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Climate of the Past Discussions

# *Interactive comment on* "Quantifying the effect of vegetation dynamics on the climate of the Last Glacial Maximum" *by* A. Jahn et al.

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## General comments

The title of the paper reflects very accurately its content. Indeed the paper is quantifying the importance of several factors in the simulated LGM climate. These factors are vegetation, ice sheets (more precisely, ice sheets + land/ocean distribution + sea level change + parameterisation of North Atlantic Gyres) and atmospheric $CO_2$ concentration. The climate model used for this study is CLIMBER-2. It is not interactively coupled with an ice sheet model for the purpose of this paper. Two methods are mixed to quantify the importance of the three factors, i.e. the factor separation and the feedback analysis. Previous studies were already done to quantify the importance of these factors and the methods used are now becoming widely used. However these former studies were not necessarily considering all the three factors together or the LGM boundary conditions. Therefore this paper might also be a basis for comparison of the relative importance of the factor against the climatic forcing.

The authors do not explain why they choose to mix these two methods instead of, for example, using the factor separation for three factors. It is in fact my major concern related to this paper. It is well known that the two methods are giving different kind of information. However, here the results of both analyses are mixed. I suggest the author (1) to explain the difference between the methods, their advantages and disadvantages, (2) (at least) to explain why they did not perform the factor analysis over the three factors. If time allows it would be interesting to have this last point done, for example, using as the third factor vegetation of either the REF or the LGM$_{CIV}$ simulations.

A table containing the global annual mean surface air temperature for the different simulations or the difference with respect to the REF and/or the different contributions would be very much welcome in addition to the discussion in the text.

**Specific comments**

1. The abstract might be misleading or at least should be clarified. It is summarised that the LGM global cooling is due to ice sheets (59%), $CO_2$ (29%) and vegetation (12%). The sum of the three is indeed 100%. However I do not think that the three numbers can be added in that way. Indeed insolation forcing is also responsible for some cooling (direct or not) and part of the 12% of the vegetation is most probably included in the 59% (ice sheets) and 29% ($CO_2$). It could also (maybe) be added that these values are direct effect (without synergy).

2. In the abstract, and more generally speaking, the role of the insolation forcing is not very often quoted. It is indeed not the purpose of the paper. Nevertheless (1) insolation is recognised to be the major forcing for climate change and (2) it is important to clearly state which insolation is used for the simulations. It might be surprising to the reader that this study of LGM is performed with present-day insolation. Could the authors elaborate on why using present-day or LGM insolation gives the same results? Do they mean that insolation is not important?



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3. Although the paper is clearly organised, the description of the experiments might be slightly improved. I would suggest reorganising section 2. I suggest (2.1) the model, (2.2) the boundary conditions, and (2.3) the performed experiments and the methods. It could be explained in section (2.2) that several simulations (equilibrium) were performed with two ice-sheet configurations, two $CO_2$ values. The insolation (present-day distribution for all simulations) and the vegetation used should also be described as well as the state of the ocean. Are there several equilibrium states for the glacial ocean? Which state is used for the simulation? Is the ocean circulation stronger or weaker than the present-day one? The simulations are equilibrium simulation. This must also be clearly stated. The length of the equilibrium should be mentioned. I assume that only the last year of the equilibrium is discussed. Is it correct or are the results a mean over several simulated years?

4. In the discussion of the results, the authors underline that the cooling in the NH leads to an increase in the Atlantic overturning circulation. However it is now largely recognised that during the LGM (cooler temperature) was most probably weaker. It should be discussed why it is not the case here?

5. The authors interpreted the synergy term as a threshold process. They explained that under higher $CO_2$ concentration this threshold would not be passed. Would it mean that this threshold could also be passed by only strongly reducing $CO_2$ concentration or by only increasing the ice sheet (without any change in the other factor)?

6. The vegetation feedback in response to ice sheet or $CO_2$ (at least in $f_I^V$ and $f_C^V$) produces a cooling in the Southern Hemisphere, in the area of the Weddell Sea. It is probably hard to attribute this cooling to a change in vegetation (as it is done for the cooling in the Northern Hemisphere). Could the authors explain the origin of this temperature change? However the vegetation feedback in response to the



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synergy between ice sheet and $CO_2$ leads to a temperature increase in the high latitudes of the Southern Hemisphere. If I am correct, the global annual mean temperature change due to vegetation in response to this synergy is positive (warming, not cooling). This would need some discussion.

7. The authors compare their results with those from Berger et al. (1996) and they conclude for a good agreement. However the study by Berger et al. (1996) takes into account the insolation changes, which is not the case for the present study. Therefore, does the authors suggest that the insolation does not have any impact on the climate at the LGM?

**Technical corrections**

Some technical vocabulary should be defined/explained, e.g. physiological effect, biogeophysical feedback, biogeochemical effect.

Page 5 – line 12–14. There is a problem in this sentence. Maybe the words 'their cooling' should be erased.

Page 5 – line 24. I am not sure that the word 'geography' is valid in this context.

Page 6 – line 10. 'the full LGM experiment' is it $LGM_{CIV}$? It should be told.

Page 8. $f_{CI}^{V}$ is not explained in the text, only in the figure caption

Page 8 – line 25. There is an unknown symbol ($\hat{f}_C$)

Page 10 – line 7. Isn't it two studies rather than two factors?

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