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Earth System Dynamics Discussions

Interactive comment on "A simple model of the anthropogenically forced CO_2 cycle" *by* W. Weber et al.

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Unfortunately, I have to reject publication of this manuscript in ESD. The authors have not satisfactorily responded to the key critical points raised by the reviewers. While simple models have their value in analysing the global carbon cycle, the approach presented in this manuscript neglects basic understanding of the global carbon cycle and makes inferences regarding the response of atmospheric CO2 to various future emission scenarios which are simply not justified. Here I just reiterate 4 major points that were made already in my access review comment and that have been more elaborated by the reviewer comments; but they were not taken into account by the authors. I refer with "WM" to the model suggested by the authors in their manuscript.

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- “CDIAC observations”: The authors claim that their model fits the “CDIAC observations”, but, as pointed out clearly by Köhler et al., the CDIAC data are not “observations” except for the atmospheric CO2 increase which is taken from direct atmospheric and from ice core measurements. The ocean and land uptake time series in the CDIAC dataset are actually computed from comprehensive ocean models, which have been scaled to give the observed decadal ocean uptake in the 1990’s. Thus the WM simply fits successfully the simulation by more comprehensive ocean models, and by mass balance the biospheric uptake time series.

- Linearity: The authors claim that if the carbon cycle were operating linearly, then the WM which fits well the atmospheric increase will also perform well into the future. This is true only if the emissions continue to increase exponentially as they did in the past. As eloquently shown by the reviewer comments a fit to the observed atmospheric increase, because it increases exponentially, determines only one single time scale. We know, however, from several decades of research in analysing and modelling of the carbon cycle, that the response of the carbon cycle, even if linearised, requires several time scales to be properly represented - see e.g. Cawley, 2011, or the work by Joos et al., 1996, 2013. The multitude of time scales cannot be determined from the response to the exponentially increasing emissions in the past, but requires additional observations (e.g. radiocarbon).

- Neglecting of ocean chemistry: The authors bluntly state that the Revelle effect is theoretical and has not yet been observed. This is blatantly not true. Indeed, already Arrhenius and Hogböhm were aware of the ocean carbonate chemistry and they calculated the ocean-atmosphere partitioning of carbon using the appropriate chemical dissociation equations already in 1898. The ocean carbonate ion chemistry has been measured in the lab and in the open ocean thousands of times and it is standard in any undergraduate textbook of aquatic chemistry. When Gloor et al. (2010) state that it is not yet discernible in the global carbon budget time series, they refer to the fact that up to now the carbon cycle operates still linear, but there is no doubt that with

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higher CO2 levels it will increasingly diminish the ocean uptake of excess CO2. Also: in the WM equation (1) states that ocean uptake is only driven by atmospheric CO2 and the ocean carbon content is kept constant. This is contrary to the thousands of ocean pCO2 measurements, which show that the surface ocean responds to the CO2 uptake by changing it's carbonate ion dissociation and increasing pCO2.

- Land biosphere representation: the WM assumes that the land biosphere uptake of CO2 is proportional to the rate of change of atmospheric CO2. This is completely at odds with the empirical evidence, e.g. from FACE experiments. In these experiments, plants grow under constant doubled CO2 concentration. According to WM the plant would thus only exhibit uptake during the initial pulse when CO2 is doubled and no further uptake when CO2 is kept constant. Such a behaviour has never been observed.

Interactive comment on Earth Syst. Dynam. Discuss., 6, 2043, 2015.