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Climate of the Past Discussions

# *Interactive comment on* "Quantifying the Influence of the Terrestrial Biosphere on Glacial-interglacial Climate Dynamics" *by* Taraka Davies-Barnard et al.

**Anonymous Referee #2**

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General comments

In this paper the authors present results of 62 equilibrium simulations with a coupled atmosphere-ocean-vegetation general circulation model covering the last glacial-interglacial cycle. They performed simulations with and without dynamic vegetation to quantify the effect of the terrestrial biosphere on glacial-interglacial climate variability in terms of both biogeophysical and biogeochemical effects. Although the results represent an important contribution to our understanding of the role of the terrestrial biosphere to glacial-interglacial variability, I have some major comments that should be addressed before this paper can be considered for publication in Climate of the Past.

Since changes in vegetation cover are key to the results presented in this study, the modelled vegetation should be compared with available reconstructions, where avail-



able. The BIOME6000 dataset for the last glacial maximum provides a unique reconstruction of vegetation cover for glacial climate conditions and could be used to evaluate the model performance. As a minimum requirement, model results and reconstructions should at least be compared qualitatively and discrepancies discussed. Comparison with other modelling studies would also be useful (e.g. (Prentice et al. 2011; Hoogakker et al. 2016)). The representation of vegetation cover in Figure 1 in terms of dominant PFTs can be misleading. For example it seems from Figure 1 that tropical forest remains practically unchanged during glacial conditions. Is this just an artifact of the dominant PFT representation or is it a real feature of the model (in which case the discrepancy with available reconstructions has to be discussed)? In any case I would instead suggest showing fractions of all 5 PFTs separately, at least for pre-industrial and LGM.

The results about the biogeophysical feedback are presented in a rather superficial way, which makes it difficult to get a quantitative understanding of the processes responsible for the positive feedback. As the authors mention in the introduction, the biogeophysical feedback results primarily from the vegetation controlling the surface energy fluxes. The results section in the paper focuses almost exclusively on the effect of changes in surface albedo. Latent heat effects are only mentioned once when referring to Figure 4b but are not discussed further, and sensible heat flux changes are not mentioned at all. Albedo changes are probably the dominant effect, but the other effects should also be quantified. I would suggest to add panels showing the changes in latent and sensible heat flux to Figure 3 and to move the albedo plots from Figure 5 to Figure 3 (it is not clear to me why albedo maps are shown together with vegetation and soil carbon). Also, I would suggest replacing the albedo figures with net shortwave radiation absorbed at the surface. Shortwave radiation is a more appropriate measure because it accounts for changes in insolation and can moreover directly be compared to the latent and sensible heat fluxes.

The authors show that the vegetation is interacting with the thermohaline circulation.

It would be interesting to understand how this is happening. Can anything be said about possible causal relations, given the available simulations? Is vegetation affecting runoff into the North Atlantic, or are vegetation and THC interacting via changes in atmospheric circulation?

In the model description section, no information is given on the soil carbon representation in the model. I expect the results of the biogeochemical part to strongly depend on how soil carbon is represented in the model. In particular, a proper representation of carbon stored in permafrost is probably crucial to model land carbon storage during glacial times. In the discussion section the authors mention that the model does not have a process-based permafrost component, but this should also clearly be stated in the description section. The amount of carbon which can potentially be buried below the ice sheets will strongly depend on how carbon in frozen soils is treated. The authors should discuss this in more detail. How does the carbon stored in permafrost in the model compare to observational estimates (Hugelius et al. 2014) for the present day?

In the biogeochemistry results section the effect of dynamic vegetation on land carbon storage is not discussed, although the differences in vegetation and soil carbon between static and dynamic simulations at LGM is shown in Figure 5 (the 30 kyr maps of vegetation and soil carbon in Figure 5 seem redundant to me). If I understand correctly, in this section only the dynamic vegetation simulations are discussed. This should be clarified in the text.

A figure showing the differences in land carbon storage between LGM and present day would be helpful.

Specific comments

Page 1, line 7: specify that the 62 simulations are 'equilibrium' simulations. Page 1, line 18: ocean/atmosphere Page 3, line 13: vegetation carbon -> land carbon Page 4, line 14: remove brackets Page 4, line 29: timer -> time Figure 1: legend is hard to read



Page 6, line 7: -0.91°C was -0.84°C in the abstract (if I understand correctly) Figure 3: Are the figures for annual mean characteristics? Please specify. Figure 4: use of different colors for different lines would improve readability Page 9, line 6: it IS unclear Page 10, line 2: carbon stores changes -> carbon stores Page 14, lines 8-11: shelf carbon stocks values should be positive Page 14, lines 13-15: check sentence

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