Interactive comment on "Impact of CO2 and climate on the Last Glacial Maximum vegetation" by M.-N. Woillez et al.

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General comment:

This paper present a very interesting modeling study of the relative impacts of CO2 and climate on the vegetation at the Last Glacial Maximum. It has broad implications for past climate inferences from vegetation proxy data (pollen, charcoal etc).This issue has been tackled by a few modeling groups but mostly with just one model. The authors here present results from a different model, with a large number of numerical experiments that allows for a detailed and very interesting analysis of the results. The paper is very well structured, clear, and easy to read.

My main issue is the following:

The simulation of the current distribution of vegetation forced by climate observation is not very good in the mid latitudes (Fig 3, a). The Boreal Broadleaved Summergreen (BoBS) trees seem to outcompete temperate trees (Fig 3, 5). Similarly, their NPP (Fig. 14) seems very high (although this is forced by IPSL_CM4 climate and could be due to biases in the climate).

The high NPP for the Boreal Broadleaved Summergreen is a bias from ORCHIDEE, and not from the climatic forcing, since their NPP is high even when we use the CRU timeseries (results not shown).

I wonder if the exaggerate dominance of this PFT does not affect the sensitivity of the results presented here. Couldn't the increased dominance of broadleaved trees under LGM conditions be partly due to the too highly competitive BoBS ? or to temperate trees that might not be competitive enough ? Similarly, I would argue that the underestimation of grasses in the current climate might play a role in the low sensitivity of tree cover to the LGM climate. These two issues should be discussed by the authors.

BoBS are indeed too competitive under present-day climate, and this high competitivity is even accentuated for the LGM because of their lower sensitivity to the low CO2 level.
But the static simulations show that the difference of sensitivity to CO2 between needleleaved and

broadleaved exists even when competitivity is not at play.

We discuss this point in section 5: the statement « However, our results..glacial forests » p21, L13-15 has been replaced by :

« The overestimation of the productivity and competitivity of BoBS compared to the other tree PFTs might affect the sensitivity of the results. On the one hand, the overestimation of BoBS in CTRLP may lead to an exaggerate forest regression at LGM compared to present-day, but on the other hand the lower sensitivity of BoBS to the CO_2 decrease in LGMG may on the contrary underestimate this regression. However, these possible biases do not affect our conclusions on the important role of the CO_2 decrease to explain the regression and/or change of composition of forests at the LGM. Nor do they affect the conclusion on the importance of the initial state (section 4.2.4) and the fact that the respsonse to CO_2 depends on the background climate (see section 4.3). »

The underestimation of grasses is indeed an issue, that we plan to investigate. Examining this issue would indeed require special additional experiments. In particular, we want to test new bioclimatic limits, and to investigate a potential problem of competitivity for water between grass and trees.

Specific comments :

P8 l 4-16 and Table 2: Did the authors really save 1000 years of 6-hourly outputs from the LGM climate simulated by IPSL_CM4_v1 ? The authors didn't select the last century or so and repeated this forcing X times ? This should be better explained.

Yes, we saved 1000 years of 6-hourly outputs.

P10. L4: Some vegetation models take into account frozen grounds. For the S limit of the forest, another explanation for the overestimation of forest cover is land-use.
We agree, and have suppressed the sentence « In fact, such an excess of trees...nutrients availability »

P10. L5: The fact that grasses can't grow below trees in ORCHIDEE can't be used as an argument here. CLM-DGVM, also based on LPJ, doesn't allow grasses under trees but overestimates grasses (Bonan & Levis, J. of Climate, 2006)

We thank the reviewer for this reference. We have suppressed « since they cannot grow below trees in ORCHIDEE » and replaced by « partly because of a bias not yet understood in ORCHIDEE, and partly because of the climatic forcing ». We plan some further tests to try to

understand the main reason of this lack of grass.

P11. L23: "...since oak forests were present over the Iberian peninsula...". The sole presence of an oak forest over the Iberian peninsula doesn't seem enough to prove that IPSL_CM4 simulates a climate closer to an interstadial. It does over Spain, but what about the rest of the Globe ?

We have modified the text as follows: «...the glacial climate simulated by IPSL_CM4 over western Europe is too warm and wet... »

P16 L6: the argument that grasses are not allowed to grow under trees is not really valid here either and it is also not necessary. In models where grasses are allowed to grow below trees, they are still shaded by the trees and only grow if the tree canopy is sparse. The same is true in nature, grasses don't grow under dense canopies.

The sentence « since as mentionned in Sect.2.1 grass is not allowed to grow below trees in ORCHIDEE » has been suppressed.

Technical corrections:
All the technical corrections have been taken into account.

Check citations (parenthesis etc)
This has been done. Sorry for the errors in positionning the parentheses.

Check past tens usage
We have attempted to use the present tense through the text.

P8. L22: To improve clarity, use "CRU timeseries" instead of "CRU data" to differentiate from the CRU climatology.
We have taken this correction into account.

P10. L15. Define global foliage projective cover and how it is calculated in the model.
Ok, the definition provided P12 has been moved at this line.

P10. L26-28 : This sentence is hard to understand. The authors should rephrase it.

« However, the LGM is often missing in pollen reconstructions of the lowland tropical forests, indicating dry and erosive climatic conditions (Ledru et al., 1996, 1998). The high bare ground fraction simulated by ORCHIDEE over South America at the LGM is thus less problematic than it is

for present-day. »

P11 L2: "where ORCHIDEE" instead of "when ORCHIDEE"
Thank you for the correction.

P11. L4: "the region of the Great Lakes". I believe the authors are talking about the African Great Lakes region. It should be specified because of the possible confusion with the Great Lakes region of North America (although it was covered by ice during the LGM).
Ok, changed to « the region of the African Great Lakes »

P11 L6: "...Fig 7) and are replaced by..."
P11. L7: "...over most parts..."
P12. L1 : "LGMG" instead of "LGMP".
P12. L14-22: The definition of LAI (may be not needed), surface of global projective cover and surface of presence should be moved to section 3.2 when these concepts are 1st used.
P12. L 22: "...differentiate these two variables because the amplitude..."
P12 L.24: "...because grasses cannot..."
P12 L24-25 : I'd suggest splitting the sentence in 2: "...below trees in ORCHIDEE. It is the forest disappearance that can allow..."
P13 L5: suggestion: "does not affect tree growth and glacial..."
P14 L22 and P15 L12: "...Northern Hemisphere..."
P14 L 24: suggestion "C3 grasses expand..."
P14 L25: "Parts of the..."
P21 L 24: suggestion: "change in climate affects..."
P21 L26: "...productivity in this zone..."
P22 L14: "have different sensitivities..."
Improve colormap for Fig 1 (negative, positive)
Fig 2: - suggestion: mask out precips<100 mm/yr to avoid big increases in Sahara - figure caption : use LGMP like in the main text
Fig 3: the North Pole seems to have risen from the waters at LGM. The authors should check the northern most latitude band.
This is just a problem with the land-sea mask, without any impact on the results. The figure has been redrawn.

Fig 3, 4, 5, 12, 15: The authors could drop Antarctica, this would free up space and allow for larger figures.

Fig 15: increase size of legend