

THE LORD MONCKTON FOUNDATION
ΑΓΑΠΗΣΕΙΣ

0.3% consensus, not 97.1%

**‘Quantifying the consensus on global warming
in the literature’: a comment**

Christopher Monckton of Brenchley

Science and Public Policy Institute
5501 Merchants’ View Square, #209, Haymarket, VA 20169

monckton@mail.com

Capsule

The latest paper apparently showing 97% endorsement of a consensus that more than half of recent global warming was anthropogenic really shows only 0.3% endorsement of that now-dwindling consensus.

Abstract

Cook *et al.* (2013) stated that abstracts of nearly all papers expressing an opinion on climate change endorsed consensus, which, however, traditionally has no scientific role; used three imprecise definitions of consensus interchangeably; analyzed abstracts only; excluded 67% expressing no opinion; omitted some key results; misstated others; and thus concluded that 97.1% endorsed the hypothesis as defined in their introduction, namely that the “scientific consensus that human activity is very likely causing most of the current GW (anthropogenic global warming, or AGW)”. The authors’ own data file categorized 64 abstracts, or only 0.5% of the sample, as endorsing the consensus hypothesis as thus

defined. Inspection shows only 41 of the 64, or 0.3% of the entire sample, actually endorsed their hypothesis. Criteria for peer review of papers quantifying scientific consensus are discussed.

Keywords

Climate change, consensus, scientific method, peer review

Introduction: no role for consensus in science

Though Cook *et al.* (2013) reviewed abstracts of 11,944 papers on climate change and concluded that 97.1% of those expressing an opinion supported consensus, the philosophy of science allows no role for head-count. Aristotle, in his *Sophistical Refutations*, (c. 350 B.C.E.), identified the argument from consensus as one of the dozen commonest logical fallacies in human discourse.

Al-Haytham, the astronomer and philosopher of science in 11th-century Iraq who is recognized as the father of the scientific method, wrote that “the seeker after truth” – his phrase for the scientist – does not place his faith in any mere consensus, however venerable. Instead, he checks. “The road to the truth,” said al-Haytham, “is long and hard, but that is the road we must follow.”

In 1860 T.H. Huxley said: “The improver of natural knowledge absolutely refuses to acknowledge authority, as such. For him, skepticism is the highest of duties: blind faith the one unpardonable sin.”

Albert Einstein, when told that 100 Nazi scientists had published a book rejecting his theory of special relativity, responded that a single paper would have sufficed to refute his hypothesis. His own single paper of 1905 on the electrodynamics of moving objects had demonstrated why Newton’s laws, till then universally accepted as true, incompletely described the motion of celestial objects.

Popper (1934) formalized the scientific method as an iterative algorithm starting with a general problem (GP_0), to address which a scientist proposed a falsifiable hypothesis or tentative theory (TT_0). Thereupon others would either demonstrate during the error-elimination phase (EE_0) that the hypothesis was false, in which event it was rejected, or, more rarely, demonstrate that it was true.

By far the commonest outcome, however, especially in the physical sciences, is that error elimination will fall short of demonstrating the hypothesis but will fail to disprove it, in which event it gains some credibility. The statement of the general problem may then be modified accordingly (GP_1), and a new tentative theory (TT_1) may later be advanced to address the modified problem; and so on. *Pedetemptim*, and if necessary *ad infinitum*, science iteratively converges upon the truth (Fig. 1). Consensus adds no value to this process.

In the scientific method, then, there is no place for mere consensus. A hypothesis that is demonstrated – such as Pythagoras’ theorem – needs no consensus, for it is objectively true. A hypothesis that is disproven needs no consensus, for it is objectively false. A hypothesis that is neither demonstrated nor disproven gains credibility, and not because a dozen or even 12,000 papers endorse it but because – and to the extent that – it has not been demonstrated to be false. Science is not a belief system. *A priori*, then, head-counts are inappropriate tests of scientific results.

Problems in defining the climate consensus

Al-Haytham’s scientific method required observing nature, stating a problem precisely, formulating a hypothesis to address it, testing the hypothesis, analyzing the results, drawing conclusions, and publishing the findings. It is essential to the scientific method that a tentative theory be stated in rigorously precise terms.

In particular, the definition of the hypothesis should be expressed quantitatively. An imprecisely defined hypothesis, especially if it is not quantitative, may be insufficiently rigorous to be testable. If it be untestable, then, *stricto sensu*, it is not of interest to science. It is a mere curiosity. Yet Cook *et al.* do not confine themselves to a single definition of the hypothesis to which their consensus is said to adhere. Three definitions of climate consensus coexist in the paper –

Definition (1): “the consensus position that humans are causing global warming” (abstract);

Definition (2): the “scientific consensus that human activity is very likely causing most of the current GW (anthropogenic global warming, or AGW)” (introduction);

Definition (3): that our enhancement of the greenhouse effect will be dangerous enough to be “catastrophic”; (implicit in the introduction, in discussion of the need to raise awareness of scientific consensus to justify a “climate policy”, and explicit in Table 2 of Cook *et al.*, citing a paper opposing “the catastrophic view of the greenhouse effect”).

President Obama was among those who thought Cook *et al.* had shown a consensus endorsing definition (3). The following tweet was posted in his name:

“Ninety-seven percent of scientists agree: #climate change is real, man-made *and dangerous.*” [Emphasis added]

Definitions (1, 3) fall short of the criteria for definition of a Popper-falsifiable hypothesis, and definition (2) could have been clearer. Not only do Cook *et al.* adopt the definitions interchangeably, but each definition is imprecise and insufficiently quantified to allow rigorous Popper-falsification. None of the definitions specifies the period to which it applies, or how much global warming was observed over that period, or whether the warming is continuing, or, if so, at what rate, or whether that rate is considered dangerous, or what rate if any is considered dangerous.

Additionally, definitions (1) and (3) do not specify what fraction of warming was considered anthropogenic, and definition (2) assigns no quantitative value to the term “very likely”. Such imprecisions render the hypotheses unfalsifiable and hence beyond the realm of legitimate scientific inquiry.

Definition (2) is akin to, but less precise than, that of the Intergovernmental Panel on Climate Change (IPCC, 2007, p. 665):

“Greenhouse gas forcing has *very likely* [90% confidence] caused most of the observed global warming over the last 50 years.”

Definition (3) is implicit in the opening words of Cook *et al.*:

“An accurate perception of the degree of scientific consensus is an essential element to public support for climate policy (Ding *et al.*, 2011). Communicating the scientific consensus also increases people’s acceptance that climate change is happening (Lewandowsky *et al.*, 2012).”

The implication is that the authors of all abstracts endorsing definitions (1) and (2) also endorse the catastrophist definition (3). However, a hypothesis to the effect that humans cause some warming, or even that most current global warming is very likely to be anthropogenic, is not – and need not imply – a hypothesis that current warming, if continued, might prove sufficiently damaging to justify a climate

policy. It is by this unwarranted extension that President Obama's Twitterer erroneously assumed that the survey indicated 97% endorsement of catastrophic global warming.

The use of multiple imprecise and ill-quantified definitions of climate consensus has some precedents in the literature. Cook *et al.* cite two instances:

“Surveys of climate scientists have found strong agreement (97-98%) regarding AGW amongst publishing climate experts (Doran & Zimmerman, 2009; Anderegg *et al.*, 2010).”

Doran and Zimmerman (2009)

The two authors sent a 2-minute online survey to 10,257 earth scientists at universities and government research agencies. Only 5% of the 3,146 respondents identified themselves as climate scientists; 90% believed mean global temperatures had generally risen compared with pre-1800s levels; and 82% believed human activity was a significant contributing factor in changing mean global temperatures. Only 79 of the respondents listed climate science as their area of expertise and had also published more than half of their recent peer-reviewed papers on climate change. Of these, 98% believed human activity was a significant contributing factor in changing mean global temperatures. However, the sample size was insufficient to deliver a statistically reliable result, and the respondents were not asked whether they believed the anthropogenic influence on temperature might become sufficiently damaging to require a “climate policy”.

Anderegg *et al.* (2010)

From publication and citation data, the authors selected 908 of 1372 climate researchers, defined as people who had published at least 20 climate papers and had either signed petitions opposing or supporting the IPCC's positions or had co-authored IPCC reports. Of these, 97-98% believed that “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”. The definition of the consensus in Anderegg *et al.* is less imprecise than definition (2) in Cook *et al.* Yet, like Cook *et al.*, Anderegg *et al.* did not seek to determine how many researchers considered global warming to be actually or potentially damaging enough to require a climate policy. Nevertheless, the two surveys are often cited as demonstrating a near-unanimous scientific consensus in favor of a climate policy, when in fact, like Cook *et al.*, neither survey had asked any question either about whether and to what extent the anthropogenic component in recent warming might be dangerous or about whether a “climate policy” should be adopted in attempted mitigation of future warming.

In Cook *et al.*, the definition of consensus hypothesis that comes closest to those of the IPCC and of other head-count papers is definition (2). Table 1 lists some of these definitions.

Source Quantitative definition of climate consensus

IPCC (2001), “... most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.”
Ch. 12 (attribution), p. 699

Oreskes (2004) As IPCC (2001), *supra*.

IPCC (2007), “Greenhouse gas forcing has *very likely* [90% confidence]

Ch. 9 (attribution), p.665	caused most of the observed global warming over the last 50 years.”
Schulte (2008)	As IPCC (2001), <i>supra</i> .
Doran & Zimmerman (2009)	“... human activity is a significant contributing factor in changing mean global temperatures.”
Anderegg <i>et al.</i> (2010)	“... 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.”
Cook <i>et al.</i> (2013), definition (2)	“...scientific consensus that human activity is very likely causing most of the current GW (anthropogenic global warming, or AGW).”

Table 1. Successive quantitative definitions of a climate consensus.

Incomplete statement of the survey results

None of the seven “levels of endorsement” by which Cook *et al.* categorize their selected abstracts provides evidence that any of the 11,944 abstracts encompasses the catastrophist definition (3):

- 1 “Explicitly states that humans are the primary cause of global warming”
- 2 “Explicit endorsement without quantification”
- 3 “Implicit endorsement”
- 4 “No opinion, or uncertain”
- 5 “Implicit rejection”
- 6 “Explicit rejection without quantification”
- 7 “Explicit rejection with quantification”

The first endorsement level, “Explicitly states that humans are the primary cause of global warming”, reflects definition (2) and is akin to the other definitions in Table 1. The second and third levels, “Explicit endorsement without quantification” and “Implicit endorsement”, reflect definition (1) in that, like it, they are not quantitative. Yet the first three levels of endorsement are treated as one in the results:

“To simplify the analysis, ratings were consolidated into three groups: endorsements (including implicit and explicit: categories 1-3) ...”.

Results of an inspection of the Cook *et al.* data file

It is not possible to discern either from the paper or from the supplementary information what fraction of all abstracts endorse definition (2). A file of raw data was supplied, though it was only posted online some weeks after publication. This comma-delimited text file was downloaded and the abstracts allocated by Cook *et al.* to each level of endorsement were counted. Results are given in Table 2:

E.Level	1	2	3	4	5	6	7	Total
	Explicit support	Explicit support	Implicit support	No opinion	Implicit rejectn.	Explicit rejectn.	Explicit rejectn.	

	+quant	-quant	-quant	/uncert	-quant	-quant	+quant	
Papers	64	922	2910	7970	54	15	9	11,944
% all	0.5%	7.7%	24.4%	66.7%	0.5%	0.1%	0.1%	100%
% opin	1.6%	23.0%	72.5%		1.3%	0.4%	0.2%	99%

Table 2. Abstracts in the seven levels of endorsement specified in Cook *et al.* (2013). Only 64 abstracts, according to the authors' data file, explicitly endorsed definition (2), the quantitative hypothesis. NB: "+quant" indicates "with quantification"; "-quant" indicates "without quantification"; "% all" indicates the percentage of all 11,944 abstracts that fell in each level of endorsement; "% opin" indicates the percentages of all 4014 abstracts, excluding the 7930 that expressed no opinion but including the 40 that expressed uncertainty (1% of all papers). These 40 are not shown separately in the datafile or in the table. Therefore, the percentages of papers expressing an opinion sum to 99%, not 100%.

Definition (1): The count confirmed the authors' count that 3896 of the 11,944 abstracts (i.e., 32.6%) fell in their endorsement levels 1-3, indicating that fewer than one-third of all abstracts indicate implicit or explicit support even for the limited definition (1) hypothesis that humans cause some warming. It was only by excluding those 7930 endorsement-level-4 abstracts that expressed no opinion (but retaining the 40 level-4 abstracts expressing uncertainty) that Cook *et al.* were able to conclude that 97.1% endorsed consensus.

Definition (2): The count, in line with an earlier result published by Friends of Science in Canada, showed only 64 papers, or just 0.5% of the sample, explicitly endorsing the quantitative hypothesis to the effect that humans are the primary cause of current warming. This value was independently verified by a separate inspection of the data file to identify occurrences of the search term ",1" at the end of each data record using the search facility in Microsoft Notepad, whereupon 64 such occurrences were indeed found. However, of the 64 abstracts to which Cook *et al.* assigned an endorsement level of 1 ("explicit endorsement with quantification": Annex 1), 23 do not in fact endorse definition (2). Only 41 papers (0.3% of the sample: Annex 2) endorse definition (2).

The conclusion of Cook *et al.*, as expressed in their abstract, is as follows:

"Among [4014] abstracts expressing a position on AGW, 97.1% endorsed the consensus position that humans are causing global warming."

A 97% consensus is also asserted in the closing words of the paper:

"Among [4014] papers expressing a position on AGW, an overwhelming percentage (97.2% based on self-ratings, 97.1% based on abstract ratings) endorses the scientific consensus on AGW."

In the introduction. Cook *et al.* define "AGW" as the "scientific consensus that human activity is very likely causing most of the current GW (anthropogenic global warming, or AGW)". However, the authors' own analysis shows that only 0.5% of all 11,944 abstracts, and 1.6% of the 4014 abstracts expressing a position, endorsed "AGW" as they had defined it. Taking into account that more than one-third of the 64 abstracts do not in fact endorse the quantitative hypothesis in Cook *et al.*, the true percentages endorsing that hypothesis are 0.3% and 1.0% respectively.

Evidence that the climate consensus is declining

Oreskes (2004) published an essay in *Science* alleging that not one of 928 abstracts she had reviewed had disagreed with the consensus as defined in IPCC (2001): “Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations”. Her adopted definition of consensus, then, was similar to but more precise than definition (2) in Cook *et al.* It, too, falls well short of stating that manmade warming may prove catastrophic.

Her essay concluded that three-quarters of her sample endorsed the “consensus” either explicitly or, by evaluating impacts or proposing mitigation, implicitly. A quarter took no view. None, she said, disagreed with the consensus as defined in IPCC (2001). Yet the fact that a paper evaluates impacts or proposes mitigation does not necessarily imply that the authors endorse the notion that more than half of the past 50 years’ global warming was anthropogenic.

Schulte (2008) reviewed 539 papers published in the three years following the period studied by Oreskes, using the same search term and the same IPCC definition of consensus. He found that “the proportion of papers that now explicitly or implicitly endorse the consensus has fallen from 75% to 45%.” Only 2% of the papers reviewed “offer new field data or observations directly relevant to the question whether anthropogenic warming has prevailed over natural variability in the past half-century”. Only one paper mentioned the possibility of catastrophic climate change, but without providing any evidence for it. No paper provided quantitative evidence for the consensus hypothesis. Schulte concluded: “There appears to be little basis in the peer-reviewed literature for the degree of alarm on the issue of man-made climate change which is being expressed in the media and by politicians.”

The 75% consensus reported by Oreskes in 2004 exceeds the 45% found by Schulte in 2008, which in turn exceeds the 0.5-1.6% (0.3-1.0% after correction) found but not reported by Cook *et al.* in 2013.

Accordingly, the undisclosed results in Cook *et al.* indicate either that earlier head-count papers had not (as Cook *et al.* in their published results had not) drawn any distinction between quantified and unquantified consensus, or that over the past decade the consensus has dwindled.

Has there been any ‘current’ warming?

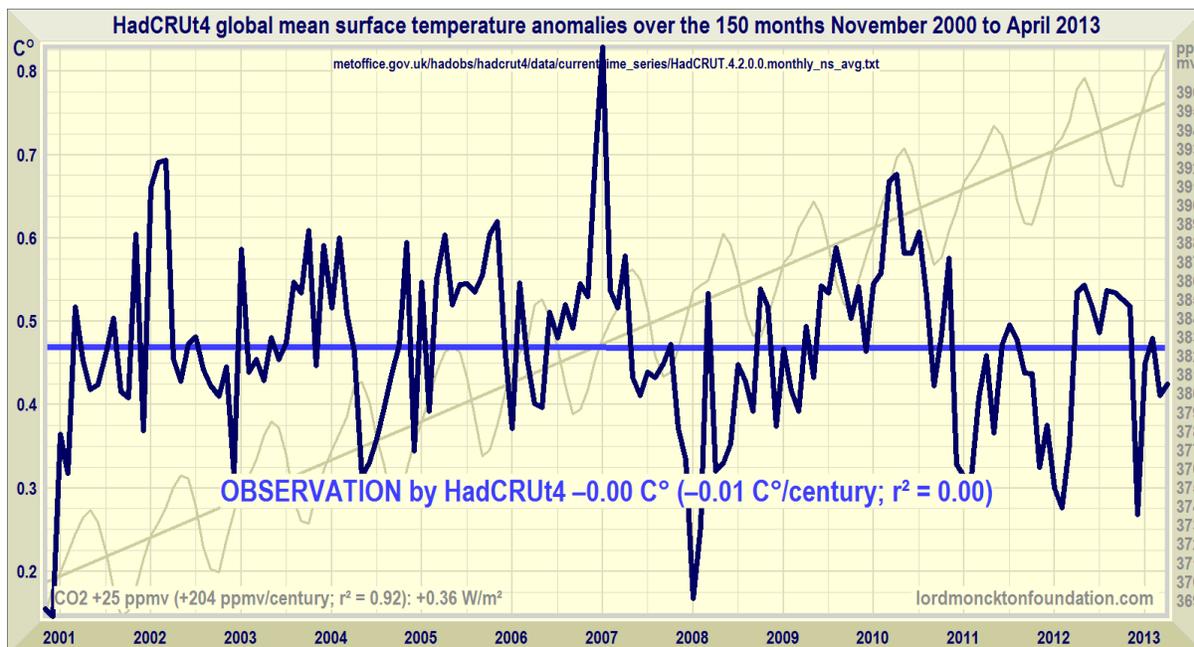


Figure 2. No global warming for 12 years 6 months, according to the HadCRUt4 dataset.

Cook *et al.*'s definition (1) is that "humans are causing global warming". Definition (2) is that humans are the chief cause of "the current warming". Though the least-squares linear-regression trend on the monthly HadCRUt4 dataset (Morice *et al.*, 2012) shows surface warming over the half-century 1956-2005 at a rate equivalent to 1.2 C°/century, trends on the same dataset over shorter periods show no warming exceeding the upper bound of the published measurement uncertainties for more than 17 years, no warming at all over the 12 years 6 months November 2000 to May 2013 (Fig. 2), and cooling at 0.5 C°/century over the decade May 2003-April 2013.

In the usual sense of the word "current", then, global warming is not currently occurring, rendering definitions (1) and (2) untestable: for no scientist could legitimately endorse a consensus to the effect that global warming is currently occurring when, currently, it is not.

Discussion

The defects identified in the surveys of climate consensus by Cook *et al.* and by the authors of some of the papers they cite follow a pattern to whose existence peer-reviewers should be alert. First, any argument from consensus on a question such as the extent to which anthropogenic global warming may prove dangerous is defective *a priori* and ought really to be rejected without further review.

Secondly, no survey of opinion for or against a consensus hypothesis ought to be regarded as scientific where it is not made clear which hypothesis is under test, or where the hypothesis under test is not clearly and precisely formulated. *A fortiori*, a survey paper that exhibits multiple definitions of the consensus hypothesis and fails to state clearly the identity and definition of the hypothesis on the basis of which the survey was actually conducted should surely be rejected.

Thirdly, the consensus hypothesis under test ought to be expressed in quantitative terms. Mere qualitative definitions of any scientific hypothesis run the risk of appearing more political than scientific

in their formulation, and papers based on such definitions may also prove more political than scientific in their effect.

Fourthly, if several “levels of endorsement” are specified, then the number of abstracts, papers, or scientists considered to have supported each level of endorsement ought to be explicitly stated in the paper under review. Cook *et al.* specified three levels of endorsement that supported the notion of anthropogenic warming (however defined); yet, on the stated ground of simplifying the analysis, the number of papers allocated to each of the three levels of endorsement – a key result on any view – was not stated. The analysis would indeed have been simpler if one endorsement level supporting one definition of climate consensus had been adopted.

Fifthly, all data files and programs should be archived at the time of submission to the journal and included at the time of publication as part of the supplementary material. Reviewers should ask for the datafiles and programs if they are not available.

Conclusion

The non-disclosure in Cook *et al.* of the number of abstracts supporting each specified level of endorsement had the effect of not making available the fact that only 41 papers – 0.3% of all 11,944 abstracts or 1.0% of the 4014 expressing an opinion, and not 97.1% – had been found to endorse the quantitative hypothesis, stated in the introduction to Cook *et al.* and akin to similar definitions in the literature, that “human activity is very likely causing most of the current GW (anthropogenic global warming, or AGW)”.

References

- Anderegg, W.R.L., J.W. Prall J. Harold, and S.H. Schneider, 2010, Expert credibility in climate change, *Proc. Nat. Acad. Sci. USA* 107: 12107-9.
- Aristotle, c. 350 B.C.E., *Sophistical Refutations*, CreateSpace Independent Publishing Platform, 2012, 52 pp.
- Cook, J., D. Nuccitelli, S.A. Green, M. Richardson, B. Winkler, R. Painting, R. Way, P. Jacobs, and A. Skuce, 2013, Quantifying the consensus on anthropogenic global warming in the scientific literature, *Environ. Res. Lett.* 8: 024024 (7 pp), doi:0.1088/1748-9326/8/2/024024.
- Ding, D., E.W. Maibach, X. Zhao, C> Roser-Renouf, and A. Leiserowitz, 2011, Support for climate policy and societal action are linked to perceptions about scientific agreement, *Nature Clim. Change* 1, 462-5.
- Doran, P., and M. Zimmerman, 2009, Examining the scientific consensus on climate change, *EOS Trans. Am. Geophys. Union* 99: 22-23.
- Einstein, A., 1905, Zur Elektrodynamik bewegter Körper. *Annalen der Physik* 322: 891-921, doi:10.1002/andp.19053221004.
- IPCC, 2001, *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 881 pp.
- IPCC, 2007, *Climate Change 2007: the Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller (eds.)], Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA.
- Lewandowsky, S., G. Gilles, and S. Vaughan, 2012, The pivotal role of perceived scientific consensus in acceptance of science, *Nature Clim. Change* 3, 399-404.
- Morice, C.P., J.J. Kennedy, N.A. Rayner, and P.D. Jones, 2012, Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRU4 data set, *J. Geophys. R.* 117:D8, DOI: 10.1029/2011JD017187
- Oreskes, N., 2004, The scientific consensus on climate change, *Science* 306: 1686.
- Popper, K.R., 1934, *Logik der Forschung*, Vienna: reprinted 1959 as *The Logic of Scientific Discovery*, Hutchinson & Co., London, 480 pp.
- Schulte, K.-M., 2008, Scientific consensus on climate change?, *Energy & Environment* 19:2, 281-286, doi:10/1060/095830508783900744.

The 41 papers endorsing the quantitative consensus

Relevant extracts from those 41 of 64 abstracts listed by Cook *et al.* as endorsing their quantitative definition of the consensus hypothesis that actually endorse it are below. The remaining 23, in Annex 2, do not endorse it.

The data entries have been edited for clarity, particularly by including a space after each delimiting comma; decapitalizing abstract titles; abbreviating and italicizing journal names; removing a “[” mark that appeared after each author’s name; capitalizing all authors’ initials; and correcting some typographical errors.

1: 1992, Implications for global warming of intercycle solar irradiance variations, *Nature*, Schlesinger M.E.; Ramankutty N, 2, 1

“... we find that since the nineteenth century, greenhouse gases, not solar irradiance variations, have been the dominant contributor to the observed temperature changes.”

4: 1994, Greenhouse statistics – Time-series analysis 2, *Theor. & Appl. Climatol.*, Tol RSJ, 4, 1

“... the hypothesis that the anthropogenically enhanced greenhouse effect is not responsible for the observed global warming during the last century is rejected with a 99% confidence, is reconfirmed.”

6: 1997, Assessments of the global anthropogenic greenhouse and sulfate signal using different types of simplified climate models, *Theor. & Appl. Climatol.*, Schonwiese CD; Denhard M; Grieser J; Walter A, 2, 1

“Our statistical assessments, based on the 1866–1994 period, lead to a GHG signal of 0.8–1.3 K and a combined GHG-SU signal of 0.5–0.8 K detectable in observations. This is close to GCM simulations and clearly larger than the volcanic, solar and ENSO (El Niño/southern oscillation) signals also considered.”

11: 2000, Recent warming in a 500-year palaeotemperature record from varved sediments; Upper Soper Lake; Baffin Island; Canada, *Holocene*, Hughen KA; Overpeck JT; Anderson RF, 5, 1

“Comparisons of Upper Soper Lake and Arctic average palaeotemperature to proxy-records of hypothesized forcing mechanisms suggest that the recent warming trend is mostly due to anthropogenic emissions of atmospheric greenhouse gases.”

14: 2002, Global Warming 2001, *J. de Physique IV*, Berger A, 4, 1

“In its Third Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) states clearly that "an increasing body of observations give a collective picture of a warming world and other changes in the climate system" and that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities".

16: 2003, Do models underestimate the solar contribution to recent climate change?, *J. Clim.*, Stott PA; Jones GS; Mitchell JFB, 4, 1

“... the results confirm previous analyses showing that greenhouse gas increases explain most of the global warming observed in the second half of the twentieth century.”

17: 2003, Modern global climate change, *Science*, Karl TR; Trenberth KE, 2, 1

“Modern climate change is dominated by human influences, which are now large enough to exceed the bounds of natural variability. The main source of global climate change is human-induced changes in atmospheric composition.”

19: 2004, Numerical simulation of global temperature change during the 20th century with the IAP/LASG GOALS model, *Advances In Atmos. Sci.*, Ma XY; Guo YF; Shi GY; Yu YQ, 2, 1

“The global warming during the 20th century is caused mainly by increasing greenhouse gas concentration especially since the late 1980s.”

20: 2004, Soot climate forcing via snow and ice albedos, *PNAS*, Hansen J; Nazarenko L, 4, 1

“... soot contributions to climate change do not alter the conclusion that anthropogenic greenhouse gases have been the main cause of recent global warming and will be the predominant climate forcing in the future.”

22: 2005, Mid-late Holocene monsoon climate retrieved from seasonal Sr/Ca and $\delta_{18}\text{O}$ records of *porites lutea* corals at Leizhou Peninsula; northern coast of South China Sea, *Global & Planetary Change*, Yu KF; Zhao JX; Wei GJ; Cheng XR; Wang PX, 5, 1

“... the increase in the concentration of anthropogenic greenhouse gases played a dominant role in recent global warming, ...”

23: 2006, Assessment of 20th-century regional surface temperature trends using the GFDL CM2 coupled models, *J. Clim.*, Knutson TR; Delworth TL; Dixon KW; Held IM; Lu J; Ramaswamy V; Schwarzkopf MD; Stenchikov G; Stouffer RJ, 4, 1

“The simulations support previous findings that twentieth-century global warming has resulted from a combination of natural and anthropogenic forcing, with anthropogenic forcing being the dominant cause of the pronounced late-twentieth-century warming.”

25: 2006, Phenomenological solar contribution to the 1900-2000 global surface warming, *GRL*, Scafetta N; West BJ, 4, 1

“We estimate that the sun contributed as much as 45–50% of the 1900–2000 global warming, and 25–35% of the 1980–2000 global warming. These results, while confirming that anthropogenic-added climate forcing might have progressively played a dominant role in climate change during the last century, also suggest that the solar impact on climate change during the same period is significantly stronger than what some theoretical models have predicted.”

27: 2006, Study on CO₂ recovery system from flue gas by honeycomb type adsorbent I – results of tests and simulation), *Kagaku Kogaku Ronbunshu*, Matsukuma Y; Matsushita Y; Kakigami H; Inoue G; Minemoto M; Yasutake A; Oka N, 3, 1

“Carbon dioxide (CO₂) included in the exhaust gas from heat power plants is the chief cause of global warming.”

29: 2007, A model for the CO₂ capture potential, *Int. J. GHG Control*, Stanyeland A, 3, 1

“Global warming is a result of increasing anthropogenic CO₂ emissions, and the consequences will be dramatic climate changes if no action is taken.”

30: 2007, Avoiding self-organized extinction: toward a co-evolutionary economics of sustainability, *Int. J. Sustain. Devel. & World Ecol.*, Gowdy J, 2, 1

“There is a a near-universal consensus that global warming is human-caused and that its effects are now accelerating.”

31: 2007, CO₂ emissions from road transport and selected parts in the Kosice City, *Acta Montanistica Slovaca*, Carach V; Muller G; Janoskova K, 4, 1

“Nowadays it is clear that the climatic instability is mostly caused by human activities.”

32: 2007, Global climate change and children's health, *Pediatrics*, Shannon MW; Best D; Binns HJ; Forman JA; Johnson CL; Karr CJ; Kim JJ; Mazur LJ; Roberts JR; Shea KM, 2, 1

There is a broad scientific consensus that the global climate is warming, the process is accelerating, and that human activities are very likely (>90% probability) the main cause.”

33: 2007, Global warming is driven by anthropogenic emissions: a time series analysis approach, *Phys. Rev. Lett.*, Verdes PF, 2, 1

“Here we show, using two independent driving force reconstruction techniques, that the combined effect of greenhouse gases and aerosol emissions has been the main external driver of global climate during the past decades.”

35: 2008, Carbonation of alkaline paper mill waste to reduce co2 greenhouse gas emissions into the atmosphere, *Appl. Geochem.*, Perez-Lopez R; Montes-Hernandez G; Nieto JM; Renard F; Charlet L, 3, 1

“The global warming of Earth’s near-surface, air and oceans in recent decades is a direct consequence of anthropogenic emission of greenhouse gases into the atmosphere such as CO₂, CH₄, N₂O and CFCs. The CO₂ emissions contribute approximately 60% to this climate change.”

36: 2008, Climate policy architectures for the post-Kyoto world, *Environment*, Aldy JE; Stavins RN, 3, 1

“The Intergovernmental Panel on Climate Change has determined earlier that most of the increase in global average temperatures is very likely due to the adverse increase in anthropogenic greenhouse gas concentrations.”

37: 2008, Cycle analysis of low and high H₂ utilization SOFCS/gas turbine combined cycle for CO₂ recovery, *Electronics & Comms. in Japan*, Taniuchi T; Sunakawa D; Nagahama M; Araki T; Onda K; Kato T, 3, 1

“Global warming is mainly caused by CO₂ emission from thermal power plants, which burn fossil fuel with air.”

38: 2008, Energy sources and global climate change: the Brazilian case, *Energy Sources A*, Simoes AF; La Rovere EL, 3, 1

“Fossil fuels consumption is the primary cause of global warming.”

41: 2008, Leaf carbon assimilation in a water-limited world, *Plant Biosys.*, Loreto F; Centritto M, 2, 1

“Over the past 150 years the amount of CO₂ in the atmosphere has been increasing, largely as a result of land-use change and anthropogenic emissions from the burning of fossil fuels.”

42: 2008, On avoiding dangerous anthropogenic interference with the climate system: formidable challenges ahead, *PNAS*, Ramanathan V; Feng Y, 2, 1

IPCC models suggest that ≈25% (0.6°C) of the committed warming has been realized as of now.

43: 2008, The potential of water power in the fight against global warming in the US, *Energy Policy*, Kosnik L, 3, 1

“The leading cause of climate change today is the burning of fossil fuels related to energy production.”

45: 2009, Climate changes and the actions of the European Union for environmental protection, *Metalurgia Int.*, Brezoi AG; Tharin M, 4, 1

“According to the meetings of the experts ... the human origin of present-day climate changes is estimated at 90%.”

47: 2010, A novel formulation of carbon emissions costs for optimal design configuration of system transmission planning, *Renewable Energy*, Sadegheih A, 3, 1

“Global warming, which is mainly caused by the emissions of Green House Gases (GHGs), is said to be a serious part of these environmental problems.”

48: 2010, Analysis of the global warming dynamics from temperature time series, *Ecol. Modelling*, Viola FM; Paiva SLD; Savi MA, 4, 1

“Global warming is the observed increase of the average temperature of the Earth. The primary cause of this phenomenon is the release of the greenhouse gases by burning of fossil fuels, land cleaning, agriculture, among others, leading to the increase of the so-called greenhouse effect.”

50: 2010, Conceptual design and simulation analysis of thermal behaviors of TGR blast furnace and oxygen blast furnace, *Science China – Technol.*, Zhang H; Li HQ; Tang Q; Bao WJ, 3, 1

“Extensive use of carbon based fuel is the main inducement for global warming and more extreme weather.”

51: 2010, Consumption-based accounting of CO₂ emissions, *PNAS*, Davis SJ; Caldeira K, 4, 1

“CO₂ emissions from the burning of fossil fuels are the primary cause of global warming.”

52: 2010, Dynamic competition under cap and trade programs, *Infor*, Jeev K; Campos-Nanez E, 3, 1

“Greenhouse gases (GHG), like carbon dioxide (CO₂), which are released in the atmosphere due to anthropogenic activities like power production, are now accepted as the main culprits for global warming.”

53: 2010, Short-term effects of controlling fossil-fuel soot; biofuel soot and gases; and methane on climate; arctic ice; air pollution; and health, *JGR Atmos.*, Jacobson MZ, 3, 1

“... net global warming (0.7–0.8 K) is due mostly to gross pollutant warming from fossil-fuel greenhouse gases (2–2.4 K), ...”

56: 2011, Early onset of significant local warming in low latitude countries, *Env. Res. Lett.*, Mahlstein I; Knutti R; Solomon S; Portmann RW, 2, 1

“... most of the global warming of the past half-century can very likely be attributed to human influence.”

57: 2011, Earth's energy imbalance and implications, *Atmos. Chem. & Phys.*, Hansen J; Sato M; Kharecha P; Von Schuckmann K, 4, 1

“The inferred planetary energy imbalance, $0.58 \pm 0.15 \text{ W m}^{-2}$ during the 6-yr period 2005–2010, confirms the dominant role of the human-made greenhouse effect in driving global climate change.”

58: 2011, Emergent dynamics of the climate-economy system in the anthropocene, *Philos. Trans. Royal Soc. A*, Kellie-Smith O; Cox PM, 4, 1

59: 2011, Insights on global warming, *Aiche J.*, Seinfeld JH, 4, 1

“The global temperature increase over the last century and a half (~ 0.8°C), and the last three decades in particular, is well outside of that which can be attributed to natural climate fluctuations. The increase of atmospheric CO₂ over this period has been conclusively demonstrated to be a result largely of fossil fuel burning. ... That the Earth has warmed and that GHGs are responsible is unequivocal.”

60: 2011, isolation and application of SO_x- and NO_x-resistant microalgae in biofixation of CO₂ from thermo-electricity plants, *Energy Conversion And Management*, Radmann EM; Camerini FV; Santos TD; Costa JAV, 3, 1

“Microalgae have been studied for their potential use in foodstuffs, agriculture, in the treatment of wastewater and, in particular, in the reduction of atmospheric carbon dioxide, the main cause of global warming.”

61: 2011, On the time-varying trend in global-mean surface temperature, *Clim. Dynam.*, Wu ZH; Huang NE; Wallace JM; Smoliak BV; Chen XY, 4, 1

“... we estimate that up to one third of the late twentieth century warming could have been a consequence of natural variability.”

62: 2011, Performance of amine-multilayered solid sorbents for CO₂ removal: effect of fabrication variables, *Int. J. GHG Control*, Jiang BB; Kish V; Fauth D; Gray ML; Pennline HW; Li BY, 3, 1

“The emission of fossil fuel carbon dioxide (CO₂) to the atmosphere is implicated as the predominant cause of global climate change.”

63: 2011, Sensitivity of the attribution of near surface temperature warming to the choice of observational dataset, *GRL*, Jones GS; Stott PA, 4, 1

“Our results show that the dominant contributor to global warming over the last 50 years of the 20th century is that due to greenhouse gases.”

64: 2011, The relative contribution of waste heat from power plants to global warming, *Energy*, Zevenhoven R; Beyene A, 4, 1

“Evidence on global climate change, being caused primarily by rising levels of greenhouse gases in the atmosphere, is perceived as fairly conclusive.”

Annex 2

The 23 papers not endorsing the quantitative consensus

Relevant extracts from those 23 of the 64 abstracts listed by Cook *et al.* as endorsing their quantitative definition of the consensus hypothesis that do not endorse it are below, with reasons why they do not endorse it. The remaining 41 abstracts, in Annex 1, endorse it.

The data entries have been edited for clarity, particularly by including a space after each delimiting comma; decapitalizing abstract titles; abbreviating and italicizing journal names; removing a “[” mark that appeared after each author’s name; capitalizing all authors’ initials; and correcting some typographical errors.

2: 1992, Past; present and future levels of greenhouse gases in the atmosphere and model projections of related climatic changes, *J. Experim. Botany*, Roeckner E, 2, 1

“The more recent increase in greenhouse gases since pre-industrial times can be related to human activities.”

Reason for rejection: The increase “can be related to human activities”, but the abstract falls short of saying that most of the increase is attributable to human activities.

3: 1993, How sensitive is the world’s climate?, *Research & Explor.*, Hansen J; Lacis A; Ruedy R; Sato M; Wilson H, 4, 1

“Observed global warming of approximately 0.5 C° in the past 140 years is consistent with anthropogenic greenhouse gases being the dominant climate forcing in that period.”

Reason for rejection: “... is consistent with” is not the same thing as “is likely to have been”.

5: 1995, Climate response to increasing levels of greenhouse gases and sulfate aerosols, *Nature*, Mitchell JFB; Johns TC; Gregory JM; Tett SFB, 4, 1

“CLIMATE models suggest that increases in greenhouse-gas concentrations in the atmosphere should have produced a larger global mean warming than has been observed in recent decades, unless the climate is less sensitive than is predicted by the present generation of coupled general circulation models.”

Reason for rejection: The abstract qualifies its first statement by saying that the climate may be less sensitive than models predict.

7: 1998, A Bayesian statistical analysis of the enhanced greenhouse effect, *Clim. Change*, Tol RSJ; De Vos AF, 4, 1

“... there is a robust statistical relationship between the records of the global mean surface air temperature and the atmospheric concentration of carbon dioxide over the period 1870–1991. As such, the enhanced greenhouse effect is a plausible explanation for the observed global warming.”

Reason for rejection: The greenhouse effect is a “plausible explanation”, but it is not definite, and there is no quantification.

8: 1999, CFC and halon replacements in the environment, *J. Fluor. Chem.*, McCulloch A, 3, 1

“Substitute fluorocarbons may have direct environmental impact, for example as greenhouse gases ... The growth in hydrofluorocarbons (HFCs) amounts to about 10% of the fall in CFCs. It is likely that the impact of new fluorocarbons on climate change will be a very small fraction of the total impact, which comes mainly from the accumulation of carbon dioxide in the atmosphere.”

Reason for rejection: The “total impact” mentioned in the abstract is the impact of Man, not that of Man and nature combined. Man’s impact does come mainly from the accumulation of CO₂ in the air, but that falls short of saying that Man’s impact has caused more than half of recent warming.

9: 2000, Causes of climate change over the past 1000 years, *Science*, Crowley TJ, 5, 1

“The combination of a unique level of temperature increase in the late 20th century and improved constraints on the role of natural variability provides further evidence that the greenhouse effect has already established itself above the level of natural variability in the climate system.”

Reason for rejection: The greenhouse effect may (or may not) have added to the warming that may have arisen from natural variability, but there is no quantification of how much it has added to natural warming.

10: 2000, Radiative forcings and global warming potentials of 39 greenhouse gases, *JGR Atmos.*, Jain AK; Briegleb BP; Minschwaner K; Wuebbles DJ, 4, 1

“Our total radiative forcing due to increase in major greenhouse gas concentrations for the period 1765–1992 is 2.32 Wm^{-2} , only 2% higher than other recent estimates; however, the differences for individual gases are as large as 23%.”

Reason for rejection: Stating the magnitude of a radiative forcing falls short of stating the magnitude of the warming the forcing may be thought to have engendered.

12: 2000, Response of the NCAR climate system model to increased CO₂ and the role of physical processes, *J. Clim.*, Meehl GA; Collins WD; Boville BA; Kiehl JT; Wigley TML; Arblaster JM, 4, 1

“Another process that contributes to climate response to increasing CO₂ is sea-ice changes, which are estimated to enhance global warming by roughly 20% in the CSM and 37% in the DOE model. Sea-ice retreat with increasing CO₂ in the CSM is less than in the DOE model in spite of identical sea-ice formulations.”

Reason for rejection: The fact that global warming in the future may be enhanced by sea-ice retreat tells us nothing about whether global warming in the past has chiefly been manmade.

13: 2001, Strong radiative heating due to the mixing state of black carbon in atmospheric aerosols, *Nature*, Jacobson MZ, 4, 1

“The magnitude of the direct radiative forcing from black carbon itself exceeds that due to CH₄, suggesting that black carbon may be the second most important component of global warming after CO₂ in terms of direct forcing.”

Reason for rejection: The abstract is talking of the manmade component, not including the natural component. So there is no quantification of the relative magnitudes of the two: nor is any period specified.

15: 2002, Modeling future climate changes: certainties and uncertainties, *Houille Blanche Revue Internationale de l'Eau*, Le Treut H, 4, 1

“Present projections indicate, in all cases, a significant change, with a global surface warming in 2100 between 2 C° and 6 C°.”

Reason for rejection: Projections are one thing; observations another. The fact that global warming is projected tells us nothing about what fraction of it in the observed past is attributable to Man.

18: 2003, Utilization of carbon dioxide as soft oxidant in the dehydrogenation of ethylbenzene over supported vanadium-antimony oxide catalystst, *Green Chemistry*, Chang JS; Vislovskiy VP; Park MS; Hong DY; Yoo JS; Park SE, 3, 1

“This work shows that carbon dioxide, which is a main contributor to the global warming effect, could be utilized as a selective oxidant in the oxidative dehydrogenation of ethylbenzene over alumina-supported vanadium oxide catalysts.”

Reason for rejection: “A main contributor” is not the same as “the main contributor”.

21: 2005, Is the Sonoran Desert losing its cool?, *Global Change Biol.*, Weiss JL; Overpeck JT, 2, 1

“Minimum temperature variability in the Sonoran Desert does, however, correspond to global temperature variability attributed to human-dominated global warming.”

Reason for rejection: A correspondence between regional and global patterns of temperature variability attributed to Man is not the same as an assertion that most recent warming is manmade.

24: 2006, Observational constraints on past attributable warming and predictions of future global warming, *J. Clim.*, Stott PA; Mitchell JFB; Allen MR; Delworth TL; Gregory JM; Meehl GA; Santer BD, 4, 1

“... the spatial and temporal nature of observed twentieth-century temperature change constrains the component of past warming attributable to anthropogenic greenhouse gases to be significantly greater (at the 5% level) than the observed warming over the twentieth century.”

Reason for rejection: A 5% confidence level is too low to be reliable.

26: 2006, Positive feedback between global warming and atmospheric CO₂ concentration inferred from past climate change, *GRL*, Scheffer M; Brovkin V; Cox PM, 5, 1

“There is good evidence that higher global temperatures will promote a rise of greenhouse gas levels, implying a positive feedback which will increase the effect of anthropogenic emissions on global temperatures. However, the magnitude of this effect predicted by the available models remains highly uncertain, due to the accumulation of uncertainties in the processes thought to be involved.”

Reason for rejection: The abstract tells us nothing of what *has* happened. It merely predicts what *will* happen.

28: 2006, Transient climate simulations with the HADGEM1 climate model: causes of past warming and future climate change, *J. Clim.*, Stott PA; Jones GS; Lowe JA; Thorne P; Durman C; Johns TC; Thelen JC, 4, 1

“The ability of climate models to simulate large-scale temperature changes during the twentieth century when they include both anthropogenic and natural forcings and their inability to account for warming over the last 50 yr when they exclude increasing greenhouse gas concentrations has been used as evidence for an anthropogenic influence on global warming. ... new simulations support previous work by showing that there was a significant anthropogenic influence on near-surface temperature change over the last century.”

Reason for rejection: “A significant anthropogenic influence” does not necessarily mean “more than 50%”.

34: 2008, Banagrass vs. eucalyptus wood as feedstocks for metallurgical biocarbon production, *Indust. & Eng. Chem. Res.*, Yoshida T; Turn SQ; Yost RS; Antal MJ, 3, 1

“Excessive emissions of fossil CO₂ are known to be a primary cause of global climate change.”

Reason for rejection: “A primary cause” is not the same as “the primary cause”.

39: 2008, Implications of “peak oil” for atmospheric CO₂ and climate, *Global Biogeochem. Cycles*, Kharecha PA; Hansen JE, 3, 1

“Unconstrained CO₂ emission from fossil fuel burning has been the dominant cause of observed anthropogenic global warming.”

Reason for rejection: The dominant cause of *anthropogenic* warming, but not necessarily the dominant cause of *all* global warming.

40: 2008, Industrialization; fossil fuels; and the transformation of land use, *J. Indust. Ecol.*, Erb KH; Gingrich S; Krausmann F; Haberl H, 4, 1

“Human-induced changes in global stocks and flows of carbon are major drivers of global climate change.”

Reason for rejection: “Major drivers”, but not “the major drivers”.

44: 2009, Climate change and drying of agricultural products, *Drying Technol.*, Piacentini RD; Mujumdar AS, 3, 1

“Global warming is affecting the world and will continue to affect humans and the ecosystem in the future.”

Reason for rejection: Global warming may or may not be “affecting the world”, but there is nothing in the abstract to tell us that more of it is anthropogenic than natural.

46: 2009, Cost-benefit analysis of climate change dynamics: uncertainties and the value of information, *Clim. Change*, Rabl A; Van Der Zwaan B, 4, 1

“We analyze climate change in a cost–benefit framework, using the emission and concentration profiles of Wigley et al. (*Nature* 379(6562):240–243, 1996). They present five scenarios that cover the period 1990–2300 and are designed to reach stabilized concentration levels of 350, 450, 550, 650 and 750 ppmv, respectively.”

Reason for rejection: The abstract concerns itself with projections, and – other than referring to Wigley’s scenarios starting in 1900 – makes no reference to past warming at all, let alone saying that most of it was manmade.

49: 2010, Assessing the climatic benefits of black carbon mitigation, *PNAS*, Kopp RE; Mauzerall DL, 3, 1

“To limit mean global warming to 2 °C, a goal supported by more than 100 countries, it will likely be necessary to reduce emissions not only of greenhouse gases but also of air pollutants with high radiative forcing (RF), particularly black carbon (BC).”

Reason for rejection: The statement of a target for future emissions is not equivalent to a statement that most recent warming was caused by past emissions.

54: 2010, The Copenhagen accord for limiting global warming: criteria; constraints; and available avenues, *PNAS*, Ramanathan V; Xu YY, 3, 1

“At last, all the major emitters of greenhouse gases (GHGs) have agreed under the Copenhagen Accord that global average temperature increase should be kept below 2 °C.”

Reason for rejection: The adoption of a target for future emissions is not equivalent to a statement that most recent warming was caused by past emissions.

55: 2011, Coupled climate-society modeling of a realistic scenario to achieve a sustainable earth, *J. Oceanog.*, Ikeda M, 4, 1

“The surface air temperature (SAT) rises due to the atmospheric carbon, which is partially absorbed by the terrestrial ecosystem and the ocean. These absorption rates are reduced by the rising SAT.”

Reason for rejection: There is no statement here that the surface air temperature rises solely or chiefly owing to the atmospheric CO₂.