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Interactive comment on "Global CO_2 uptake of cement in 1930–2019" *by* Rui Guo et al.

Anonymous Referee #1

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Ms. Ref. No.: essd-2020-275-manuscript-version2 -peer-review-v1 Global CO2 uptake of cement in 1930–2019 Reviewer comments: SUMMARY The manuscript deals with an investigation on the use of an analytical model to estimate the amount of CO2 that had been absorbed from 1930 to 2019 in four types of cement materials including concrete, mortar, construction waste and cement kiln dust (CKD). This is a topic that has not been widely covered in the literature, therefore, this a subject of great interest, but it is somehow limited in the analysis and application of these results. MAIN IMPRESSIONS This paper has an undeniable practical usefulness. However, from a scientific point of view, the following issues must be addressed: i) A key aspect for the IPCC Emission Factor Database is the uncertainties calculation, then, this part should be presented, explained and discussed in detail in the paper; and ii) References and data should be updated.

MORE DETAILED COMMENTS Abstract: Link https://doi.org/10.5281/zenodo.4064803

should not be given in the abstract. Please, include it in the references. Line 32: Please, update the information and references. According to https://doi.org/10.3390/app10010339 "cement production is considered as responsible for approximately 7.4% of the global carbon dioxide emission (2.9 Gtons in 2016)". Line 42: Please, update the information and references. Clinker factor is decreasing according to World Business Council for Sustainable Development (WBCSD); Cement Sustainability Initiative's (CSI). Cement Industry Energy and CO2 Performance. Getting the Numbers Right (GNR) Project, 1st ed.; World Business Council for Sustainable Development: Geneva, Switzerland, 2018. Line 42: " ... be around 0.5 t CO2/t cement ... clinker ratio >95% ..." According to Table 3 in reference https://doi.org/10.3390/app10020646, the maximum stoichiometric amount of carbon dioxide that can be absorbed goes from 0.49 kg CO2/kg Cement (for CEM I Portland cement CEM I (OPC)) to 0.10 kg CO2/kg Cement CEM V/B. Line 45: "The universal carbonation mechanisms that are responsible for the carbon uptake of cements can be attributed to their hydroxide(s) and silicate(s) constitutes, as described by Eq. (R1) and (R2):". This is not the only one. In addition, ettringite (https://doi.org/10.1680/adcr.2000.12.3.131) and calcium aluminates may be carbonated at low partial CO2 pressure, resulting in formation of gypsum, alumina gel and vaterite crystals (https://doi.org/10.1016/j.conbuildmat.2011.07.043). Line 45: More precise chemical mechanism that could be referenced are given in https://doi.org/10.1557/JMR.2002.0271, https://doi.org/10.1016/j.cemconcomp.2018.04.006, https://doi.org/10.1680/adcr.2000.12.3.1 Line 49: With regard to this "... multi-giga-tonne potential of CO2 abatement ...", the effect of the high level of alkaline blending (e.g. blast furnace) for CO2 abatement was proposed previously in ref. https://doi.org/10.3390/en12122346 ("The main finding is the extreme sensitivity of the GGBFS mortars to the curing intensity and, therefore, they can be used cured under controlled conditions to minimize carbon footprints"). Line 50: " ... reducing clinker ratio is still the key to lower the emission level ..." : reducing clinker ratio is one of the key levers to lower the emission level. Could please bring up some

others? For instance, several Carbon Dioxide Uptake levers have been proposed in the Roadmap 2050 of the Cement Industry (Refs.: https://doi.org/10.3390/en13133452 and https://cembureau.eu/media/kuxd32gi/cembureau-2050-roadmap_final-version_web.pdf Line 59: I agree with the statement "... the results by applying more realistic clinker ratio data is necessary ...". Then, I suggest to add the clinker ratios published in the Getting the Numbers Right (GNR) Project, Carbon Capture TechnologyâĂŤOptions and Potentials for the Cement Industry, 1st ed.; European Cement Research Academy (ECRA): Düsseldorf, Germany, 2007 and reference https://doi.org/10.3390/app10010339 Line 61: Could you please to cite your paper https://doi.org/10.1038/ngeo2840 ("...has been sequestered in carbonating cement materials from 1930 to 2013, offsetting 43% of the CO2 emissions from production of cement over the same period") and justify this new figure? Line 140: The fraction of CaO that could be converted to CaCO3 is given in Table 3 in reference https://doi.org/10.3390/app10020646. Line 147: The area behind the front cannot be regarded fully carbonated. You should consider a degree of carbonation. Please, check references discussing the effect of the degree of carbonation and surface/volume on the carbonation uptake. Line 187: There are great differences between different countries in the same regional subcategory (Please, check the carbonation behaviour of recycled aggregate concrete reported in https://doi.org/10.1016/j.cemconcomp.2015.04.017. In particular, the use of mineral additions as cement replacement causes greater carbonation depths than those of mixes without them. If you assume a uniform distribution between a and b for each reginal subcategory the uncertainty will be affected. Line 395: "...more than 72% of which have occurred since 1990.„" as reported in other papers (See Fig. 9 in ref. https://doi.org/10.3390/en13133452). Line 398: Could you please add a reference? Line 410: Andrew (2018) report could be updated with reference " Robbie M. Andrew. Global CO2 emissions from cement production, 1928–2018. Earth Syst. Sci. Data, 11, 1675–1710, https://doi.org/10.5194/essd-11-1675-2019, 2019"? Line 416: In "3.2. Cement carbon uptake by region and material type", could you please discuss

the main differences between the results given in (Xi et al., 2016) and SI data 4 in "cement carbon emission and uptake results.xlsx". Line 417: Could you please explain in detail how the uncertainty has been calculated? Associated uncertainties are available by Zenodo at https://doi.org/10.5281/zenodo.4064803, however, the excel worksheet (Uncertainty of cement carbon emission and uptake.xlsx) does include any formula. A key aspect for the IPCC Expert Group on Data for the IPCC Emission Factor Database is the uncertainties calculation. Therefore, this part should be highlighted in the paper. Line 429: Could you please add a reference to support "... This is mainly attributed to the faster carbonation kinetics of mortar ...". Line 429: Could you please add a Table with typical diffusion coefficients for mortars and concretes around the world or, at least, provide some references with diffusion coefficients calculated in the main country/regions? Line 240: What about the effect of curing conditions and fly ash, GGBFS, etc., content? Could you please discuss it? (https://doi.org/10.1016/j.cemconcomp.2012.08.024 , https://doi.org/10.1016/j.cemconres.2007.08.014 , https://doi.org/10.1016/j.cemconcomp.2018.04.006) Line 440: In Figure 6, which letter corresponds to each area (China, India, the US, Europe and the rest of the world)? Line 447: "... more than 75% of the total uptake was attributed to ... the cement materials produced/consumed after the 1990s ..." as reported in other papers (See Fig. 9 in ref. https://doi.org/10.3390/en13133452). Line 467: Could you please write the equations and procedure used for the simulation, as well as for the associated uncertainties? Line 474: Could you please delete "microscopic". Line 475: In agreement with other papers, it has been found that "post-1990 era sees more than 75% of the total uptake estimated.". Line 477: Could you please give figures about the result of the clinker ratio overestimation? This conclusion should compare clearly the results provided in (Xi et al, 2016) and in the present paper. Line 479: Could you please delete "(see Figure 4a)". Line 480: It is clear that to increase the accuracy of the uptake estimates is necessary. Therefore, conclusions should include the uncertainties obtained in this paper as well as the evaluation of the uncertainty's calculation process. Line 484: Which experiments in

“determined by experiment “?

RECOMMENDATION In conclusion, Major changes have been proposed.

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