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Climate of the Past Discussions

Interactive comment on "Influence of dynamic vegetation on climate change and terrestrial carbon storage in the Last Glacial Maximum" *by* R. O'ishi and A. Abe-Ouchi

Anonymous Referee #2

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General comments

Based on a modelling approach, O'ishi and Abe-Ouchi discuss climatic and vegetation changes during the Last Glacial Maximum (LGM) with a focus on elements of the carbon cycle. Through a combination of fully-coupled and offline simulations, they investigate the vegetation feedback on glacial climate, but also the relative influence of different forcing factors (CO_2, temperature and precipitation) in shaping the glacial vegetation response. A factor analysis nicely illustrates the dependence of different vegetation types and net primary productivity on glacial forcings in an idealized way as

feedbacks of the vegetation onto climate are neglected in these simulations using an offline dynamic vegetation model. Additional information on the glacial carbon cycle is presented from the analysis of simulated terrestrial carbon storage. Furthermore, results are discussed in the general context of glacial CO2 lowering. The approaches seem reasonable, the paper presents interesting details and should be published in Climate of the Past. I would, however, suggest major revisions, e.g. in terms of the writing and presentation of the methods and arguments so that these become more obvious. Some rewriting would also be necessary to emphasize the novelty of the study compared to other studies which use AOVGCMs and discuss the (glacial) carbon cycle.

Specific comments

- LPJ is a widely used model, also in paleo applications. In this respect, it would be important to emphasize in more detail how the present study and its setup are different from earlier works using LPJ. This could be done in the abstract, but it should be definitely included in the Introduction section.
- The last sentence of the Abstract should be rephrased, it is not straightforward to understand.
- As the study covers several different aspects and uses different model setups and model components, it would be helpful to more clearly state the main goals and approaches of this study at the end of the Introduction section.
- Section 1 should mention that the "working horse" of this study is an AGCM with a slab-ocean component. This becomes only clear from the last sentence of section 2.1. From reading section 1, people might think of the "typical" PMIP setups using fully coupled AOGCMs with the ocean being represented by a comprehensive GCM as well. I am fine with the slab-ocean setup, but it should be

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stated much more clearly, maybe also together with a motivation why choosing this setup.

- For readers who are no MIROC experts, it can be confusing whether MIROC is the coupled model or the AGCM only. This should be written in a clear and consistent way, in particular in section 2.1.
- The authors use the expression "separated DGVM experiments". I think such experiments are more commonly referred to as "offline" simulations. So I suggest to use this term throughout the paper.
- p. 5789 l. 8: I would add the MARGO paper (Nat. Geosci. 2009) to the Reference list.
- p. 5789 l. 27 - p. 5790 l. 3: This should be rephrased for improvement. Also, mentioning published AOVGCM studies for the LGM requires a statement what is special about your new study.
- p. 5790 l. 25: "so that we could assume" - What do you mean by that? Please rephrase, e.g. into "we apply an AOVGCM to simulate the climate of the LGM, but in contrast to earlier studies, the vegetation feedback onto climate is included".
- Section 2.1 and 2.2: Since there is a section on its own ("Bias correction") in the paper, I would only mention the bias-correction procedure there and not yet in section 2.1 (line 11/12). What do you mean by "the GCM bias"?
- p. 5791 l. 26 - p. 5792 l. 3: This is a bit hard to read. I would first describe how the model with fixed vegetation works and then describe what is different when coupling the model with the DGVM.
- p. 5792 section 2.2: What do you mean by "control and present day"? Is "control" pre-industrial? "false response" could also be misleading as it should be

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consistent within in the model. Is the bias correction exactly the same for modern and paleo simulations, i.e. with the underlying assumption that the model bias is independent of the respective climate? As details on the bias correction are given in O'ishi and Abe-Ouchi (2011), it would be interesting to list two examples of regions most concerned by the bias in this section.

- section 2.3: One could add the whole carbon model description to section 2.1 where LPJ and PFTs are already introduced. At least, all important elements of the model which will be discussed later (litter in Fig. 4) should be introduced here. Since quite some part of the discussion is on the separation of carbon storage (as outlined on p. 5791 l. 2-3), it would be important to introduce everything needed for this in the context of the model description.

- p. 5793 l. 12: I would mention here which ice sheet version is used (ICE-5G?) and whether all the boundary conditions are following PMIP2/PMIP3 guidelines. It would be worth mentioning and interesting for all people aware of PMIP activities.

- p. 5793 l. 16: Do you mean the vegetation map fixed in terms of PFT? Is the AOV equilibrium state a multi-year mean annual cycle (e.g. monthly means)?

- p. 5793 l. 19: This confuses me, especially "using the LGM land cover". Do you mean the LGM distribution of ocean and land points? You should also add why you didn't take the mean LGM vegetation from the AOV (LGM) experiment.

- p. 5793 l. 23: what is meant by "after two AOV experiments"?

- p. 5794 section 3.2.1: You should definitely mention here which setup you are using here, e.g. "We performed three sensitivity experiments using the LPJ-DGVM in an offline mode. In order to compare the impact of...., in each of these experiments, one factor is set to the PI value..."

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- p. 5794 section 3.2.1: It would be interesting to add the length of the sensitivity experiments to Table 2 and to the text of this section as well. Are you also showing results from the last 50 years of these experiments as stated at the end of section 3.1?
- p. 5794 l. 11: With 400 years, are you referring to the length of the AOV (LGM) in Tab. 1?
- p. 5794 section 3.2.2: I am a bit confused by this experiment description. Did you actually perform several experiments with AO (LGM) input (line 19/20)? And what is meant by using the last 50 years from the AOV GCM experiments and running the DGVM for the equivalent of 1000 years? Do you prescribe a climatological average or do you repeat 50 years forcing for 1000 years in total? Some reference for the "traditional offline diagnosis" (l. 21) also would be nice.
- p. 5795 section 4.1: Are you referring to 2m air temperature as stated in the titles of Fig. 1?
- p. 5795 ll. 14-15: Where do you derive from that 30% of the total cooling is vegetation-induced?
- p. 5795 l. 23: If you didn't perform a statistical test, the word "significant" should be replaced.
- p. 5795 section 4.1: Please be careful with the description of your results. You want to distinguish pure LGM changes (such as Fig. 1a,c) from the effects of vegetation. The same is true for section 4.2 where you want to distinguish between the description of the general LGM changes and the changes due to a certain forcing factor on PFTs and NPP. Sometimes this seems a bit mixed and would benefit from organizing the discussion more along the figures.

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- Section 4.2: Please be consistent in the wording. Fig. 2 caption says "potential vegetation", the legend lists the different PFTs, and in the text (e.g. p. 5796) you are using expressions like "tropical forest", "temperate forest".
- p. 5796: discussion of NPP: If you are looking at global averages of NPP (l.16), shouldn't it have the same unit as shown in Fig. 3? Or are you showing an integral over the globe? Furthermore, I don't understand the "reduction of NPP" in the PI experiment (l. 19).
- p. 5796 l. 21: rephrase to "additional sensitivity experiments for the LGM using the offline LPJ-DGVM, but setting one of the forcing parameters to preindustrial values." This will provide the link to the experiment description.
- p. 5797 l. 15: From Fig. 2e, it seems as if CO_2 has a strong influence on Southeast Asia and Australia.
- p. 5797 l. 20 and 24: I think it should be "additive" or "combined" instead of "non-linear". Replace "these three variables" by "the three different forcing factors".
- p. 5798 l. 1: rephrase into "Output from two AOV...were chosen as input for the offline LPJ model (see Table 1 last column)." I don't understand the sentence in ll. 2-4 and the expression "after the AOGCM result" in l. 4.
- p. 5798 section 4.3: I would suggest to present the difference numbers in a modified Table 3, so that it becomes immediately obvious which differences between experiments you are talking about.
- p. 5798 l. 12: At some points, you mention the equivalence of terrestrial carbon reduction to CO_2 emissions to the atmosphere. A reference for the conversion between the two numbers would be helpful. Zickfeld et al. (2011), for instance, use 0.48 for the conversion between PgC and ppm.

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Interactive Comment

- In section 2.3, the types of carbon storage and carbon pools are mentioned (p. 5792) but seem a bit decoupled from the discussion in section 4.3 and Fig. 4 (where different expressions in the Figure titles and captions are used, e.g. litter). Please use consistent terms to present your arguments.
- p. 5800 ll. 11-12: Is it really possible from your set of experiments to draw this conclusion (albedo most important factor)? This also refers to p. 5803 l. 3.
- p. 5800 ll. 14-16: I find this sentence confusing.
- p. 5800-5801: You announce three reasons for the overestimation of boreal forest (l. 21), but I only find two.
- p. 5800 l. 28-29: This is an important information for the section of model description, since it also helps to correctly interpret Fig. 2.
- p. 5801 l.1: Please be more precise, "using variables" is very general. This is also true for p. 5803 l. 10 ("using separate dynamical vegetation modules with GCM variables").
- p. 5801 ll. 8-9: How do you estimate the 1-2°C change with a change in the fractional land-surface scheme? This would require additional experiments. Also p. 5802 l. 15: Did you perform additional experiments with a moderate (how much?) sea-level change?
- Please be consistent in using acronyms (e.g. AOV, AOVGCM and AOV GCM) and LGM throughout the paper. Sometimes, it is not completely clear what you are referring to by either using "LGM" for the climate state or instead of the experiment name AOV (LGM). This holds for the text, but also for the caption of Fig. 1. Another example would be p. 5801 l. 3.
- Please revise the manuscript with respect to adding figure references in the text. This would point the reader directly to the figure being discussed.

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- Fig. 1: What happens in the white areas of Fig. 1a? Furthermore, I am not completely sure about what is shown in Fig. 1f.
- Fig. 1c: Why is there an impact of vegetation on the albedo response in regions covered by the continental ice sheets?

Technical corrections and other minor suggestions

- Abstract l. 6: replace the 2nd "level" by "concentration"
- Abstract l. 11: "The result shows..". "that" is missing here.
- p. 5789 l. 10: replace "than it is in the present-day" by "than at present-day"
- p. 5789 l. 25: replace by "using vegetation models with GCM results as input"
- p. 5789 l. 25/26: consistent with what?
- p. 5791 l. 14: The AGCM acronym has already been introduced earlier.
- p. 5792 l. 6: delete "points"; l. 10: delete "problem of"
- p. 5792 l. 23: Do you mean "in the coupled MIROC-LPJ"?
- p. 5793 l. 2-3: should read "integration years" and "in a coupled MIROC-LPJ setup"
- p. 5793 l. 8: "In the pre-industrial control experiment...."
- p. 5793 l. 9 and 11: I would prefer "orbital parameters" to "orbital elements"
- p. 5793 ll. 17-20: I would split this long sentence. "Land cover ...present day. Thus, in order to...."
- p. 5793 l. 21: I guess you mean "land grid cells".
- p. 5795 l. 8: I would write "The global distribution of temperature..."
- Section 6: This section could be slightly shortened, as it repeats some parts (e.g. around p. 5803 l. 15 and p. 5804 l. 6)
- Fig. 4: For the caption, I suggest "....obtained from LPJ forced by a)..."

In general, the manuscript contains a number of typos and minor language errors. The

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manuscript should be improved in this respect.

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