**We have revised our manuscript 'Impact of ice sheet meltwater fluxes on the climate evolution at the onset of the Last Interglacial'.**

**We would like to thank both reviewers for their constructive comments that helped to improve the manuscript.**

**Please find below the reviewer's comments in regular italic and a point-by-point rebuttal in bold font.**

## Reviewer 1

*General comments:*

*The manuscript by Goelzer et al. investigates the impact of ice sheet changes (and resulting freshwater fluxes (FWF)) during the period of 135ka – 120 ka, which includes Termination II and most of the last interglacial (LIG). The analysis is based on a set of transient simulations with the EMIC LOVECLIM1.3 which are forced with somewhat realistic boundary conditions with respect to ice sheet geography and freshwater fluxes. More precisely, they force LOVECLIM1.3 with a reconstruction of the Northern Hemisphere (NH) ice sheets as well as with output of ice sheet models for Greenland and Antarctica. The latter distinguishes the paper from the relatively closely related work the authors published as Loutre et al. 2014. The main result of the paper is that the climate in the Southern Ocean area is crucially affected by the ice sheet changes and associated FWF in the NH through the so-called seesaw effect as well as by direct FWF from melting of the Antarctic ice sheet.*

*The paper takes up relevant scientific questions regarding the temporal evolution of the LIG climate and elaborates on to which extent FWF (and from which ice sheets) are shaping this climate evolution. The chosen setup and the set of simulations are novel although somewhat rather similar than Loutre et al. 2014. Unfortunately, the present manuscript lacks a thorough analysis and the number of novel results, figures and conclusions is rather limited. The simulated seesaw effect can somehow be anticipated from previous freshwater experiments (e.g., Menviel et al. 2011) and the main conclusion that NH freshwater fluxes crucially affect the evolution of the NH climate including AMOC has already been reached in Loutre et al. 2014. In order to make full use of the simulations and to increase the relevance of the paper, I expect, a more detailed analysis, particularly for the Southern Ocean/Antarctic region. I would prefer to see more results illustrated with figures as the paper in its present form discusses many features in text-form only.*

*Concerning the formal aspects, I rate the manuscript to be of good quality as it is well- structured and mostly clearly written. In my view, Sections 2 and 5 are sometimes hard to follow and consequently need a revision (see specific comments below). I am very optimistic that a revised version of the manuscript will be a valuable contribution to its research field and should be fit for publication in Climate of the Past.*

*Specific comments:*

*A: Similarities with Loutre et al. 2014*

*As already mentioned in the general section this work seems closely related to Loutre et al. 2014. Consequently, this should be clearly stated in the manuscript and the authors should clarify how the setup and the results advance from the previous work.*

**We have clarified the relation to the work by Loutre et al. (2014) by including a further description in the introduction.**

***"With this study we extend the work of Loutre et al. (2014) by additionally including dynamic ice sheet changes of the GrIS and AIS and focusing on the effect of ice sheet freshwater fluxes on the climate."***

**We have also extended the description at the end of the first paragraph in section 4, which is in reference to the Loutre work:**

***"Here, these experiments are complemented by runs with the same model that additionally include changes in ice sheet configuration and FWF from the GrIS and AIS."***

*It seems that the biggest plus of this study is the inclusion of Antarctic ice sheet changes and FWF. Consequently, it would be very valuable to determine the benefit of this inclusion and therefore provide a detailed analysis of the Southern Ocean and Antarctic surface climate including a comparison with proxies (analogue to Fig. 7 in Loutre et al. 2014). One interesting question is if the agreement with the EPICA Dome C temperature record (Fig. 7h in Loutre et al. 2014) and other proxy records can be improved when implementing the temporal evolution of the Antarctic ice sheet?*

**Included new Fig. 6, a comparison of modeled East Antarctic temperature evolution with four ice core temperature reconstructions. The comparison indicates that the representation of modeled EAIS temperature evolution is improved compared to earlier work excluding Antarctic ice sheet changes (Loutre et al. 2014).**

*B: Additional information regarding the NH ice sheet reconstruction/ ice sheet model simulations needed*

*Sects 2.1 and 2.2. have the difficult task to describe the rather complex origin of the ice sheet boundary conditions. In its present form it is quite hard to read as it includes many technical details but at the same time lacks crucial information. In my view an additional introductory paragraph in Section 2 which describes the "three ice sheet components approach" (complementing Fig. 1) might help the reader to get a quick impression of your setup without going through all the details of Sects. 2.1 and 2.2.*

**We have included an additional paragraph in section 2 as suggested, to give an overview of the ice sheet forcing, which is then further**

**elaborated in sections 2.1 and 2.2.**

*It would also be valuable to elaborate on the advantages/problems of your approach. Do you think it is a problem that the three ice sheet components (NH, Greenland, Antarctica) are based on different technical approaches and therefore do not necessarily combine to a globally consistent ice sheet/sea level realization?*

**Limitations in our approach are now discussed in detail in a new paragraph at the end of the discussion section.**

*Section 2.1: Has this NH ice sheet reconstruction been newly created for this study and Loutre et al. 2014? Or is there a reference for this approach/reconstruction which apparently combines geomorphological data with the ice sheet modeling effort published by Zweck and Huybrechts, 2005? More details are needed.*

**The penultimate NH configuration is based on a reconstruction of the post-LGM retreat that was produced in conjunction with the modeling work of Zweck and Huybrechts (2003, 2005), but has not been published. We have included an extended description of the reconstruction in Appendix A, which details the steps to produce the reconstruction used in this paper and earlier in Loutre et al. (2014). Correcting a mistake in the display we had to update Fig. 2, which now represents the correct time slices for the NH configuration.**

*Similarly, it is not completely clear to me if the Greenland and Antarctic ice sheet simulations have been produced specifically for this paper or if they stem from previous publications which can be referenced.*

**The GrIS and AIS simulations have been adapted from existing ice sheet experiments, which are now referred to with Huybrechts (2002). We have added following clarification in Section 2.2.**

***"For the present study, the climate components are partially forced by results from stand-alone simulations of the GrIS and AIS, which have been adapted from existing ice sheet model experiments (Huybrechts 2002)."***

*On page 4396, lines 26ff you mention that the Greenland and Antarctic ice sheet models use different sea level information as forcing data. As shown in Fig. 4c, the two sea level curves differ quite remarkably. Why haven't you used the Grant et al. 2012 curve, which you judge to be more accurate, for both ice sheet models? Do you know about the consequences of using two different sea level curves?*

**We indeed believe the Grant et al. 2012 reconstruction to be more accurate and therefore used it for the Antarctic ice sheet, where the sea-level forcing is of strong importance for the model response. The impact of using another record for the GrIS simulation over the LIG is small, because of the largely land based character of the ice sheet during that**

**period. For the present work we therefore decided to keep using LR05 as forcing for the GrIS in line with the LR05 based reconstruction of the NH forcing shown by Loutre et al. (2014) to produce a better match with reconstructions.**
**We have included a clarification about the consequences of using a different forcing for Greenland in the text:**

***"The impact of using another sea-level record for the GrIS simulation over the LIG is small, because of the largely land-based character of the ice sheet during that period"***

*C: Ice volume/sea level curve which corresponds to implemented ice sheets*

*Relating to the previous comment **B** I am missing a figure with the 135ka-120ka ice volume/sea level equivalent for Greenland, Antarctica, the NH ice sheets, and their sum to complement Fig. 3. As the authors claim to force LOVECLIM with realistic ice sheet boundary conditions (e.g., stated on page 4406, line 14) this ice sheet volume/ sea level curve used for the "Reference" experiment should be validated with an observational reference (e.g., Kopp et al., 2009). A respective figure would be very helpful for the reader and illustrate the descriptions on page 4397, lines 16-27.*

**We agree that such a figure would be in place here. However, we have a companion paper in CPD (Goelzer et al., 2016), which complements the present work with specific focus on the sea-level reconstruction of the LIG period. We have therefore decided to only add a reference to the other work with focus on this specific problem:**

***"More details about the sea-level evolution can be found in a companion paper (Goelzer et al., 2016) that specifically deals with the sea-level contribution of the ice sheets during the LIG in a fully coupled model set-up. "***

*I am curious if the Antarctic ice volume is growing from 125ka to 120ka as implied by Fig. 2. This seems to be in contrast with the ongoing Antarctic FWF throughout the LIG (Fig. 3b) which I connect with a retreating ice sheet.*

**The volume of the ice sheet does grow between 125 kyr and 120 kyr BP. However, there is always a flux of freshwater from the ice sheet from ice and meltwater discharge into the ocean, irrespective of the change in ice volume. We believe there is a misunderstanding based on the confusion between freshwater flux and net total mass balance. See also next point D.**

*D: Questions regarding FWF (Fig. 3)*

*Moreover, I feel I have to question the massive Antarctic FWF between 128ka and 120ka. A rough calculation for 8000 years of 0.1Sv is equal to a global sea-level rise of ~70m - is this totally balanced by evaporation from the oceans or any other process?*

**As mentioned in response to the last point, we show in Fig. 3 the actual freshwater flux from the ice sheets to the ocean. The ocean model has an implicit free surface meaning that the surface freshwater fluxes can be explicitly taken into account. Nevertheless, for simulations with that large amount of freshwater input, there is an option to conserve global salinity and global ocean volume to avoid problems, which is applied here.**

*Do the substantial Antarctic FWF truly have no effect on the SH temperature between 128ka - 120ka as implied by the comparison of noAG,noIS in Fig. 5?*

**Antarctic FWF is excluded in both cases (noAG and noIS). Maybe the reviewer is interested in the comparison between Reference and noAG (or noIS). The effect of Antarctic FWF is largely visible at the time of the perturbation and the climate system has limited memory beyond the multi-centennial time scale. This has been similarly shown by Loutre et al. (2014) for the climate response to NH FWF. In the text we have added:**

***"… . This implies that the temporal memory of FWF in the system is limited to the multi-centennial time scale, at least for the surface climate."***

*Why is the Antarctic FWF so peaked whereas the Greenland FWF is so steady throughout 135 – 120 ka?*

**This is mainly an effect of scale, since the Greenland FWF is an order of magnitude lower than the Antarctic contribution. A zoom into Fig. 3b would reveal similar variability of the Greenland FWF on its own scale.**

*Do the implemented FWF (as shown in Fig. 3) completely exclude surface runoff from deglaciated areas (i.e. simulated by the land model) and is this justified? How does surface runoff from land masses compare to ice sheet melting?*

**Since the given FWF represent the total freshwater flux to the ocean, it also includes the runoff from ice-free land. In the model, FW fluxes are diagnosed separately for the different components (see e.g. Huybrechts et al., 2011 for the different mass balance components for a schematic future simulation). Runoff over land increases (in Greenland) as the ice sheet retreats and can reach a magnitude larger than the total melt water runoff, depending on the ice sheet extent.**

*<u>E: Extended analysis on the Greenland and Antarctic climate response</u>*

*A fair part of Section 4 describes temperature responses in Greenland and Antarctica which could be extended by map plots at selected times to provide more details regarding how the temperature evolution differs regionally and to which extent this relates to the FWF.*

*As mentioned in comment **A** an additional comparison with proxies could clarify whether your "Reference" simulation improves upon the simulations in Loutre et al. 2014. One possibility would be to evaluate the "Reference"* *simulation against proxies at first and secondly compare the different model simulations with each other. An extended comparison (e.g., also for the AMOC) of the "Reference" simulation with proxies would also better support the findings in the discussion (page 4404, lines 8-19).*

**As mentioned in response to comment A, we have included new Fig. 6 to show improvements in the Antarctic temperature evolution for the Reference run compared to earlier simulations. The LIG evolution of the NH characteristics (including the AMOC) have been sufficiently analyzed by Loutre et al. (2014) for a large range of different ice sheet reconstructions including the one used in this study (except for Greenland). Since additional Greenland forcing is of minor impact, we have attempted to avoid duplication of the results from Loutre et al. (2014) here and focus instead on the Antarctic and Southern Ocean response.**

<u>*F: Please revise the text of Section 5*</u>

*Section 5 describes the interesting and information-loaded Figure 6. However, as a reader I feel poorly guided through the figure so I kindly ask the authors to revise this Section in order to increase its comprehensibility.*

*For example, the statements regarding the sensitivity of the AMOC seem to jump around and the reader hardly knows which curves of Fig.6b he should study to comprehend the findings of the text.*

**We have revised Section 5 by making clearer separation between paragraphs and adding more references to the individual panels and what experiments to compare in the text. The description starts with general explanations and then goes on panel by panel.**

*Furthermore, this Section might benefit from a short notion that the effect of the Antarctic ice sheet FWF is the difference between noAGfwf and noGfwf whereas the effect of the Greenland ice sheet is noGfwf vs. Reference.*

**Yes, included following clarification in the text:**

***"The effect of AIS FWF can therefore be evaluated as the difference between noGfwf and noAGfwf, whereas the effect of GrIS FWF becomes apparent from comparing the reference simulation with noGfwf"***

<u>*G: Extend final paragraph of Section 6*</u>

*The final paragraph of Section 6 (page 4403, lines 26ff.) is another example where the reader is left with sparse information, no figures or references to any figures. In its present form I fear this paragraph is hardly an asset. Nevertheless, I think the mechanism of a freshwater induced cooling and possible analogies/differences to the Antarctic cold reversal during the last deglaciation might be very interesting and I encourage the authors to deepen the analysis of there simulations in this respect.*

**The described ocean cold reversal is part of the discussion on the heat buffering effect and well represented in Figure 8 (was Fig. 7). We have (re-) combined the discussion and added reference to figure 8c to the text to clarify that connection:**

***"The maximum sea-ice extent in the SH (Figure 8c) occurs at the time of largest surface cooling at 129.5 kyr BP. This freshwater induced surface cooling at the onset of the LIG appears to be …"***

*Technical corrections:*

*1. page 4393, line 3: Define the abbreviation of 'LGM' here at its first occasion rather than on page 4395, line 13.*

**OK, text changed.**

*2. page 4394, lines 23-25: The numbering of the sections in this list does not correspond to the actual section's numbers (e.g., model and experimental setup actually are Sects. 2 and 3).*

**Thanks for spotting this. Corrected**

*3. page 4395, line 3: remove the term 'and the ice sheets' here, as it implies that the ice sheet model is used as an interactive model component of LOVECLIM which is not the case.*

**The ice sheets are included as one of the components in the modeling. Especially with reference to Fig 1 it seems wrong not to mention them here. We modified the statements at the end of this paragraph to clarify the one-way coupled nature of the ice sheets.**

*4. page 4395, line 21: If I understand it correctly the NH reconstruction is largely based on the model presented in Zweck and Huybrechts, 2005? If so this should be referenced here.*

**The information has been extended and was moved to the appendix. Please see response to major comment B.**

*5. page 4400, line 6: "Greenland experiences maximum summer warming in the "Reference" experiment around 125 kyr BP of less than 3 C over ..." 3 C warming compared to pre-industrial? Please clarify.*

**Yes, correct. Compared to the pre-industrial. Modified the text accordingly.**

*6. page 4400, line 22: Add reference to Fig. 5 after "NH temperature evolution"*

**OK**

*7. page 4402, lines 21-26: Please add a figure to complement these statements or at least finish the paragraph with a "(not shown)".*

**We believe an additional figure is not necessary and have added "(not shown)", as suggested.**

*8. page 4403, lines 14-25: Please include more references to Fig. 8 in this paragraph.*

**OK. See also comment Rev. 2.**

*9. Fig. 1: The references of ECBilt, VECODE and CLIO only appear in this figure but not in the reference list.*

**OK. References were added.**

*10. Fig. 5: Please add a,b,c, labels to the panels and adapt the references to this figure in the text, respectively.*

**OK. Added labels in Fig. 5 and updated references in the text.**

*11. Fig. 6: Please add the definitions/calculations of AMOC and AABW in the figure caption or somewhere else in the manuscript.*

**OK. Added description in the text where Fig. 6 is discussed.**

***"Here, AMOC strength is calculated as the maximum value of the meridional overturning stream function below the Ekman layer in the Atlantic Ocean between 45° and 65° N."***

***"Here, the strength of AABW formation is calculated as the minimum value of the global meridional overturning stream function below the Ekman layer south of 60° S."***

*12. Fig. 4c: I assume the LR04 curve should be named LR05 as it relates to Lisiecki and Raymo, 2005.*

**OK. Changed labels in Fig. 4 to "LR05" and "Gr12"**

*13. Fig. 7: As an alternative, complementary illustration to Fig. 7a,b the authors could plot the noAGfwf minus Reference ocean temperature anomalies as a time-depth section (Hovmoeller diagram) for the South Ocean.*

**Thanks for the suggestion, but we prefer to keep the display as is. The additional depth information is likely adding more confusion than helping to clarify the mechanism.**

*14. Fig. 8: Add circles of latitudes (e.g., 75S, 60S, 45S etc) to Fig. 8 to better illustrate the statements in the text.*

**OK. Added circles of latitude in Fig. 8.**

## Reviewer 2

*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).*

**A companion paper with a fully coupled approach is now under discussion in CPD (Goelzer et al., 2016). We have referred to this paper when describing the general limitations of the one-way coupled approach in the discussion:**

***"The exclusion of climate feedbacks on ice sheet evolution is a general limitation of our present one-way coupled modelling approach, which we have addressed in a separate study with a fully coupled model (Goelzer et al., 2016)."***

*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?*

**We have extended the discussion of the NH ice sheet reconstructions (including a reference to Hughes et al.) in Appendix A.**

**As mentioned in response to general comment 1 and to comment C of reviewer 1, we discuss further details of the GrIS and AIS reconstructions in a companion paper (*Goelzer et al., 2016) with focus on the ice sheet and sea-level evolution during the LIG. Nevertheless, we have included a comment in Sec. 2.2 to give a further indication of the ice sheet evolution:***

***"This places the GrIS evolution in the range of former model estimates during that period (e.g. Robinson et al., 2011; Born and Nisancioglu, 2012; Stone et al., 2013)"***

*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 d18O 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?*

**We have replaced "is standard" by "often done" in the description of the index method in response to the reviewer's comment.**

**Thank you very much for spotting a problem with the conversion factor, which was a typing error. We closely follow the approach of Huybrechts (2002) with temperature anomalies calculated from ΔT=2.4 °C/‰*(δ18O+34.83). This has been corrected in the text.**

**The scaling of NEEM temperature anomalies with a factor 0.6 is unrelated to the d18O conversion of the other records. The NEEM scaling is now motivated in the text with following addition:**

***"Such scaling is in line with recent studies (e.g. Van de Berg et al., 2013; Merz et al., 2014; Sjolte et al., 2014; Steen-Larsen et al., 2014) that put in question the high temperature of the central estimate reconstructed from the NEEM record."***

*4) Also, how do you calculate the precipitation over the ice sheets?*

**We have included general references to Huybrechts (2002) and a further description:**

***For Greenland: "Precipitation rates vary percentagewise as a function of the $\delta^{18}O$ record."***

***For Antarctica: "Precipitation changes are assumed proportional to the water vapour pressure gradient relative to the condensation temperature above the surface inversion layer (Huybrechts, 2002)."***

*5) How do you derive temperature and precipitation forcing over the Antarctic ice sheet from the Dome C record?*

**We again refer to Huybrechts (2002) for a more detailed description:**

***"The AIS forcing is derived directly from the Antarctica Dome C record (EPICA community members, 2004), following again procedures described by Huybrechts (2002)."***

*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 to you assume the additional peak contribution of glaciers and thermal expansion of the ocean to occur (timing)?*

**Please see response to comment C of reviewer 1.**

*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.*

**We have followed the suggestion to clarify the different steps in the discussion by including following statement in Section 4:**

**"We next discuss the effect of including these additional ice sheet boundary conditions. A specific focus on the FWF follows in section 5. "**

**We have reordered Section 6 to combine the paragraph on the ocean cold reversal with the discussion of subsurface heat buffering, both related to the same mechanism. See also response to comment G of reviewer 1.**

*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.*

**Over central Greenland, where the simulated temperatures can be compared to ice cores data, the evolution in the reference experiment is largely comparable to the runs without Greenland changes taken into account. We therefore refer the reader to Loutre et al. (2014), who have extensively validated the climate evolution to paleo data, in this case against the NEEM temperature reconstruction. The text has been modified accordingly.**

*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.*

**The qualification of the event as "short lived" in the text is in contrast to the Antarctic cold reversal, to emphasise the differences between the two periods. The temporal resolution of the mentioned sediment records appears to be sufficient to represent the cold event not as a wiggle on a curve, but as a feature large enough for the authors to care about discussing it.**

*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 possible be done in combination with the more thorough comparison to previously published LIG ice sheet variations (see General comment 2).*

**We have added a paragraph to the discussion on limitations of our approach. Please see also response to comment B of reviewer 1.**

*<u>SPECIFIC AND TECHNICAL COMMENTS</u>*

*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.*

**OK. Split sentences as suggested, e.g. last sentence in Section 2.1.**

*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)*

**OK. References were checked.**

*3) Check abbreviations for GrIS and AIS, and make sure the full terms are stated only once, and afterward use the abbreviation*

**OK. We have checked and used the abbreviations now everywhere except in the abstract, in section heading 3.2 and in the conclusion.**

*Page 4392, line 1: explain when Termination II occurred*

**OK. Included a further description: "the transition between the penultimate glacial period and the Last Interglacial".**

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

**Not changed. This sentence (P4393!) is part of the introduction describing the general scientific challenges. There is no claim here that our model setup does include that feedback. Furthermore, forcing a climate model excluding that feedback with realistic ice sheet boundary conditions, nevertheless helps to evaluate "possible feedbacks".**

*Page 4393, line 25: "If active", what is "active"? – rewrite sentence*

**If the see-saw effect was active. Included in the text.**

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

**OK. Reference included.**

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

**OK. Reference included.**

*Page 4393-9394: 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 caused increased Antarctic ice shelf melting and West Antarctic ice sheet (WAIS) retreat (Duplessy et al., 2007). "*

**OK.**

*Page 4394, line 23: delete "remaining"*

**OK. Replaced "remaining" by "other".**

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

**The comparison is between reconstructed FWF fluxes and records of IRD. We have replaced "similar variability" by "variability of similar signature" to clarify that relation.**

*Page 4396, line 14: change "form" to "from"*

**OK.**

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

**OK.**

*Page 4397, line 2: "is expected" instead of "may be expected" Page 4397, line 3: "former method" instead of "first"*

**OK.**

*Page 4397, line 4: Delete "Finally"*

**OK.**

*Page 4397, line 9: "overrides" instead of "masks out"*

**OK.**

*Page 4397, line 12: "dynamic GrIS" instead of "activated"*

**OK.**

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

**No change. The climate model is one-way coupled to the ice sheet components.**

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

**Yes, for the overlapping period (132 – 120) kyr BP. No change, described in detail in Loutre et al. (2014).**

*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.*

**OK. Section heading changed.**

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

**OK.**

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

**OK.**

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

**OK.**

*Page 4400, line 6: Change to "... but warming at the northern margin..."*

**OK.**

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

**OK. Replaced "Influence" by "Role".**

*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)*

**OK. Added a sentence "The ice sheet configuration (topography and albedo) remains unchanged in these experiments".**

*Page 4400, line 26: omit "additional"*

**OK.**

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

**OK. Added (~132 kyr BP) in the text**

*Page 4402, lines 2-3: "lends further credibility"? Please rewrite.*

**No change.**

*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)."*

**OK.**

*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?*

**No change. Yes, the reconstruction is created independent of 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..."*

**OK.**

*Page 4403, line 2: omit "at different levels"*

**OK.**

*Page 4403, line 4-5: add "compare noGAfwf to Reference"*

**OK.**

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

**OK, added Bellingshausen Sea, Gunnerus ridge and Dronning Maud Land in Fig. 7c.**

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

**OK.**

*Page 4403, line 14: Change "time" to "timing"*

**OK.**

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

**OK.**

*Page 4403, line 22: Change "falls together" to "coincide"*

**OK.**

*Page 4403, line 24: omit "in either way"*

**No change. Important to note that we find MWT shift forwards and backwards in time.**

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

**OK. Sentence was split in two.**

*Page 4405, line 23: Change "The" to "the"*

**OK.**

*Page 4406, line 9: "environmental" ?*

**OK. Replaced by "atmospheric and oceanic"**

*Page 4406, line 10: change to "in-depth"*

**OK.**

*Page 4406, line 18: "retreating" instead of "decaying"*

**OK.**

<u>*REFERENCES*</u>

*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.*

*CAPE Last Interglacial Project Members: Last Interglacial Arctic warmth confirms polar amplification of cli- mate change, Quaternary Sci. Rev., 25, 1383–1400, 2006.*

*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 ISSN 0300-9483.*

*Marino et al.: Bipolar seesaw control on last interglacial sea level, Nature, 522, 197-201, doi:10.1038/nature14499, 2015*

*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.*

**REFERENCES**

**Goelzer, H., Huybrechts, P., Loutre, M.-F., and Fichefet, T.: Last Interglacial climate and sea-level evolution from a coupled ice sheet-climate model, Clim. Past Discuss., doi:10.5194/cp-2015-175, in review, 2016.**

**Huybrechts, P., Goelzer, H., Janssens, I., Driesschaert, E., Fichefet, T., Goosse, H. and Loutre, M. F.: Response of the Greenland and Antarctic Ice Sheets to Multi-Millennial Greenhouse Warming in the Earth System Model of Intermediate Complexity LOVECLIM, Surv Geophys, 32(4-5), 397–416, doi:10.1007/s10712-011-9131-5, 2011.**

**Zweck, C. and Huybrechts, P.: Modeling the marine extent of northern hemisphere ice sheets during the last glacial cycle, Annals of Glaciology, 37(1), 173–180, 2003.**