

## ***Interactive comment on “CDIAC-FF: Global and National CO<sub>2</sub> Emissions from Fossil Fuel Combustion and Cement Manufacture: 1751–2017” by Dennis Gilfillan and Gregg Marland***

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Overall: This is an important contribution documenting recent significant changes to the methodology used to construct the CDIAC (now CDIAC-FF) emissions dataset. This dataset is widely used, and thorough documentation is therefore of high importance. The paper is well written, but since many people misunderstand how the dataset is produced and what it includes, I would like to see some ambiguous language tightened, and have made a number of suggestions to help this.

Comments:

C1

Line 18 "combustion": Please be clearer here. Non-combustion emissions are included for solid and gaseous fuels.

Line 41: Ditto.

Lines 44-45: The carbon cycle community has begun to use the more encompassing term "fossil CO<sub>2</sub>". Consider using this.

Line 49: Update to 2020.

Line 53 "fossil fuels": This excludes carbonate emissions. Please reword.

Line 58 "economic sectors": Be careful with this imprecise term. It means something very different to economists, see Andrew 2020.

Lines 65-66 "does not involve combustion or the oxidation of non-fuel hydrocarbon products": Clumsy and potentially confusing wording. Might be simpler just to say doesn't involve fossil fuels? Further, combustion and oxidation are not mutually exclusive: Combustion is one form of oxidation.

Lines 70-72 "Although other industrial processes discharge CO<sub>2</sub> into the atmosphere, e.g. iron and steel production, they are often not currently included in emissions inventories": IEA includes these, EDGAR too. And as I understand it, CDIAC-FF does too (only liquid fuels are adjusted for non-fuel uses, see Andrew 2020). BP does not. I'm not sure "often" is reasonable here.

Line 76 "often included": IEA does not include these.

Line 80 "international trade": 'transport' is better here, since much international trade occurs without transport.

Line 91: "fossil-fuel combustion": It also includes non-combustive oxidation of solid and gaseous fuels.

Line 94 "focused": It's not clear to me what is intended by this word.

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Lines 95-96 "CDIAC emissions estimates are based largely on energy statistics from the UN Statistics": Insert words "since 1950".

Line 109 "historic": Replace with "historical".

Line 151 "questionnaire for member countries": Not just members, see Andrew, 2020: "The IEA and Eurostat have developed questionnaires that are sent to at least 61 countries: all members of the Organisation for Economic Co-operation and Development (OECD), European Union (EU), United Nations Economic Commission for Europe (UNECE), "and a few others"."

Lines 151-2 "data sharing with the UN for most other countries": Data are obtained from the UN only for small countries. Many more are obtained directly from national statistical publications.

Lines 154-5 "do not include emissions from fossil fuel products that are used for non-energy applications": Be careful here. IEA does include non-energy use in iron and steel manufacture.

Line 156 "do not include emissions from gas flaring": While IEA's main "CO2 Emissions from Fuel Combustion" database does not include emissions from gas flaring, they began to provide separate estimates for flaring emissions in 2020.

Line 169: Also other carbonate decomposition, not just cement.

Line 171 "rely on cement data": Change to "rely at least partly on cement data"

Line 181 "and no other industrial processes": Nor flaring. See Andrew 2020.

Line 187 "international commerce": I think "international transport" is clearer.

Line 202 "reduced uncertainty": I think "lower" is better. Uncertainty is not actively reduced.

Line 205 "fraction of the fuel": More correctly "carbon".

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Line 206 "oxidized each year": I'm not sure "each year" is helpful here, and might just confuse people into thinking you have a vintage model, with emissions from a combusted fuel spread over several years.

Line 212 "fuels that are not oxidized": Please be very clear that this only applies to liquid fuels.

Lines 213-4 "fuels used in international commerce": Again, this is highly unclear. Many fuels are traded internationally, and this will give some the impression (or temporarily confuse them) that emissions from traded fuels are not included.

Lines 281-21: This is a little difficult to parse. Perhaps simplify to: This implies that the stock of carbon in long-lived products increases each year by 6.7% of that year's production of liquid fuels.

Line 231 "In the 2016 update to the time series": This will suggest to many readers that this change first appeared in your 2016 release, but you mean the first release to include 2016 estimates. Please reword for clarity.

Line 239 "The assumption": Be clear that this was an assumption made in the CDIAC process, not by the UN.

Line 243 "historic": Change to "historical".

Line 245 "Fig. 1a": I cannot see this figure.

Line 249 "Figure 1b": Should probably be "Figure 1".

Line 282 "assumed to be zero for solids and gases": Please comment on the validity of this assumption.

Line 284: Replace the full-stop with a colon to help the reader understand the connection.

Line 288 "fertilizer production using natural gas": But you have just said that the share

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of natural gas not oxidised is assumed to be zero. This is therefore not an example of a non-energy use that is excluded from your emissions estimates.

Lines 299-300 "we use the standard projections of population": It doesn't matter which projection set you use, since they all have the same historical estimates. Please reword.

Lines 311-12 "the assumption that all hydraulic cements had a high proportion of clinker (90-95%)": According to Andrew 2019, the assumption was a proportion of 98% (p1681). What is the reason for the difference here?

Line 315 "This made it clear": Some references should be made here to studies that made this statement. The earliest were probably those discussing China's cement emissions.

Line 317 "reevaluation": Change to "re-evaluation".

Lines 318-319: Provide a reference, or bring forward sentence from 345-347 to here.

Line 328 "are calculated as follows": Provide reference(s).

Lines 336-338: I believe the authors strictly speaking are looking at the Common Reporting Format tables as part of National Greenhouse Gas Inventory (NGHGI) reports submitted by Annex 1 parties to the UNFCCC. There are in fact a number of other countries that officially report clinker production statistics in their National Inventory Reports that are not Annex 1 parties (and do not submit CRFs), and these are used by Andrew, 2019. Please reword.

Line 319 "addition of 2% for cement kiln dust": Please add this to the two equations.

Line 352: "now reported by the GCCA": Some comment should be made on the validity of these data. You don't give a reason for not using GCCA for China. See Andrew 2019, e.g. for China: "The numbers from WBCSD are unreliable because of a very small sample size in China (~4% of all clinker production), likely to be biased to producers of

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higher-quality cement." Similarly, only 47% of India's (second-largest cement producer) production is sampled.

Line 359 "the dearth of international data on clinker production and trade": It is the dearth of data on clinker production that is a reason not to calculate directly from clinker production. But the lack of clinker trade data is a reason not to use cement production statistics. Please reword.

Line 362: Make clear that this is only fossil CO<sub>2</sub> (excludes other anthropogenic sources: LUC).

Line 363 "Professor": It isn't necessary or common to give a scholar's position in an academic article, and this usage is inconsistent with all other citations in the present article.

Line 366: Please replace asterisks with multiplication signs.

Line 380 "CO<sub>2</sub> emissions": Do you decompose total CO<sub>2</sub> emissions from CDIAC, or just those related to energy? It would be sensible to omit cement emissions from this analysis.

Line 381 "for each of": Ambiguous: should this be "any" or "all"?

Line 385 "combustion": Please consider using "oxidation" instead of "combustion".

Line 388 "all fuels": Be clear that you're referring to the three over-arching fuel categories. Perhaps just "all three fuels" is sufficient.

Line 409 "the improving quality of data on cement (Han et al., 2020)": I cannot see any comment in Han et al 2020 about the improving quality of data on cement, so perhaps the citation should be moved earlier in the sentence. The implication of your wording is that data on cement are of better quality in recent years than in earlier years, leading to uncertainty. Is this correct? Are you referring to the availability of clinker production (or ratio) data from 1990?

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Line 410: "largest reported growth in emissions": Insert "relative" and report the relative growth here rather than the absolute growth.

Lines 410-1 "reported" & "reportedly": This would be the correct word if you were discussing the energy data, which someone else (UN) reports, but you are discussing the emissions estimates, which you calculate yourselves. I suggest you omit this word.

Line 424-5 "potential statistical anomalies": I suggest adding "particularly for very small countries".

Line 433 "boundary conditions": I'm not sure this is the right term. Boundary conditions is a mathematical term describing what happens when a dynamic system reaches a boundary. "System boundaries" would be preferable here.

Line 462-3 "underestimates" & "overestimates": The use of 'underestimates' and 'overestimates' here implies strongly that you consider CDIAC-FF estimates to be correct and the others are not, but you elsewhere do not give this impression. Please re-word.

Line 463: "India": Andrew 2020b gives some specific reasons why CDIAC estimates are too high for India (Figures 3 and S17: <https://doi.org/10.5194/essd-12-2411-2020>). For coal, the UN values for carbon content (used by CDIAC, and provided to the UN by India) before 2014 are very likely incorrect. This suggests errors rather than just 'different system boundaries' as you suggest.

Line 477 "within 5% of Andrew (2019)": Some comment might be appropriate. For example, Andrew 2019 sources clinker production for a number of other countries from their reporting to the UNFCCC.

Lines 480-1 "Much like the global comparisons, Andrew (2019) and CDIAC-FF are within 5% of each other.": Some comment on why these might differ is appropriate. For example, Andrew 2019 uses published clinker production data, while the present article uses clinker ratios.

Line 488: This section shows results of some Kaya analysis, but with little interpretation

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and no comparison with numerous other studies that do similar analyses. Perhaps this is ok in a data journal, so I will allow the editor to comment here. But in most journals additional interpretation and comparison would be required.

Lines 507-8 "With the exception of the impacts of the dissolution of the Soviet Union on Russia, increasing wealth (per capita GDP) is a driving force on increasing emissions": I'm not sure the exception is required in this sentence. The general rule observed is that as wealth increases, so do emissions. In Russia following the break-up, wealth declined.

Line 517 "top 10 emitting countries from the Middle East": Remove "10".

Lines 527-8 "this potentially explains the minimal relative growth in CO2 emissions": The implication being that they make more effort because they're required to report? I don't think this follows. More likely that these countries accepted targets/reporting requirements because they were past the kuznets peak.

Line 549 "boundary conditions": As above, I suggest instead "system boundaries".

Line 550 "demonstrate": This is too strong. Use rather "suggests" or "indicates". You point to this very issue in the sentence that follows.

Line 545 "comprehensive": It is not entirely comprehensive, since it omits both emissions from non-energy uses of oil products and emissions from decomposition of carbonates other than in cement production. Please reword slightly.

Line 545 "consistent": This should also be worded more carefully. The data source pre 1950 is quite different. Further, while CDIAC-FF uses a consistent approach and data sources for estimates starting 1950, those data sources themselves are produced somewhat inconsistently across countries and time. Consider for example the contrasting case of GCP, whose methods are relatively inconsistent across countries, but if author X were to cite GCP as their data source for further calculations, X could readily say their method and data are 'consistent'. So what is the value of the 'consistent'

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description? The value here is that it reduces the burden on producing the dataset, which is good. But I recommend that the authors avoid implying anything more than that.

One last minor comment: While it makes little difference, the authors might consider in a later revision extending the dataset back to 1750. The source used by Andres et al 1994 (i.e. Etemad & Luciani) interpreted a source (Pollard 1980) incorrectly. Pollard provides "quinquennial" estimates (averages over five-year periods) of coal production for Great Britain, but the first period is six years, starting in 1750. This is why GCP's data now start in 1750.

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Interactive comment on Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2020-337>, 2020.