We thank Reviewer 2 for the comments on the different aspects of the manuscript. We answer them below (in blue) and will make changes accordingly in the revised manuscript.

1) Introduction:

Maybe expand the section on glacial-interglacial CO_2 variations (p.2, ll.39-49). In the context of the current study, recent estimates of total changes in land carbon storage between the last glacial maximum (LGM) and preindustrial (PI) might be of interest (e.g. Müller and Joos, 2020 BG; Jeltsch-Thömmes et al., 2019 CP). Further, many studies have invoked processes other than physical changes in the ocean (see e.g. Menviel et al., 2012 QSR or Sigman et al., 2010 Nature for a review, and many others) to explain glacial-interglacial CO_2 variations.

Following your comment, we further developped the section on the glacial/interglacial atmospheric CO_2 variations to explain them from changes in physical and biological conditions of the ocean. We also give an estimate of the terrestrial and marine carbon pools for the LGM and Preindustrial. The text of the introduction has been modified in the revised manuscript.

2) Prescribed atmospheric CO_2 concentration:

At the end of section 2.1 the authors note that all atmospheric concentrations are prescribed in the simulations. One of the goals of glacial-interglacial simulations with ESMs is to simulate the change in atmospheric CO_2 concentration, i.e. the ~90 ppm increase since the LGM. While making sure to have the correct atmospheric inventory, prescribing atm. CO_2 comes with drawbacks. For example, without other changes this would lead to a smaller LGM DIC inventory as the atmosphere would act as a sink until equilibrium is reached with the ocean. The authors circumvent this by initializing the spinup simulations with higher alkalinity concentrations. Is there a specific reason for not letting atm. CO_2 evolves freely over the course of the simulation? I don't think, though, this would change the findings of the study, as the effect of terrestrial organic carbon fluxes is diagnosed from the difference of two runs, but would like to see at least a short discussion of this choice.

Up to now, we only ran the deglaciation simulation with prescribed CO_2 to test and validate the state of the model during the deglaciation with the new developments that have been added in the model framework. A new simulation with prognostic atmospheric CO_2 / interactive carbon cycle (i.e. prognostic CO_2 for global carbon cycle but prescribed CO_2 for radiation) will be performed in near future. This will allow us to address the gap on the interaction between the ocean biogeochemistry and the climate during the last deglaciation. We added a new sentence to explain it in Section 2.4.

Are changes in tracer concentrations as a result of lower sea-level considered here as well?

We initialized the model with nutrient concentrations from a present day MPI-ESM simulation. We didn't adjust for the 3.5 % change in oceanic volume between the present day and the LGM, i.e. the prescribed total nutrient inventory at LGM is slightly smaller than for Preindustrial. We specify it in the revised version of the manuscript.

3) Simulated terrestrial carbon inventory

In general, I was a bit surprised to read that the effect of terrestrial organic carbon fluxes as a result of flooding are rather small and am wondering whether this might link to the size of the simulated terrestrial carbon inventory and thus the amount of carbon available in flooded gridcells. On page 10, l.232-233 the authors state that the terrestrial carbon inventory increased from 922.9 GtC to 1302.7 GtC between 21-15 kaBP and amounts to 1563.6 GtC in 12 kaBP. I am no expert on land modeling, but in a recent paper Müller and Joos (2020, BG) simulate total terrestrial carbon at the LGM at about 2000 GtC, which increases to about 2500 GtC in 12 kaBP. This is almost twice the amount shown in this study. Also, Ganopolski and Brovkin (2017, CP) simulate a larger terrestrial carbon inventory. Is the assumption correct that a higher terrestrial carbon pool would also increase the terrestrial organic carbon flux during flooding? If yes, this might be a point to be included in the discussion of uncertainties of the findings.

The change in terrestrial carbon content from 21 to 12 ka is slightly higher in our model with 640 GtC compared to 500 GtC from the study of Müller and Joos (2020). However, it is true that the initial value for the LGM is larger in their paper than in our simulation. This could partly be explained by the fact that we don't include peatland in this version of the model, so that we miss around 300 GtC as estimated in their paper. Other estimations (e.g. Prentice et al., 2011) suggest a total land carbon content of 1070 GtC for the LGM using a Dynamic Global Vegetation Model, which is close to our value. Compiled land carbon estimations from different modelling studies also suggest a change between the LGM and the preindustrial from 450 to 1250 GtC (Jeltsch-Thömmes et al., 2019). Even if our simulation doesn't go yet further than 12 ka, we are within the range of the estimated change.

More carbon stored in the terrestrial carbon pools doesn't necessarily imply an increase in terrestrial organic carbon fluxes to the ocean during flooding. The local carbon pool calculated as the sum of the vegetation, litter and soils pools varies depending on the vegetation type and on the latitude. During the simulated MWP1a, the flooding induced terrestrial organic carbon fluxes mainly happen at low latitudes, characterized by tropical vegetation which has a relatively high carbon biomass above ground (short-living material such as leaves) and typically doesn't have a high carbon content in soils. As in our simulation only long-living material from land carbon pools enters the ocean during a flooding event, our results for MWP1a might rather be insensitive to a higher local total carbon content in the tropical vegetation. Of course, this could be different for high latitudes characterized by organic rich soils in tundra, shrub or grassland which could be flooded later in the deglaciation.

In the same paragraph (p.10, ll.235-237) include Müller and Joos, 2020 BG into the estimates of terrestrial carbon evolution.

We added the reference in the text.

Are peatlands included in the land component of the model?

The applied version of JSBACH does not include peatlands.

Are there other uncertainties that would be good to be discussed (other than C:N:P ratios)?

This is a good point to mention. Besides the C:N:P ratios, the remineralization rates of the terrestrial organic matter in sea water are not well constrained parameters. The choice of different rates could lead to higher or lower CO_2 flux to the atmosphere. In the deglaciation run and presented sensitivity simulations with higher and lower stoichiometries of terrestrial organic matter, the remineralization rates were prescribed to 2.7×10^{-5} d^{-1} for wood, 2.7×10^{-4} d^{-1} for woody litter and 5.5×10^{-4} d^{-1} for humus. To investigate the influence of higher remineralization rates, we perform an additional sensitivity experiment for MWP1a. The new values are $1.0\text{x}10^{-4}$ d^{-1} for wood, $2.0\text{x}10^{-3}$ d^{-1} for woody litter and $8.0\text{x}10^{-3}$ d^{-1} for humus. This simulation uses the same higher stoichiometry ratios as one of the first sensitivity studies (see Table 3) to get an upper estimate of the potential impact of terrestrial fluxes.

We observe higher CO_2 outgassing in the defined equatorial box over a shorter time period. Figure 11 has been revised including a new grey curve that represents the simulation with high stoichiometry and high remineralization rates. For the northern part, the CO_2 flux to the atmosphere reaches $20\text{x}10^{-9}$ kg C m^{-2} s^{-1} after the flooding at 14.64 ka and decrease twice as fast as the simulation with high stoichiometry only (orange curve). Similar behaviour is observed for central and southern part with an outgassing peak after the flooding at 14.54 ka and 14.18 ka of $32\text{x}10^{-9}$ kg C m^{-2} s^{-1} and $27\text{x}10^{-9}$ kg C m^{-2} s^{-1} respectively (Figure 11b, c). This increased CO_2 flux to the atmosphere is primarily a result of wood remineralization since, as for previous simulations, wood dominates the terrestrial organic matter input to the ocean during flooding events at that latitude. Since wood is not buried in the sediment, the amount of material that can be remineralized is the same as in previous simulation, but at faster rate. Part of the outgassing is still due to the remineralization of woody litter and humus before they are buried. This text has been added at the end of Section 3.3 of the revised manuscript.

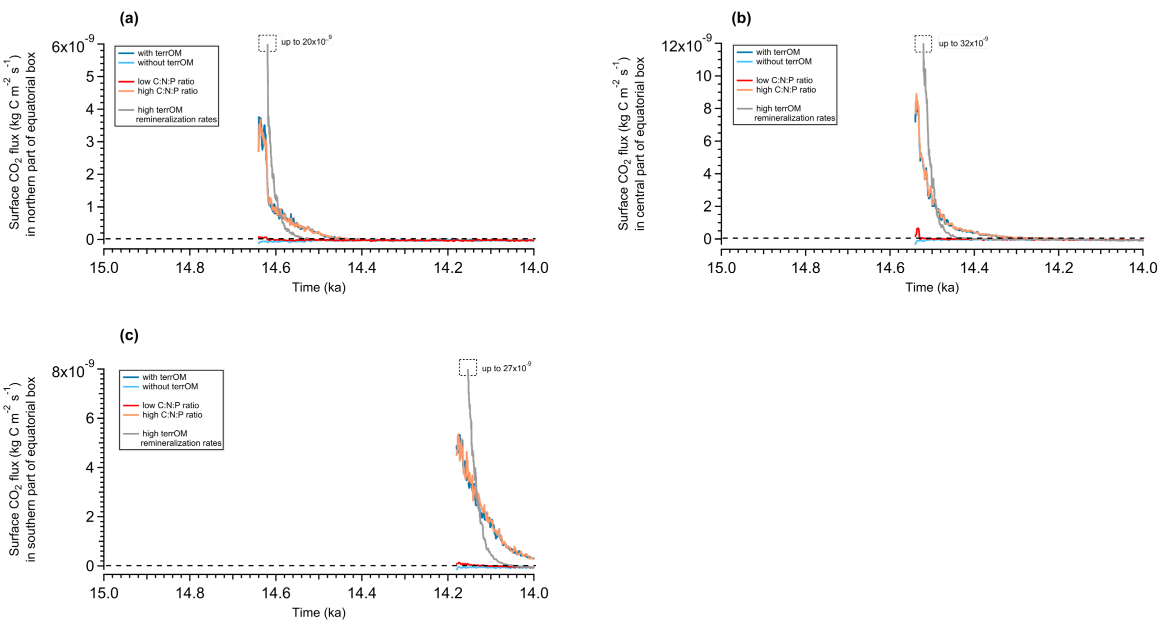

Figure 11. Evolution of the surface CO_2 flux during MWP1a for flooded grid cells in northern part (a), central part (b) and southern part (c) of the equatorial box defined between 15°N and 15°S for 5 different simulations: the reference simulation with the terrestrial organic matter fluxes (dark blue), the sensitivity experiment without terrestrial organic matter fluxes (light blue), the sensitivity experiment with low stoichiometry for terrestrial organic matter (red), the sensitivity experiment with high stoichiometry (orange) and the sensitivity experiment with high stoichiometry and high remineralization rates (grey). 50 years running mean is plotted for each simulation. Positive values indicate an outgassing to the atmosphere and negative values indicate an uptake by the ocean. The time series start when a flooding event occurs at that location.

p.5, ll.129-130: either 'presented a new development' or 'presented new developments'

Change done.

p.11, Fig. 4: why not compare 21 ka model with 21 ka reconstruction?

Following your comment and the one from Reviewer 1, we added a new Fig. 4 to compare the modelled biome distribution and the pollen data at 21 ka. The previous comparison between the modelled biome distribution at 15 ka and pollen data at 21 ka remain on the new figure and in the text.

We added the following text in the revised manuscript: “The LGM modelled biomes on Fig. 4a show an overall good agreement with the pollen data. At high latitudes of the Northern Hemisphere, tundra and boreal forests are simulated in regions that are not covered by ice, which is consistent with the few pollen data sets available at these locations. Temperate forest is modelled over part of North America, grassland over Europe and temperate/warm forest over East Asia. This is generally in agreement with the pollen record even if some local discrepancies are observed like in central Asia. At low latitudes the model mostly reproduces the tropical forest (over Eastern South America, West Africa and Indonesia) as observed in the pollen data (Figure 4a). Although the LGM conditions were different from those at 15 ka before MWP1a, in absence of other reconstructions we also used the LGM BIOME6000 pollen record to compare to model results. According to our model, the biome distribution doesn’t change much between 21 and 15 ka (Figure 4a, b) so that for many regions, the LGM pollen data show the same pattern as the simulated biomes at 15 ka. However, climatic differences between these two periods lead to small differences between the simulated biomes at 15 ka and the 21 ka pollen data. Part of the LGM tundra at high latitudes of the Northern Hemisphere is replaced by the boreal forest or grassland at 15 ka. At low latitudes, there is a slightly larger extent of the temperate forest over East Asia and of the tropical forest over South America at 15 ka. The tropical forest over Indonesia is however already present since the LGM.”

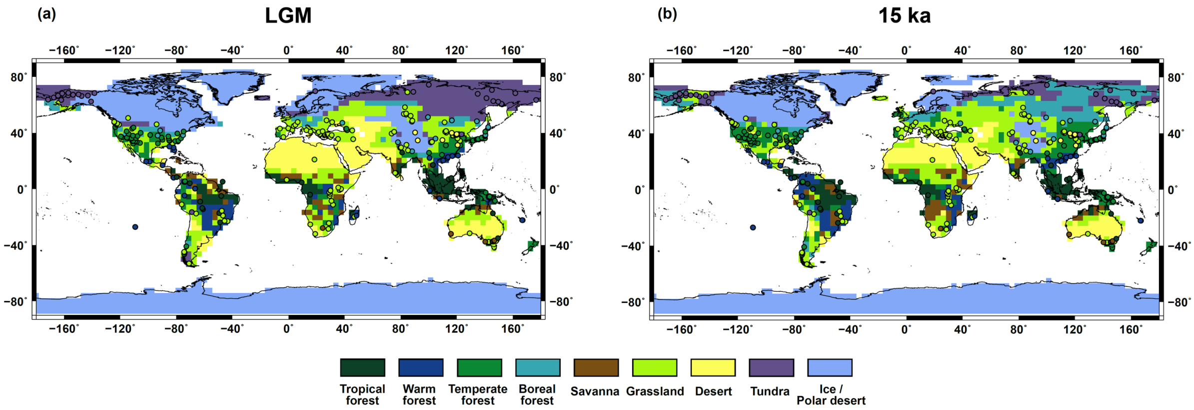

Figure 4. Biome distribution modelled by JSBACH at 21 ka (a) and 15 ka (b). The superimposed circles are the pollen data from the BIOME6000 Version 4.2 reconstruction at 21 ka for both figures (Harrison et al., 2017).

<u>References</u>

Harrison, S.: BIOME 6000 DB classified plotfile version 1, available at: http://researchdata.read.

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