bad", "There's hope".") (Evidence Squared, 2017). Thus, the same authors of the 'consensus' claim publications actively engage in shortening the message into "experts agree".

This is questionable in several dimensions, and it clearly points to a mechanism of intended-result driven evidence-making (Rose, et al. 2020, Strassheim & Kettunen 2014). This is clearly very critical in conjunction with a political 'unite behind the science' notion, often encountered in the public space, as this notion actually derives its political force only from a perceived unity or consensus of the scientists.

This work further substantiates that the central GHG-AGW-hypothesis of a scientific consensus has not only not been documented, but in fact does not exist in the analyzed papers.

It should be noted that not refuting the 'consensus' notion puts the scientific community in a dilemma, as perceived discrepancies need to be bridged, albeit there is actually no basis for them.

It is evident that such a 'consensus' has a stronger political appeal, even if not rooted in science (Barrio, 2009). As stated by Michael Crichton, in the editorial from Barrio (2009),

> "Science, on the contrary, requires only one investigator who happens to be right, which means that he or she has results that are verifiable by reference to the real world. In science, consensus is irrelevant, what are relevant are reproducible results. The greatest scientists in history are great precisely because they broke with the consensus. There is no such thing as consensus science. If it's consensus, it isn't science. If it's science, it isn't consensus".

We quote the very first part of a line of argumentation, from the first paragraph of a key perspective by Palmer and Stevens (2019) recently published, titled: "*The scientific challenge of understanding and estimating climate change*". The authors start the perspective with the following words: "The idea that the science of climate change is largely 'settled', common among policy makers and environmentalists but not among the climate science community, (…)" Here Palmer and Stevens think that the notion that science is largely 'settled' is not common within the climate science community, but amongst "policy makers and environmentalists".

A dangerous line of argumentation for the scientific community: As long as the consensus claims are not refuted in peer-review literature, no policy maker or environmentalist can or indeed should be blamed for citing them.

So how strong is the level of agreement or disagreement in the scientific community regarding the GHG-AWG-hypothesis? If that question is really to be answered there can only be one real avenue, see Figure 1: The truth lies in the data. Thus, one needs to evaluate and categorize the actual study, investigations, modelling, and review data pertinent to the question at hand. This group is working on this task which, despite the numerous climate research publications published during the last years, has not been performed or at least not been reported so far.

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Author Contributions:

P. L and F. V. conceived the original idea, and M. G. refined the concepts. P. L. and M. G. produced and performed the analysis. The main authors for the writing and executing of the paper are P. L and M. G. Then in later stages M. G, A. A, and A. G examined and verified the analysis. Finally, all authors edited the completed work including adding, definitions, further calculations, and specific paragraphs for deeper development of the text. All authors discussed the results and contributed to the final manuscript.

Competing Interest Statement:

re:look climate is a gGmbH, i.e. a non-profit institute funded by tax-deductible donations to advance science and research – details, including scientific principles, list of donations on www.relook-climate.de. The authors from re:look climate gGmbH work under these codes. As with any other research institute re:look's core task and intrinsic motivation is scientific advancement and publishing. Given this background, there is no competing interests or conflict of interest from any of the authors directly related to this work.

Significance Statement

This work sheds light on and discusses the various mechanisms used in a selection of climate change consensus studies. This is a significant contribution not only for our interpretation of such works but also our general awareness of such issues in social sciences. As the issues of result filtering, sample selection bias, and triggering of inflated secondary communication can have implications beyond; the published work, the science community but also affect future results interpretation, and in later stages disperse into the political sphere.