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Comment on cp-2021-112

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Community comment on "Local oceanic CO₂ outgassing triggered by terrestrial carbon fluxes during deglacial flooding" by Thomas Extier et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-112-CC1>, 2021

I am very happy to see ES models starting to include the coast, and specifically the water depth range of the ocean margins between current and last glacial sea levels that is subject to exposure in glacials and subsequent flooding in interglacials. I am also happy to see the change in ocean/land surface area being considered.

In this paper, I feel despite the complexity of the processes considered in the ESM the general system view and the start conditions are biased by a marine view and limited by the deglaciation-only time frame:

I understand the basic assumptions and start conditions include:
1 terrestrial biomass is stored in the coast during low sea levels and "awaits" flooding, to then be more effectively decomposed and add to the marine carbon budget.
2 The coastal areas exposed in glacials (here the LGM) contain only terrestrial organic material.

This scenario - if globally relevant - will produce some positive feedback effect on CO₂ (which is likely globally irrelevant and it was not considered in the model). I personally would expect flooding to rather slow down or suppress degradation of terrestrial OM than enhancing it (It will be enhanced only focussed to the tidal water depth range)

I understand from your model description, the decomposition of terrestrial OM increases when the cell is flooded (this is why it produces a CO₂ peak?).

Widening the time window beyond the LGM: the coastal areas exposed during the LGM have been marine shelf sediments ("organic sediment" in fig 1) during a good part of the glacial cycles. Shelf sediments contain large amounts of carbonates, marine OM and significant amounts of sulphides (mainly iron sulphides such as pyrite). Exposing these sediments in combination with increased erosion (more relief at lowered sea levels) results in oxic degradation of both, the organic matter and the pyrite. Both processes ultimately result in CO₂ release from the terrestrial coastal areas to the atmosphere. In the case of pyrite, this works via pyrite oxidation -> sulphuric acid production-> carbonate dissolution -> CO₂ release which in its global effect is comparable in magnitude to volcanic CO₂ release (Kölling et al ngeo, 2019).

These processes thus act as a negative feedback (-CO₂/T/SL -> +CO₂) yet with an underlying shrinking reservoir effect: They can be active only as long as OM or sulphides on the exposed shelves are present and accessible to oxic degradation. Both processes

should have a buffering effect on CO₂. For pyrite there is independent isotopic evidence, that pyrite weathering in glacials is a relevant process (e.g. Turchyn & Schrag, Science 2004) and we have shown that a shrinking reservoir would cause this buffer to be "switched on" only at increasingly low sea levels (Kölling et al. ngeo 2019) potentially controlling the lower CO₂ threshold of around 190 ppm (Galbraith et al., ngeo 2017) in the post-MPT glacial cycles.

It would be exceptionally interesting to incorporate these processes in ESMs. The way shelf processes have been addressed in this paper seems very promising, to generate a much more accurate evaluation of the global effects that have - for sulphide oxidation forced carbon release - only been modelled in a very rough way that yet seems to mimic the basic feedbacks (Kölling et al, ngeo 2019).

References

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