



Interactive comment on “Quantifying the effect of vegetation dynamics on the climate of the Last Glacial Maximum” by A. Jahn et al.

A. Jahn et al.

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We want to thank Referee #2 for the helpful and positive review. In regards to the proposed inclusion of oceanic feedbacks we want to note that we do not see a substantial rationale for studying oceanic feedbacks in this manuscript mainly for two reasons:

1. We prefer to consider the atmosphere-ocean system as a unitary interactive system for the simple reason that the ocean covers 2/3 of the earth surface and, therefore, it is responsible for major part of the system response. Prescribing sea surface temperatures or sea ice from different steady state, e.g. for analysis of LGM climate from present-day, would severely dampen the LGM cooling, and modify atmospheric state to a mixture of extremely cold continents and relatively warm oceans.
2. We think that adding oceanic feedback analysis would erode the clear focus of the given paper: to quantify the role of the interactive vegetation relative to

the prescribed ice sheet and CO₂ factors. There are many oceanic feedbacks (e.g., via SST, sea ice) that could be studied in a step-by-step approach and this analysis would require a lot of new discussion since consequences are sometimes counter-intuitive. In our view, this discussion is more suitable for a new paper rather than for the given one.

In the following, comments are addressed in the same order as in the review:

1. Page 4, Methods: The experiments were run over 5000 years, and averages over the last 10 years of the simulation were used to produce the results (as explained also in the response to the comment of M. Loutre, #3). This information will be included in the revised version of the paper.
2. In our previous LGM simulations, we followed PMIP (2000) protocol, which prescribed an atmospheric CO₂ concentration of 200 ppm for the LGM. However, more recent data (e.g., EPICA, 2004) indicate atmospheric CO₂ levels at the LGM in the range of 180–190 ppm. In our study, we adopted 190 ppm (as in Petit et al., 1999), which is 5 ppm higher than in PMIP-2 protocol. The sea-level was only lowered by 105 m, as in previous LGM experiments; the 115 m was a typing error that will be corrected in the revised version.
3. Page 7: Here we use the same version of the CLIMBER-2 model and the same boundary conditions (except for CO₂ concentration) as in Ganopolski and Rahmstorf (2001) and the new results are fully consistent with the earlier ones. Ganopolski and Rahmstorf (2001) performed their stability analysis with the fully coupled (atmosphere-ocean-vegetation) model for pCO₂=200 ppm. For this CO₂ concentration, in *LGM_{CIIV}* the cold mode is the only stable mode of thermohaline circulation (THC) (as reported in Ganopolski and Rahmstorf, 2001), but this is not the case in *LGM_{CI}*. However, for pCO₂=190 ppm, the cold mode is simulated both in *LGM_{CI}* and *LGM_{CIIV}*.

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4. Page 7: Indeed, both in LGM_C and LGM_I , the THC is in the warm mode and stronger than in the control experiment (REF), although the changes are not the same (larger change in LGM_I than in LGM_C). We will make this clearer in the revised version of the manuscript.
5. Page 8: Although vegetation or CO_2 changes affect somewhat the hydrological cycle, this is not the primary reason for the THC regime change. As it was shown in Ganopolski and Rahmstorf (2001), for the full glacial conditions the bifurcation transition between cold and warm modes occurs in the domain of negative anomalous freshwater forcing, and for the unperturbed climate state (zero anomalous freshwater forcing), only the cold mode is stable. However, for a somewhat warmer climate, the position of bifurcation transition moves to the domain of positive freshwater flux, i.e. the warm mode becomes stable under zero freshwater anomalous flux. Thereby the global cooling is another bifurcation parameter of the model, and for unperturbed freshwater flux, the global temperature determines which mode of the THC is stable. This critical temperature is crossed either when CO_2 is lowered from 200 to 190 ppm in LGM_{CI} , or when LGM vegetation is used instead of the modern one for $pCO_2=200$ ppm. We will include part of this explanation in the revised version of the manuscript to make the reason for the shift in the THC clear.
6. Page 7/8: The synergy between ice sheets and CO_2 is rather small in term of globally averaged temperature ($-0.1^\circ C$), and strong regional cooling and warming is solely attributed to the reorganization of the ocean circulation. The latter occurs because the combined effect of CO_2 and ice sheets produces a cooling that is sufficient to make the warm mode of the THC unstable.

Additional Reference:

EPICA community members: Eight glacial cycles from an Antarctic ice core, *Nature*, 429, 623–628, 2004.

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Interactive comment on Climate of the Past Discussions, 1, 1, 2005.

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