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Interactive comment on “What was the source of the atmospheric CO$_2$ increase during the Holocene?” *by* Victor Brovkin et al.

Anonymous Referee #1

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Brovkin et al. present the results of two transient simulations covering the period 6000 BCE to pre-industrial 1850 CE with the Earth system model MPI-ESM-LR. The goal is to constrain the processes leading to the changes in atmospheric CO2 concentration during that period. The conclusion of the study is that a surface alkalinity decrease, for example due to enhanced carbonate accumulation on continental shelves, is necessary to explain the Holocene atmospheric CO2 trajectory.

This is an interesting and very valuable study. Please find some comments below that should be addressed before publication.

1) Experimental set up:

The model was equilibrated under 6000 BCE conditions, with an atmospheric CO2

concentration lower (260ppm) than during the pre-industrial. If the global alkalinity concentration was kept constant, then the ocean would have lost carbon during the spin-up phase. Then forced with a transient increase in atmospheric CO2, all else being equal, the ocean should take up carbon. This is apparently what is happening as changes in SST, ocean circulation. . . are small. Potential bias due to imposing an atmospheric CO2 concentration should be briefly mentioned.

2) Justification of surface alkalinity decrease and comparison with previous studies:

The authors have previously done extensive work on the topic of global carbon cycle changes on glacial-interglacial cycles. They are therefore well aware of the literature on the topic, on the rationale behind decreasing surface alkalinity during the Holocene, and on the results from previous studies. However, given that here it is given as the main mechanism controlling Holocene atmospheric CO2, I would have expected a more in depth introduction of the topic and discussion with respect to previous studies. There is no mention in the introduction of the timing and magnitude of carbonate sedimentation on shelves, as well as on the results of previous modelling studies on the topic. There are only a few words on the topic in the introduction (p2, L.13-14), a few words in the method without any quantification (p4, L.17-18). As a side note, the introduction given in Kleinen, Brovkin et al., (2016) was much more informative. The results and a rapid comparison to Vecsei and Berger (2004) is given p7, L 23-25, but there is no comparison with results from previous studies. In addition, the magnitude of the necessary alkalinity change and its equivalent change in carbonate sedimentation could also be discussed in the context of the simulated changes in land carbon (see section 3).

3) Changes in terrestrial carbon:

Using a mass balance approach and high-resolution atmospheric CO2 and d13CO2 records, Elsig et al., 2009 suggest a land carbon uptake of ~290 GtC between 11ka and 5 ka B.P. I am surprised to see no reference/discussion to this study. As far as I can see this result seems supported among others by Stocker et al., (2017), Menviel & Joos (2012)… Here, the model suggests a terrestrial carbon uptake of ∼50 GtC between 8 and 2 ka B.P, which is much smaller and with a different timing. A discussion should be added on the results of this study, compared to the estimates of Elsig et al., (2009). The authors should discuss how their results could be reconciled with the atmospheric d13CO2 record, as also shown in other modelling studies, which included carbon isotopes.

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