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Climate of the Past
Discussions
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Interactive comment on "An investigation of carbon cycle dynamics since the Last Glacial Maximum: Complex interactions between the terrestrial biosphere, weathering, ocean alkalinity, and CO_2 radiative warming in an Earth system model of intermediate complexity" *by* C. T. Simmons et al.

Anonymous Referee #1

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General comments:

This paper investigates how ocean and land carbon cycle respond to the deglacial climate changes using an Earth system model of intermediate complexity. The novelty of this paper is to evaluate the effects of the climate variability and the associated carbonate compensation on the atmospheric CO2 from multiple sets of deglacial transient

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Discussion paper

simulation. They also show the importance of CO2–driven warming for the reconstruction of ocean circulation and the oceanic carbon release on the deglaciation. The paper argues that deglacial warming accelerates Atlantic meridional overturning through the sea-ice retreat at both hemispheres and then the replacement of low-alkalinity deep water to the surface contributes to the CO2 release to the atmosphere. This result provides new information for the deglacial climate system. Overall, this paper helps understanding the question, how the climate system drives the glacial-interglacial atmospheric pCO2 change, although the results of multiple sensitivity experiments cannot reproduce the full deglacial rise in atmospheric CO2. I recommend that it would be accepted with minor revisions addressing the concern below.

Specific comments:

The authors argue that the deglacial warming increases zonal wind speeds in the subtropics and thus dynamical upwelling (page 16, l. 11). Why does the warming enhance zonal winds at the tropics in this model? Since this wind-upwelling response is a key in this paper to explain the CO2 release from the tropical ocean to the atmosphere, it would be helpful to show the spatial pattern of physical anomaly (winds or vertical upwelling). Furthermore, it may be valuable to show the delta 14C signal to confirm the ventilation changes. For example, the difference in delta 14 C between surface and deep ocean changes (ventilation age) is used as an index of ocean stabilization in paleo proxy field. Does the response of modeled ventilation age also support the enhanced ventilation?

The configuration of sedimentation outflow/riverine inflow and total carbon conservation is a little unclear. The model is assumed to accumulate (sediment) all of calcite at depth upper 1450m. In this case, does the model also treat the burial of organic carbon in sediments at these depths? If so, does the model conserve total nutrient in the ocean in the long-term experiments? In addition, I suppose that the sediment model needs the deposition flux of detrital material as well as organic carbon and CaCO3 flux for the calculation of early diagenesis. Did you give a spatially uniformed flux of detritus or the spatiotemporal pattern to the model? The detail description of deposition fluxes is helpful to follow your experiments and understand how to treat the sedimentation rate in the long-term transient simulations.

At the end of Conclusions (page 34, l. 16), the authors argue the effect of the tropical temperature increase on ocean dynamics and vegetation carbon. Furthermore, I think that the change in soil carbon reservoir also affects the atmospheric CO_2 concentration. In fact, the soil carbon is decreased by around 30 GtC in CO2rad CA than in FC CA (Figure 1c and d). Is this because warming enhances decomposition of soil carbon? How large does the soil carbon change contribute to the atmospheric CO_2 rise?

Technical Corrections:

Page 3, l. 22: suggests -> suggest

Page 12, l. 8: “Fig. 1b” should be “Fig. 1c”?

Page 14, l. 6: provides -> provide

Page 18, l. 8: sentence needs period after "15500 BP".

Page 29, l. 8: “a low [Alk-DIC] anomaly drove down deep ocean values” is unclear for me. Please revise this sentence.

Page 30, l. 9: concentrations -> concentration

Page 31, l. 11: appears -> appear

Page 36, l. 25: Chickamoto -> Chikamoto

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