Response to CC1

Dear Paul Pukite,
Many thanks for your community comment; we hope we can clarify any misunderstandings. Please find our point-to-point responses to the individual comments below (community comment in black, our response in blue).

Why is it that the predominating mechanism behind the fat-tails of CO2 persistence in the atmosphere is never mentioned in the article? CO2 enters the ocean and only gradually diffuses downward, modeled as an infinite number of slabs according to conventional 1D physics.
The mechanisms behind the long ("fat") tail of the anthropogenic CO_2 anomaly in the atmosphere is well-understood and already discussed on Page 4 (Lines 63-64) where we cited relevant papers. Indeed, most of anthropogenic CO_2 (up to 80%) will dissolve and diffuse into ocean, where wind-driven mixing and large-scale ocean circulation (e.g., thermohaline circulation) will transport it into the deeper waters at the millennial time scale. The rest of anthropogenic CO_2 is removed from the atmosphere by interaction with marine sediments (10^4 yr) and silicate weathering (10^5 yr). Thus, the contribution of carbonate chemistry and weathering to the continued absorbtion by the oceans cannot be ignored (as done with a diffusion-only model).

This leads to an inverse power law tail, matching to the BERN heuristic of a set of damped exponentials and a fudge factor constant level representing the rest of the tail. The paper estimates that "75% of anthropogenic CO2 is removed within 197–1,820 years after emissions end". It would be useful to explain that statistical moments such as the mean adjustment time can only be expressed as such a range because the value will actually diverge with a fat tail.
We wish to clarify that the anticipated "long tail" of CO_2 uptake is due to the relatively slow process of silicate weathering, not ocean diffusion. This is illustrated in Figure 1 of Archer & Brovkin (2008). We are aware of the "BERN heuristic of a set of damped exponentials", but this is used exclusively to analyze our results (not used as a model for the oceanic uptake of anthropogenic CO_2). This is applied in Section 3.3, where such a set of exponential decay functions are used to estimate the removal timescales of ocean invasion, carbonate chemistry, and silicate weathering.

References:

Archer, D. & Brovkin, V. (2008). The millennial atmospheric lifetime of Anthropogenic CO2. *Climatic Change*, 90(3), 283–297. https://doi.org/10.1007/s10584-008-9413-1