

## Review of Goelzer et al, 2015, CPD

This study investigates the effect of changes in ice sheet configuration and related meltwater fluxes on the climate evolution during Termination II and the Last Interglacial. The authors first reconstruct the evolution of the ice sheets by looking at reconstructions of the Northern Hemisphere ice sheet and simulating the Greenland and Antarctic ice sheets. This is then used as a boundary condition or forcing for simulations with the LOVECLIM model. The research is performed well, produced interesting results and should be published. However, some parts are unclear and/or could be discussed better. Please discuss the comments below before publication in CP.

### GENERAL COMMENTS

- 1) The changes in ice sheet configuration and related freshwater fluxes are treated as a forcing. The feedback effect of the resulting climate change on the ice sheets themselves is not included. This is fine – as a first step – but should be stated more clearly and should be discussed more (not only for the Greenland ice sheet – ocean interaction of page 4405, ~line 20).
- 2) I'm missing a more thorough comparison of the reconstructed/simulated ice sheets to paleo data. A figure comparing your ice volume or extent for the different ice sheets to reconstructions or previous ice sheet modelling work could help. For the Eurasian ice sheet recently a digitized dataset became available (Hughes et al., 2015). And tens of studies simulated the Greenland ice sheet during the Last Interglacial. How similar/different is your reconstruction?
- 3) Related, the description of the set-up of the Greenland ice sheet simulations is not very clear. Your method (also called “index” method in the literature) is a valid, but slightly older method, not “standard” (page 4396, line 15). Why do you use such a small conversion factor between  $\delta^{18}O$  and temperature (1.5 degC/permil), and then amplify this by a factor of 0.6? This is confusing. Huybrechts (2002) uses about 2.4degC/permil, why not use that?
- 4) Also, how do you calculate the precipitation over the ice sheets?
- 5) How do you derive temperature and precipitation forcing over the Antarctic ice sheet from the Dome C record?
- 6) Last part of Section 2.2 is rather unclear. Would be nice if you include a figure showing the differences to the Kopp et al. (2009) reconstructions. Also when do you assume the additional peak contribution of glaciers and thermal expansion of the ocean to occur (timing)?
- 7) Sections 4 to 6 are again difficult to follow. Maybe it is better to first explain the Reference experiment, and then make very clear that you investigate the combined effect of the ice sheets (both topography and freshwater flux) before investigating the effect of freshwater from the “dynamic” ice sheets on the LIG climate.
- 8) The simulated temperature over Greenland (Section 4) should be discussed and compared to paleo data. See for example: CAPE members, 2006; Otto-Bliesner et al., 2006; Alley et al., 2010; Axford et al., 2011.
- 9) In the Discussion you mention that the AIS retreat could be constrained by the oceanic cold event that you simulated. However, you also mention in Section 6 that this event is rather short lived. What is the temporal resolution of the sediment cores in the SO? Do they have a resolution high enough to detect a few kyr lasting cold event? Please discuss.
- 10) Great that you perform an additional simulation where Antarctic FWF are halved (see Discussion). Some more discussion on the robustness of the computation of the FWF

fluxes (also from the other ice sheets) is needed. This can possibly be done in combination with the more thorough comparison to previously published LIG ice sheet variations (see General comment 2).

## **SPECIFIC AND TECHNICAL COMMENTS**

- 1) Many sentences are rather long. It would clarify the content remarkably if some of the sentences would be split in two. Some examples are marked below, but a thorough check of all the text is needed.
- 2) Check if the references are correct. For example, the Langebroek and Nisancioglu paper was published in 2014 (correct in Reference list, but not in text, e.g. page 4392, line 23)
- 3) Check abbreviations for GrIS and AIS, and make sure the full terms are stated only once, and afterward use the abbreviation

Page 4392, line 1: explain when Termination II occurred

Page 4392, lines 18-21: rewrite sentence. “possible feedbacks on the ice sheet evolution”? That feedback is exactly NOT included in this study...

Page 4393, line 25: “If active”, what is “active”? – rewrite sentence

Page 4394, line 2: add reference to Langebroek and Nisancioglu (2014) for SO warming cause by orbital forcing

Page 4393/4394: add reference Marino et al. (2015), “Bipolar seesaw control on last interglacial sea level”

Page 4393-4394: lines 29-4: split in two: “The see-saw mechanism was evoked to explain part of the peak Antarctic warming during the LIG (e.g. Holden et al., 2010), even though some Southern Ocean (SO) warming was shown to be possible with orbital forcing alone (without NH freshwater forcing). The mechanism has been speculated to cause increased Antarctic ice shelf melting and West Antarctic ice sheet (WAIS) retreat (Duplessy et al., 2007). “

Page 4394, line 23: delete “remaining”

Page 4396, line 6: “similar variability” between what? Last deglaciation and at ~128kyr BP?

Page 4396, line 14: change “form” to “from”

Page 4396-4397, lines 27-3: rewrite such that “for the GrIS” and “for the AIS” are placed at the end of the sentence

Page 4397, line 2: “is expected” instead of “may be expected”

Page 4397, line 3: “former method” instead of “first”

Page 4397, line 4: Delete “Finally”

Page 4397, line 9: “overrides” instead of “masks out”

Page 4397, line 12: “dynamic GrIS” instead of “activated”

Page 4398, line 3&7: “coupling”? There is no coupling, or? Please rewrite.

Page 4398, Section 3: Are those GHG levels following the same values as used in PMIP3?

Page 4399, line 4: Maybe change the title to “Effect of GrIS and AIS on the temperature evolution at the onset of the LIG”, see also General comment #7.

Page 4399, lines 13-16: Change to something like: “Here, these experiments are complemented by model runs that ...”

Page 4399, line 26: Change to “... FWF remain similar. Exception is GrIS, which ...”

Page 4400, line 2: Change to “... between 40 and 80N. Here changes in the AMOC cause a perturbation ...”

Page 4400, line 6: Change to “... but warming at the northern margin...”

Page 4400, line 16: Influence on what? Maybe add “on AMOC and sea ice”?

Page 4400, lines 17-20: Please make it very clear here that you separate the FWF effect from the ice sheet configuration (topography and albedo) effect on climate (rewrite sentence)

Page 4400, line 26: omit “additional”

Page 4401, line 6: Add dates to indicate when the Heinrich Stadial 11 occurred

Page 4402, lines 2-3: “lends further credibility”? Please rewrite.

Page 4402, lines 15-16: Change to “Including Antarctic FWF leads to a generally weaker AABW formation as surface waters become fresher (compare noAGfwf to noGfwf).”

Page 4402, lines 19-20: Not sure if you can say that this result supports your ice sheet reconstructions. Is the ice sheet evolution really created independently from the radiative forcing?

Page 4402, lines 22-23: Change to “Millennial scale sea-surface temperature variations induced by NH FWF are strongest in the SO, where...”

Page 4403, line 2: omit “at different levels”

Page 4403, line 4-5: add “compare noGAfwf to Reference”

Page 4403, line 11: Add these locations to the map of figure 7c

Page 4403, line 13: Text states 129.5 kyr BP, whereas figure caption states 129 ky BP. Change to make consistent.

Page 4403, line 14: Change “time” to “timing”

Page 4403, line 16: Add reference to Fig. 8 here already

Page 4403, line 22: Change “falls together” to “coincide”

Page 4403, line 24: omit “in either way”

Page 4405, lines 9-13: Very unclear sentence. Please rewrite.

Page 4405, line 23: Change “The” to “the”

Page 4406, line 9: “environmental” ?

Page 4406, line 10: change to “in-depth”

Page 4406, line 18: “retreating” instead of “decaying”

## REFERENCES

Alley, R. B., Andrews, J. T., Brigham-Grette, J., Clarke, G. K. C., Cuffey, K. M., Fitzpatrick, J. J., Funder, S., Marshall, S. J., Miller, G. H., Mitrovica, J. X., Muhs, D. R., Otto-Bliesner, B. L., Polyak, L., and White, J. W. C.: History of the Greenland Ice Sheet: paleoclimatic insights, *Quaternary Sci. Rev.*, 29, 1728–1756, 2010.

Axford, Y., Briner, J. P., Francis, D. R., Miller, G. H., Walker, I. R., and Wolfe, A. P.: Chironomids record terrestrial temperature changes throughout Arctic interglacials of the past 200,000 yr, *Geological Society of America Bulletin*, 123, 1275–1287, 2011.

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Hughes, A. L. C., Gyllencreutz, R., Lohne, Ø. S., Mangerud, J., Svendsen, J. I.: The last Eurasian ice sheets – a chronological database and time-slice reconstruction, DATED-1. *Boreas*. [10.1111/bor.12142](https://doi.org/10.1111/bor.12142) ISSN 0300-9483.

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Otto-Bliesner, B. L., Marshall, S. J., Overpeck, J. T., Miller, G. H., Hu, A., and CAPE Last Interglacial Project members: Simulating Arctic Climate Warmth and Icefield Retreat in the Last Interglaciation, *Science*, 311, 1751–1753, 2006.