THE UNIVERSITY of EDINBURGH

Edinburgh Research Explorer

Comment on “World Atmospheric CO2, Its 14C Specific Activity, Non-fossil Component, Anthropogenic Fossil Component, and Emissions (1750–2018)”

Citation for published version:
Rice, K, Schade, GW & Maslin, MA 2022, 'Comment on “World Atmospheric CO2, Its 14C Specific Activity, Non-fossil Component, Anthropogenic Fossil Component, and Emissions (1750–2018)”', *Health Physics*, vol. 123, no. 1, pp. 28-30. https://doi.org/10.1097/HP.0000000000001582

Digital Object Identifier (DOI):
10.1097/HP.0000000000001582

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Health Physics

General rights
Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

OPEN ACCESS

Download date: 05. Jul. 2023

Dear Editor,

We are writing to comment on a recent paper published in your journal, Health Physics. The paper is titled *World Atmospheric CO_2, Its ^{14}C Specific Activity, Non-fossil Component, Anthropogenic Fossil Component, and Emissions (1750–2018)* by Skrable, Chabot & French (Skrable et al. 2022)(hereinafter called "the paper").

Our comment is two-fold: We will first highlight the fundamental error the authors make, then briefly discuss the implications of publishing such work.

Firstly, the paper concludes that "*the percentage of the total CO_2 due to the use of fossil fuels from 1750 to 2018 increased from 0% in 1750 to 12% in 2018, much too low to be the cause of global warming.*"

The premise of this argument is incorrect, and indicates a fundamental misunderstanding of the causal link between anthropogenic emissions and rising atmospheric CO_2. The fact that atmospheric CO_2 has been rising at only about half the rate of anthropogenic emissions establishes that the natural environment is a net carbon sink and has been actively opposing the rise for at least the last 60 years. Hence we know that anthropogenic emissions, predominantly from fossil fuel combustion and land use change, involve more than sufficient carbon to entirely explain the post-industrial rise (Canadell et al. 2021).

However, an increase in atmospheric CO2 originating from anthropogenic emissions does not imply that the current increase in atmospheric CO2 is made up entirely of CO2 molecules directly linked to anthropogenic emissions. Due to natural processes, carbon atoms are rapidly exchanged between the atmosphere, ocean, and biosphere. This means that carbon atoms from fossil fuels can be exchanged with non-fossil carbon atoms, and in particular, these exchanges occur much more quickly than the overall carbon dioxide concentration changes. Once these well-known carbon cycle exchanges are considered, the abundance and composition of the current carbon in the atmosphere is entirely consistent with anthropogenic emissions being the sole cause of the post-industrial rise (Canadell et al. 2021).

One way to understand this is to consider the period immediately prior to the start of the industrial revolution. Atmospheric CO_2 concentrations had remained roughly steady, at about 280 ppm, for several thousand years (Prentice et al. 2001). The reason for this was that the fluxes into, and out of, the atmosphere were in balance (Siegenthaler and Sarmiento 1993). Any CO_2 lost from the atmosphere into one of the natural sinks (ocean or terrestrial biosphere) was replaced by CO_2 emitted from one of the natural sinks (global carbon cycling).

During the pre-industrial era, the flux of CO_2 from the atmosphere into the ocean was about 60-70 GtC/yr, while into the terrestrial biosphere it was just over 100 GtC/yr (Ciais et al. 2013). Given that the total atmospheric carbon mass – at that time – was ~600 GtC, meant that all the atmospheric CO_2 could be turned over in only a few decades. In other words, the residence time of an individual CO_2 molecule in the atmosphere was about 4 years.

Increasing land use change and the combustion of fossil fuels, starting with the industrial revolution, introduced a new flux of CO_2 into the atmosphere. This meant that the atmospheric CO_2 fluxes were no longer in balance and atmospheric CO_2 started to rise. However, the residence time of an individual CO_2 molecule is still only about 4 years (Kohler

et al. 2018). Hence, a CO_2 molecule emitted into the atmosphere from an anthropogenic source will still only remain in the atmosphere for about 4 years before being taken up by one of the natural sinks.

This, however, does not mean that an enhancement in atmospheric CO_2 would decay on a timescale of about 4 years. The residence time of an atmospheric CO_2 molecule depends only on the flux out of the atmosphere, while the adjustment time for an enhancement in atmospheric CO_2 depends on the balance of net fluxes. The uptake of extra CO_2 by the natural sinks also increases the flux of CO_2 from these sinks back into the atmosphere (Ciais et al. 2013). So, even though the residence time for an individual CO_2 molecule is only a few years, the adjustment time for an enhancement of atmospheric CO_2 is typically estimated to be of order a hundred years, or longer (Archer et al. 2009; Cawley et al. 2011).

Hence, even though individual CO_2 molecules coming from fossil fuel emissions will cycle out of the atmosphere on a timescale of a few years, anthropogenic emissions have led to an enhancement in atmospheric CO_2 that will have an adjustment timescale of a century or more. As many detailed carbon cycle studies have shown, anthropogenic emissions certainly are the cause of the increase in atmospheric CO_2, and there are multiple lines of evidence that support this conclusion (Prentice et al. 2001; Canadell et al. 2021). Also, that the adjustment timescale is a century, or longer, means that this enhancement in atmospheric CO_2 will persist for a very long time (Ciais et al. 2013).

We should add that even the first Intergovernmental Panel on Climate Change (IPCC) Report, published in 1990, warned that "*[t]his short time scale [residence time] must not be confused with the time it takes for the atmospheric CO2 level to adjust to a new equilibrium if sources or sinks change [adjustment time]"* (Watson et al. 1990). There have also been a number of published responses to papers that have confused these two timescales (e.g., Cawley 2011; Kohler et al. 2018).

Also, although an enhancement in atmospheric CO2 decays on a timescale of about a hundred years, this does not mean that atmospheric CO2 concentrations will return to pre-industrial levels on this timescale. About 20% to 30% of total anthropogenic emissions will remain in the atmosphere after the initial equilibrium is reached (Archer et al. 2009; Ciais et al. 2013). It will eventually be drawn down through very slow reactions leading to mineralization and burial. Consequently, the total timescale over which atmospheric CO2 concentrations will return to pre-industrial levels is of order 100 kyr (Archer et al. 2009; Ciais et al. 2013).

In summary, even though a relatively small fraction of the CO_2 molecules in the atmosphere - at a particular time - have a recent, direct fossil fuel origin, does not mean that the increase in atmospheric CO_2 is not due to anthropogenic emissions and does not mean that this is not the cause of global warming. That the increase in atmospheric CO_2 since the industrial revolution is due to anthropogenic emissions is a scientific conclusion about which we can be extremely confident (Friedlingstein et al. 2020; Canadell et al. 2021). Similarly, that this is the dominant cause of global warming is also a conclusion about which there is great confidence (Eyring et al. 2021; Masson-Delmotte et al. 2021). We would need much more than a misunderstanding about the cause of the increase in atmospheric CO_2 to overthrow these extremely robust conclusions.

Secondly, throughout the paper, the authors have (i) failed to cite numerous related, and relevant, earlier publications in this field, and (ii) demonstrated a lack of fundamental understanding of biogeochemical carbon cycle processes. For example, suggesting:

> "*It appears in the figure that Earth is still in the Holocene interglacial period that started 11,500 y ago. Its peak temperature change over the 11,500 years, thus far in 1950, appears to be significantly less than those over the three previous interglacial periods. Its peak CO_2 appears less than 300 ppm and less than the peak value in the previous interglacial period.* ***Thus, the increase in CO_2 that Earth has been experiencing since 1800 appears to have started more than 5,000 years ago.***"

This statement ignores an entire body of scientific literature (on Holocene and modern climate change), and then arrives at a non-sequitur conclusion based on that ignorance.

Under any normal peer review circumstances, a combination of failing to properly cite the state of the science, alongside a demonstrated lack of understanding and clarity in writing, would have led to immediate rejection of this work.

Therefore, that this manuscript was published suggests a major failure in the Health Physics peer review process. Publishing this paper is akin to the authors "proving" no connection between smoking and cancer, without referencing any of the many Surgeon General reports. It is equivalent to a climate science journal publishing a manuscript claiming that there are no radiological effects on health, and implying that most of what was published in Health Physics was thus invalid, without actually referencing a single article from Health Physics.

We are aware of several previous instances of failures in peer review that have led to very poor papers passing initial peer review, resulting in a significant loss of trust in the scientific journal and its editors. A recent example is the journal *History of Geo- and Space Sciences*, details of which you can access here: https://hgss.copernicus.org/articles/12/97/2021/. A further example is the publication of a paper in *Global and Planetary Change*, that also confused residence and adjustment times. Three of the editors later commented that *"[t]he acceptance of this paper has exposed potential weaknesses in the implementation of the peer review system, and quality control mechanisms have failed in this particular case"* (Grosjean et al. 2017).

We ask you to consider the peer-review failure in this case, and to carry out a post-hoc review, which we are confident will produce a more reasonable outcome. While writing this, we also became aware of a paper by Pieter Tans in which he reminisces on the "use and abuse of ^{14}C and ^{13}C in atmospheric CO_2" (Tans 2022). It is relevant to the issues highlighted here, and we'd encourage the authors, and editor, to consider reading it.

Sincerely,

Ken Rice, School of Physics and Astronomy, University of Edinburgh
Gunnar W. Schade, Texas A&M University, Atmospheric Sciences Department
Mark A. Maslin, Department of Geography, University College London

References:

Archer D, Eby M, Brovkin V, Ridgwell A, Cao L, Mikolajewicz U, Caldeira K, Matsumoto K, Munhoven G, Montenegro A, Tokos K. Atmospheric Lifetime of Fossil Fuel Carbon Dioxide. Annual Reviews of Earth Planetary Science 37:117-134; 2009.

Canadell JG, Monteiro PMS, Costa MH, Cotrim da Cunha L, Cox PM, Eliseev AV, Henson S, Ishii M, Jaccard S, Koven C, Lohila A, Patra PK, Piao S, Rogelj J, Syampungani S, Zaehle S, Zickfeld K. Global carbon and other biogeochemical cycles and feedbacks. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press; 2022

Ciais P, Sabine C, Bala G, Bopp L, Brovkin V, Canadell J, Chhabra A, DeFries R, Galloway J, Heimann M, Jones C, Le Quere C, Myneni RB, Piao S, Thornton P. Carbon and Other Biogeochemical Cycles. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA; 2013.

Cawley GC. On the atmospheric residence time of anthropogenically sourced CO2. Energy Fuels 25: 5503–5513; 2011.

Eyring V, Gillett NP, Achuta Rao KM, Barimalala R, Barreiro Parrillo M, Bellouin N, Cassou C, Durack PJ, Kosaka Y, McGregor S, Min S, Morgenstern O, Sun Y. Human Influence on the Climate System. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press; 2022

Friedlingstein P, O'Sullivan M, Jones MW, Andrew RM, Hauck J, Olsen A, Peters GP, Peters W, Pongratz J, Sitch S, Le Quere C, Canadell JG, Ciais P, Jackson RB, Alin S, Aragao LEOC, Arneth A, Arora V, Bates NR, Becker M, Benoit-Cattin A, Bittig HC, Bopp L, Bultan S, Chandra N, Chevallier F, Chini LP, Evans W, Florentie L, Forster PM, Gasser T, Gehlen M, Gilfillan D, Gkritzalis T, Gregor L, Gruber N, Harris I, Hartung K, Haverd V, Houghton RA, Ilyina T, Jain AK, Joetzjer E, Kadono K, Kato E, Kitidis V, Korsbakken JI, Landschutzer P, Lefevre N, Lenton A, Lienert S, Liu Z, Lombardozzi D, Marland G, Metzl N, Munro DR, Nabel JEMS, Nakaoka S-I, Niwa Y, O'Brien K, Ono T, Palmer PI, Pierrot D, Poulter B, Resplandy L, Robertson E, and Rodenbeck C, Schwinger J, Seferian R, Skjelvan I, Smith AJP, Sutton AJ, Tanhua T, Tans PP, Tian H, Tilbrook B, van der Werf G, Vuichard N, Walker AP, Wanninkhof R, Watson AJ, Willis D, Wiltshire AJ, Yuan W, Yue X, Zoehle S. Global Carbon Budget 2020. Earth System Science Data 12: 3269-3340; 2020.

Grosjean M, Guiot J, Yu Z. Commentary: H. Harde: "Scrutinizing the carbon cycle and CO_2 residence time in the atmosphere". Global and Planetary Change 164: 65-66; 2017.

Kohler P, Hauck J, Volker C, Wolf-Gladrow DA, Butzin M, Halpern JB, Rice K, Zeebe RE. Comment on “Scrutinizing the carbon cycle and CO2 residence time in the atmosphere by H. Harde”. Global and Planetary Change 164: 67-71; 2017.

Masson-Delmotte V, Zhai P, Pirani A, Connors SL, Pean C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekci O, Yu R, Zhou B. Climate change 2021: The physical science basis Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press for the Intergovernmental Panel on Climate Change (IPCC); 2021

Prentice IC, Farquhar GD, Fasham MJR, Goulden ML, Heimann M, Jaramillo VJ, Kheshgi, HS, Le Quere C, Scholes RJ, Wallace DWR, Archer D, Ashmore MR, Aumont O, Baker D, Battle M, Bender M, Bopp LP, Bousquet P, Caldeira K, Ciais P, Cox PM, Cramer W, Dentener F, Enting IG, Field CB, Friedlingstein P, Holland EA, Houghton RA, House JI, Ishida A, Jain AK, Janssens IA, Joos F, Kaminski T, Keeling CD, Keeling RF, Kicklighter DW, Kohfeld KE, Knorr W, Law R, Lenton T, Lindsay K, Maier-Reimer E, Manning AC, Matear RJ, McGuire AD, Melillo JM, Meyer R, Mund M, Orr JC, Piper S, Plattner K, Rayner PJ, Sitch S, Slater R, Taguchi S, Tans PP, Tian HQ, Weirig MF, Whorf T, Yool A. The carbon cycle and atmospheric carbon dioxide. In: Climate change: the scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate (IPCC). Cambridge University Press, Cambridge, pp 183–237; 2001.

Revelle R, Suess HE. Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO_2 during the past decades. Tellus 9: 18–27; 1957.

Siegenthaler U, Sarmiento J. Atmospheric carbon dioxide and the ocean. Nature 365: 119–125; 1993.

Skrable K, Chabot G, French C. World Atmospheric CO2, Its 14C Specific Activity, Non-fossil Component, Anthropogenic Fossil Component, and Emissions (1750–2018). Health Physics 122: 291-305; 2022.

Tans P. Reminiscing on the use and abuse of ^{14}C and ^{13}C in atmospheric CO_2. Radiocarbon In press; 2022.

Watson RT, Rodhe H, Oeschger H, Siegenthaler U. Greenhouse Gases and Aerosols. In: Climate Change: The IPCC Scientific Assessment. Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, pp 1–40; 1990

Zeebe RE, Wolf-Gladrow DA. Seawater: Equilibrium, Kinetics, Isotopes, Elsevier Oceanographic Series 65. Elsevier. New York, USA; 2001.