**Introducing a new approach to the climate consensus question by testing the 97 % climate consensus with 2707 published climate change papers from: 1991,1995, 1999, 2009, and 2019.**

**Abstract:**

The 97 % consensus level from Cook et al. (2013) is the most prominent climate change consensus work often referenced as evidence for ‘science being united’ on anthropogenic global warming (AGW) – with greenhouse gases (GHG) being the major driver. This study takes a closer look by testing the Cook work resulting in the 97% consensus figure. This was done by conducting a mini analysis comparing the abstract based analysis utilized by the Cook team, and a new data-centered approach introduced by our team. The result of the analysis of 2707 published climate change papers from (September) 1991, 1995, 1999, 2009, 2019 demonstrate less data support for the GHG-AGW hypothesis contrary to consensus claims. Our result also shows the importance of a data-focused approach, (as opposed to abstract based analysis) in determining the true level of scientific support for AGW or any other specific scientific question.

**Keywords:**

Critical Analysis, Scientific Consensus, Anthropogenic Global Warming, Global Climate Change, Literature analysis

**Introduction:**

The climate change consensus has been postulated in a number of widely cited manuscripts (Cook, et al., 2016; Cook, et al., 2013; Doran & Zimmerman, 2009; Oreskes, 2004; Verheggen, et al., 2014), of which the most prominent one is by Cook et al. (2013). The 97 % agreement level from Cook et al. (2013) is one of the most cited values for providing evidence on ‘the science being united’-notion regarding GHG-AGW hypothesis.

There is an argument that a ‘consensus’ in science, e.g. on climate change is not something the scientific community should be striving for because such a ‘consensus’ has a more political appeal, and therefore not rooted in forces of science whose objective is to find results that are relevant, reproducible, and verifiable (Barrio, 2009). However, a much bigger concern relates to the fact that the consensus-notion might actually mask a deep gap in knowledge and certainty around the drivers in in the complex question of climate.

The aim of this paper is to put the Cook-claim to a reality test and introduce an alternative, data-centric view on scientific literature analysis. The results will not only convincingly demonstrate the validity of the original criticism of the “consensus”-works and the scientific value of the stated 90 %+ claims, but will also highlight the importance of focusing on what the actual data and studies reveal about the level of certainty on a specific scientific question. Contrary to the perception generated by the “consensus”-claims, data support for GHG-AWG seems to be surprisingly weak, opening new fundamental questions and more study in climate change research.

**Background and methodological frame:**

The published climate change consensus works can be classified based on their methodologies as outlined in Figure 1. All works published so far revolve around the positioning of the scientists, with the very prominent works of Oreskes and especially Cook et al. (2013) centring around the positioning of the scientists in the abstracts. None of the published works so far actually analyses what the data contribute to the question on what the key drivers of climate change are, or whether in fact GHG-AGW is really the key climate driver in modern times. This may actually be the key weakness of all the consensus papers published so far (Lengsfeld et al. 2021, Grabert et al. 2021). (Insert figure 1)

In the climate change ‘consensus’ work from Cook et al. (2013) the key finding they stated is that “Among abstracts expressing a position on AGW, 97.1 % endorsed the consensus position that humans are causing global warming” (Cook, et al., 2013, p. 1). This is the widely cited 97 % climate change agreement level. However, a careful scientific re-analysis reveals fundamental issues with the approach employed by the Cook et al. (2013) team (Lengsfeld et al. 2021).

In short, Lengsfeld et al. (2021) argues that basing the consensus question on an explicit positioning of the authors in the abstracts likely leads to substantial bias: The large number of ‘no position’ abstracts as well as a sizable number of ‘endorsing’ abstract are likely misclassifications of what the underlying data and studies actually contribute.

The aim of this work is to put this criticism to a test by means of a mini analysis. This was accomplished by gauging a subset of the scientific literature using both the established Cook-abstract analysis and comparing this to a newly proposed data-centric evaluation. This work puts both the Cook-conclusions to a reality test, as well as establishes a new and different approach to gauge in the published scientific literature on what it actually says about the forces on climate change. Starting with the Cook-notion, this work concentrates on the question of scientific support for GHG-AGW, but the methodological approach can also be transferred to any other question, be it climate change related or otherwise.

**Methodology:**

To conduct this mini analysis, we utilized the EBSCO database. We have a paid subscription to EBSCO STM Source where we conducted this search and have access to all the given papers. For details on EBSCO STM Source see appendix 1.

In an effort to compare the abstract analysis methodology, in particular the method of Cook et al. (2013), to a data centred approach, we have selected a sample that is essentially a sub-subsection of the literature from the work of Cook et al. (2013). Their analysis spanned from 1991 until 2011 and included just shy of 12,000 abstracts. Hence, we have taken the climate change literature from an arbitrary month from the years: 1991, 1995, 1999, 2009, and also included 2019 as a means to test if the methodology still holds outside the original time frame and in a more recent time period. Focusing on one month from each of the years allows for a more diversified sample, rather than looking at only one year, while keeping it at manageable size.

The specific search criteria that were used to identify the climate change related papers are the following.

The Search string: “global warming” OR “global climate change”.

With the following advanced search specifications:

* Results in: English
* Also search within the full text
* Date: 01.09.\*YEAR\* – 30.09.\*YEAR\*
* Peer-reviewed
* Academic Journals

*Methodological Remarks*

The procedure began with a preparatory training for the assessment team (consisting of eight persons) to ensure thorough understanding of the assessment criteria. Six of individuals are MSc degree holders while the remaining two are (MSc and BSc) students. The papers were then apportioned in different proportions to each individual for assessment. Afterwards, we cross checked the results by implementing a four eyes principle, correcting possible errors. In situations of assessment uncertainty concerning any of the papers, we reserved them for a subsequent truth panel discussion to determine appropriate assessments (this was efficient because we had already gained some experience conducting truth panels for other previous projects). The whole process of evaluation took approximately eight weeks, including the truth panels.

After we exported all the papers for each year, we then began the analysis – assessing only the viable papers which amounted to 2707 papers in total (Table 1). As discussed earlier, all the abstracts and papers were analysed with two methods. Firstly, we followed the Cook et al. (2013) methodology where the abstracts were analysed for any explicit or implicit statements regarding AGW. The methodology is outlined in greater detail in their work (Cook et al., 2013). The abstract rating and examples can be found in Figure 2 which is directly from their paper (Cook et al., 2013, p. 3). However, for the purpose of this analysis we simplified it to produce similar results to that of Cook et al. (2013) (i.e. to recreate the “endorsing” percentage). Therefore, using Cook et al. (2013) specifications from Figure 2 we categorised the abstracts, as either “neutral” – they expressed no position on AGW, “endorsing” – they either had an implicit or explicit statements supporting AGW, then finally “rejecting” – where they either implicitly or explicitly are rejecting the concept of AGW. (Insert figure 2)

**Table 1:** The number of papers on climate change on EBSCO STM source for September for each year included in this analysis. Where the “Number of Initial Papers'' shows the exact number of papers we got on EBSCO STM Source with the specifications outlined in the methodology section. Then the “Number of Viable Papers'' shows the number of papers that were actually analysed, as even with the speciation we employed, we still had a selection of papers that were in fact non-academic work and hence removed the analysed pool. Such work includes: conference summaries, news articles, book chapters among other non-academic literature. The results in table 2 are as of 7th of January 2021.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year | 1991 | 1995 | 1999 | 2009 | 2019 | Total |
| Number of Initial Hits | 24 | 19 | 100 | 776 | 2059 | 2978 |
| Number of Viable Papers | 18 | 15 | 83 | 666 | 1925 | 2707 |

The first main difference of the second methodology is that it is centred around the data and results of the papers rather than statements in the abstracts. The second key difference is that in this methodology, instead of assessing each paper we first classify if it is relevant to climate change science specifically, and not just climate change as a whole. This is essentially the first part of the assessment; we find out if the paper carried out an analysis on the drivers of climate change, therefore furthering our scientific understanding of climate change rather than just taking anthropogenic climate change as a given. This is what we classify as a “relevant” paper, otherwise it would be termed “non-relevant”. This is not to say that the work is not useful but rather that it is not directly relevant to our understanding of the science of climate change. To determine if a paper is “relevant”, evaluating the title and abstract will usually suffice, but if need be, reviewing the whole paper can be done. Examples of “relevant” and “non-relevant” paper titles can be found in appendix 2. After this initial step, if that paper was relevant we would then evaluate whether or not the data, analysis, and overall findings “support” AGW, “reject” AGW, or have no direct conclusions to the topics of “AGW”, making it neutral regarding this topic.

**Results and Discussion:**

*Search String Results*

In order to ensure that the papers analysed were as close to Cook et al. (2013) as possible we used the same search strings (“global warming” and “global climate change”). These exact search strings were used for each (September) month in the five mentioned years. The number of papers that were found in each year are shown in Table 1. When initially looking at these results the number of papers increases rapidly, however this comes as no surprise as there has been a steady growing interest in climate change over the last few decades, signalling to the scientific community to produce and publish more of such research.

It is important to note that this analysis specifically looked at the papers resulting from the key search terms (“September” of each of the mentioned years) related to climate change. The month of September itself played no significance in this analysis, September is just continuously chosen to keep a consistency in the study. In an effort to show that September played no significance, Table 2 shows the number of papers for each month using the same climate change search strings for the year of 2009. As it can be seen there is variation, however, September itself does not pose any particular significance or differences compared to the other months of the year.

**Table 2:** The number of papers on climate change on EBSCO STM Source for each month in 2009. Note that here it says in September 2009 there are 832, however in table 2 it is 776. This is not a mistake but rather that EBSCO updates their papers daily, and hence can create different numbers of hits each day. The results here in table 1 are as of the 24th of March 2021, whereas the results in table 2 are as of 7th of January 2021.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Papers in 2009 | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| Actual number | 995 | 675 | 730 | 722 | 722 | 805 | 725 | 702 | 832 | 747 | 782 | 884 |

*Comparing Results of Both (Abstract based and* *Data-centric) Methodologies*

The results of testing the Cook et al. (2013) methodology show that we are able to replicate the Cook (abstract based) methodology quite accurately in all the years (2019, 2009, 1999, 1995, and 1991). After we removed all “no position” abstracts, we were left with only the papers expressing an explicit or implicit stance on AGW. This led us to finding a ‘consensus’ figure close to their 97 %.

The results from September 2019 (which is also the year that has the most papers) show that there are 81 % from the 1925 abstracts having “no position”. This leaves 362 abstracts with a “position” where 346 are “endorsing”. This creates a “consensus” of 96 % which is very close to the original 97 % reported in Cook et al. (2013) (Insert figure 3&4).

The results of September 2009 also gives a similar result of 93 % and the same holds true for 1999, 1995, and 1991 results. Although, these datasets are significantly smaller than 2009 and 2019 as seen in Table 2, when we look at the initial results from 1999, 1995, and 1991 in Figures 5, 6, and 7, it is clear from the Cook et al. (2013) methodology that after removing the “no position” group, a large majority of “endorsing” is left – the Cook et al. (2013) “consensus” results being 80 %, 88 %, and 100 % respectively for 1999, 1995, and 1991. We also see a similarity between 1999 and 1995, the majority of the “relevant” papers were “neutral”, however 1991 is an exception as there were no “relevant” papers in that sample (Insert figure 5,6, &7).

The results of the Data-centric methodology on the other hand found starkly different results. Our alternative (data-centred) approach initially looks similar to that of Cook et al. (2013) (as seen on the left side of the 2019 pie chart in Figure 3). However, the key difference is that 234 papers are considered “relevant” to our understanding of climate change science rather than just having a “position” in the abstract. Furthermore, the results of the data-centric methodology within this “relevant” category keep papers that have neutral results. These key factors led to us to have 215 papers that are neutral, 11 that have results rejecting AGW, and then 8 that have data based results supporting AGW. Therefore, in this case the percentage of “supporting” is only 3 %.

A clear case of mis-categorization is seen when we compare both methodologies. In the 2019 results for instance, there are 1563 papers classified as having “no position” in Cook methodology, while the data-centric methodology classified most of the papers as “non-relevant”. However, there are still 168 that are “relevant” papers, with significant scientific results, but did not make any explicit or implicit AGW statements in their abstracts (Table 3).

**Table 3:** The full results of the analysis for September 2019 in table form.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Cook et al (Results)** |  | **Data-centric approach (Results)** | | Relevant |  |
| No Position (Neutral) | 1563 | Non-Relevant | 1395 |  |  |
|  |  | Relevant | 168 | Neutral | 164 |
|  |  |  |  | Supporting | 1 |
|  |  |  |  | Rejecting | 3 |
| Endorsing | 346 | Non-Relevant | 294 |  |  |
|  |  | Relevant | 52 | Neutral | 42 |
|  |  |  |  | Supporting | 7 |
|  |  |  |  | Rejecting | 3 |
| Rejecting | 16 | Non-Relevant | 2 |  |  |
|  |  | Relevant | 14 | Neutral | 9 |
|  |  |  |  | Supporting | 0 |
|  |  |  |  | Rejecting | 5 |

In a similar fashion, the “endorsing” category from Cook methodology had 346 papers, however of these 346 papers, data-centric methodology classified 294 papers as “non-relevant”, meaning that these papers had statements in their abstracts endorsing AGW but when we actually analysed the paper’s results, it did not in fact conduct an analysis that further our understanding of the scientific drivers of climate change (e.g. papers with topics such as climate mitigation, engineering, or impacts, etc). Hence, their research and analysis does not evaluate the causes of climate change, but rather how to address it, therefore having explicit or implicit endorsing statements in their abstracts.

An interesting finding is that the percentage of “relevant” papers decreases as we move from 1995 to 2019 (not including 1991 as there were no relevant papers in that sample). This could however be a coincidence given that the samples in 1995 and 1999 are relatively small. Nonetheless, this finding is rooted in some logic as during the 90s we can argue that the debate on climate change was relatively new and hence a lot of the published work would’ve been rooted in science. Another interesting trend is that the “rejecting” papers in both methodologies remained quite consistent. There were no large spikes or declines throughout the years, in 1995 and 1999 the percentages were higher but this is also because the samples were a lot smaller.

*Limitation of Cook Methodology – Abstract Based Analysis*

The literature analysis is an important tool that can be reproducible. The overall result shows that the Cook et al. (2013) methods are indeed reproducible, and the same pattern of a high consensus figure can be seen in all the sampled years (Figure 8). However, the resulting difference between the two methodologies brings to light the limitations of abstract analysis, indicating a mis-qualification between the abstracts and the underlying data (or paper). A significant portion of abstracts (81 %) that were marked as “no position” in the Cook et al. (2013) methodology actually contained “relevant” literature but they did not have any direct or indirect AGW statements in their abstracts. The contrary was also noticed in the Cook et al. (2013) “endorsing” group, in that, a large portion of the papers that had statements in their abstracts supporting AGW were not actually relevant towards understanding the science of climate change. (Insert figure 8)

Hence, a mere assessment of the abstract positioning of publications is a less efficient means of understanding the level of scientific support for AGW since it is likely for papers to endorse AGW without a relevant supporting data in their study. Also, papers might have a relevant supporting data which is relevant to the science of climate change and be regarded as no position if it has no clear positioning. It is therefore important to focus on a much more reliable approach which is focused on the data content.

In this study, we used the same search strings as that of Cook et al. (2013) in order to test the consensus figure claim, and also provide a better approach. However, we find the search string too restrictive, as many relevant papers may not be included in the search. In addition to a data centred approach, using an optimized search strategy would ensure a wider reach of relevant papers that needs to be included in the consensus study.

Nevertheless, despite the issues highlighted, we acknowledge the contribution of Cook et al. (2013) to the question of climate change consensus, we hope it will also give rise to further improved approach to the understanding of the science of climate change, and also the level of data support for AGW. Our team, for instance, is committed to this cause by utilizing a more effective and improved search strategy and approach.

*Importance of a Data-centric Approach for GHG-AGW Hypothesis*

Our results provide evidence for less supporting data for the GHG-AGW hypothesis than widely claimed. As seen in Table 4, there is a wide gap between the results of both methodological approach in regards to AGW support.

**Table 4:** Summary of the key results on AGW according to Cook and the Data-centered assessments.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Year (September) | 1991 | 1995 | 1999 | 2009 | 2019 | Overall |
| No. of viable papers | 18 | 15 | 83 | 666 | 1925 | 2707 |
| AGW support in abstract (Cook methodology) | 100 % | 88 % | 80 % | 93 % | 96 % | 94 % |
| Data supporting AGW (data-centric methodology) | 0 % | 0 % | 0 % | 7.7 % | 8.3 % | 4 % |

According to our study, there is a need to focus on the relevance and results of a paper, and not statements given in an abstract or abstract positioning. As reported in the results, only a subsection of the results (less than 33 %) was actually relevant literature to our understanding of the science behind climate change. After identifying this relevant literature, it was clear that the majority was neutral (80 % or more). This means that the majority of the scientific climate change literature does not provide strong data support for or against AGW.

**Conclusion:**

This work puts to test the cook methodology and sheds light on the issues with the abstract based analysis while providing a data-centred approach – filling the climate change “consensus” gap. Conducting a consensus study via literature analysis is a good methodology in itself, however abstract based analysis is a risky approach since it is prone to error. Through our study we recommend a more efficient approach of literature analysis in future studies which takes into account the data and relevance of a paper. Also, the use of refined search strings should be able to better capture relevant papers to a specific question of research instead of the broad conventional literature search which might miss out on some important literature.

Despite the highlighted issues, we acknowledge that through the contribution of Cook et al. (2013) to the question of climate change consensus we are able to further investigation, and introduce a new approach to assess the level of support for AGW. Hopefully, this will also elicit more studies in the research of key climate change drivers. We are on the cause of further investigation, conducting research on both ends of relevant and non-relevant data for robust understanding of the true level of data support for AGW.

**References:**

Anderegg, W. R., Prall, J. W., Harold, J., & Schneider, S. H. (2010). Expert credibility in climate change. Proceedings of the National Academy of Sciences, 107(27), 12107–12109. doi:http://dx.doi.org/10.1073/pnas.1003187107

Barrio, J. R. (2009). Consensus Science and the Peer Review. Molecular Imaging and Biology volume, 11, 293. doi:https://doi.org/10.1007/s11307-009-0233-0

Carlton, J., Perry-Hill, R., Huber, M., & Prokopy, L. S. (2015). The climate change consensus extends beyond climate scientists. Environmental Research Letters, 10(9), 1-12. doi:http://dx.doi.org/10.1088/1748-9326/10/9/094025

Cook, J., Nuccitelli, D., Green, S. A., Richardson, M., Winkler, B., Painting, R., & et al. (2013). Quantifying the consensus on anthropogenic global warming in the scientific literature. Environmental Research Letter(8), 1-7. doi:http://dx.doi.org/10.1088/1748-9326/8/2/024024

Cook, J., Oreskes, N., Doran, P. T., Anderegg, W. R., Verheggen, B., Maibach, E. W., & et al. (2016). Consensus on consensus: a synthesis of consensus estimates on human-caused global warming. Environmental Research Letters, 11(4), 1-7. doi:http://dx.doi.org/10.1088/1748-9326/11/4/048002

Doran, P., & Zimmerman, M. K. (2009). Examining the Scientific Consensus on Climate Change. Eos, Transactions American Geophysical Union, 90(3), 22-23. doi:http://dx.doi.org/10.1029/2009EO030002

Grabert, M., Lengsfeld, P., Adedokun, A., Glassl, A., Vahrenholt, F. (2021). Climate Change Consensus only achieved with filtering and selection bias - A review of secondary consensus claim paper. (Manuscript submitted for publication).

Lengsfeld, P., Glassl, A., Adedokun, A., Vahrenholt, F. (2021). The famous 97.1%-climate consensus (“Cook-consensus”) is unsubstantiated and misleading. figshare. Preprint. https://doi.org/10.6084/m9.figshare.14611227.v1

Oreskes, N. (2004). The Scientific Consensus on Climate Change. Science, 306(5702), 1686-1688. doi:http://dx.doi.org/10.1126/science.1103618

Stenhouse, N., Maibach, E., Cobb, S., Ban, R., Bleistein, A., Croft, P., & et al. (2014). Meteorologists' Views About Global Warming: A Survey of American Meteorological Society Professional Members. Bulletin of the American Meteorological Society, 95(7), 1029–1040. doi:http://dx.doi.org/10.1175/BAMS-D-13-00091.1

Verheggen, B., Strengers, B., Cook, J., van Dorland, R., Vringer, K., Peters, J., & et al. (2014). Scientists’ Views about Attribution of Global Warming. Environmental Science & Technology, 48(16), 8963–8971. doi:http://dx.doi.org/10.1021/es501998e

**Appendix:**

**A1**. The details on STM Source directly from EBSCO.

“STM Source is the world's most comprehensive full-text database geared specifically toward addressing the needs of research and development. This product contains over 6,000 full-text journals, including more than 5,500 peer-reviewed journals in science, technology, engineering and medicine. In total, STM Source offers content from more than 9,400 publications including journals, monographs, reports, conference proceedings, etc. Key Features: More than 17 million records. Searchable cited references for nearly 800 journals. International full-text journals. Updated daily to ensure the most current content. Easy to use interfaces (via EBSCOhost or EDS).”

**A2.** Examples of papers for the data-centric “relevant” and “non-relevant” classification.

These are examples taken directly from our analysed sample, that we downloaded from EBSCO STM Source. These are all the papers found using the search strings and search constraints outlined in the methodology. Note: “non-relevant” does not mean the work does not contribute to climate change or the academic literature as a whole, but rather that the paper does not conduct independent data analysis on the science of climate change.

Relevant:

* “A model study of the Little Ice Age and beyond: changes in ocean heat content, hydrography and circulation since 1500.” - Sedláček, Jan 2009.
* “Carbon dioxide and the early Eocene climate of western North America.” - Thrasher, Bridget 2009.
* “Possible complexity of the climatic event around 4300-3800 cal. BP in the central and western Mediterranean.” - Magny, Michel 2009.

Non-Relevant:

* “Body weight and blood parameters of Old Norse Sheep grazing coastal heathland.” - Hovstad, K. A. 2009
* “Landsliding and Its Multiscale Influence on Mountainscapes” - Ramos-Scharrón, Carlos 2009
* “Forecasting future cooling demand in London” - Day, A.R. 2009

**Data Accessibility Statement:**

Authors can confirm that all relevant data are included in the article and its supplementary information files.