

Clim. Past Discuss., author comment AC1
<https://doi.org/10.5194/cp-2021-112-AC1>, 2021
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Reply on CC1

Thomas Extier et al.

Author 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-AC1>, 2021

Dear Martin Kölling, thank you for your comments and for pointing out other coastal carbon sources that could be included in future model development. Following your first comment, we will include additional text to detail the remineralization timescale of terrestrial organic matter in the revised manuscript.

"I personally would expect flooding to rather slow down or suppress degradation of terrestrial OM than enhancing it (It will be enhanced only focused to the tidal water depth range)."

On land, most of the short-living terrestrial organic matter (green biomass, non-woody litter above and below ground) is recycled within one year. We assume conversion of land to ocean by flooding happens over 10 years. After this time, all the short-living terrestrial organic matter is remineralized and emitted as CO₂ to the atmosphere. Regarding the long-living terrestrial organic matter, the prescribed remineralization timescales in water are 100 years for wood, 10 years for woody litter and 5 years for humus. Either way, the simulated local outgassing is only due to higher stoichiometry of the terrestrial organic matter (C:N:P = 7600:51:1 for woody litter above and below ground, 3650:11:1 for wood and 465:10:1 for humus; Goll et al., 2012) compared to marine organic matter (C:N:P = 122:16:1; Takahashi et al., 1985). These higher values lead to an excess of carbon in the ocean once the terrestrial organic matter has been remineralized.

"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?)."

The decomposition of terrestrial organic matter happens once the material is in the water column, i.e. after permanent flooding of a land grid cell. The release of carbon from terrestrial material is much higher than for nutrients in comparison to the stoichiometry of marine organic matter (see comment above). Net primary productivity might uptake these additional available nutrients, but it consumes only 122 moles of carbon per mole of phosphate. This leaves a large fraction of remineralized terrestrial carbon in the water column and leads to outgassing of CO₂ to the atmosphere.

"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."

Thank you for pointing out other coastal carbon sources. At the moment we don't include other carbon fluxes at transiently changing land-sea interface even if we already have specified the transfer of marine sediments to soils on land during desiccation from interglacial to glacial from a technical point of view. However, there are currently no processes included to degrade these new soil components. Furthermore, as long as we prescribe CO₂ concentration in the atmosphere, extra sources are irrelevant. The next step is to run interactive CO₂ simulation in which we might include CO₂ from natural volcanic sources.

"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, 2019)."

It would be indeed very interesting to incorporate new processes like pyrite degradation on shelves in future model development and to investigate the effect on the CO₂ variation in a coupled carbon cycle simulation. The model development presented in the manuscript is a first step towards a fully coupled carbon cycle in an ESM, necessary for transient simulations over the last glacial/interglacial cycles.

References

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