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Climate of the Past Discussions

Interactive comment on "Oceanic forcing of the Eurasian Ice Sheet on millennial time scales during the Last Glacial Period" *by* Jorge Alvarez-Solas et al.

Anonymous Referee #3

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Alvarez-Solas et al. present a modelling study that investigates the impacts of millennial-scale climatic and oceanic forcings on the Eurasian ice sheet during the last glacial period, and in particular during MIS 3. A 3D thermo-mechanical ice-sheet model is used, with an offline forcing that provides a more robust representation of millennial scale climate variabilities compared to traditional methods. Explicit treatment of sub-marine melting within the ice model allows the authors to consider the relative contributions of ice-surface melting (ablation) vs dynamic process related to ice-ocean interactions (ocean surface and subsurface melting).

Results show oceanic forcing plays a dominant role over surface melting in controlling

dynamic losses of the EIS over sub-millennial timescales, as well as its importance spatially. Of particular interest is the predicted role that subsurface ocean temperatures can play in enhancing ice discharge during stadial conditions in the Barents Sea/high latitudes, thus supporting empirical observations for the presence of Eurasian IRD in the North Atlantic during stadials. The approach of the manuscript, alongside sensitivity experiments, appears robust and the results provide an important contribution to further understanding ice-dynamical processes occurring in this understudied domain. I suggest minor revisions to the manuscript based on comments and questions below:

P2L22: In terms of underlying mechanisms contributing to collapse of the BSIS, there are additional papers to cite beyond Gudlaugsson. e.g., ice stream surging (Andreassen et al., 2014); subglacial meltwater (Esteves et al., 2017); subsurface melting/ocean warming (Ivanovic et al., 2018; Rasmussen and Thomsen, 2004).

P2L19: The acronym LGM is not defined

P2L25: It would be useful for readers not familiar with marine isotope stages to also state the timeframe in years BP

P2L32: I think this understates the uncertainty in marine sectors – minimum extents for ice in the Barents/Kara seas during MIS 3 are essentially unknown: Hughes et al. (2016) do not try to speculate on limits here prior to 32 ka BP. It would be appropriate to discuss the glacial history of the Eurasian Arctic during MIS3 within the context of long-term IRD records (e.g., Kleiber et al., 2001; Knies et al., 2001; Mangerud et al., 1998).

P3L10: Also should mention Petrini et al. (2018), which does have explicit treatment of ocean forcing for modelling retreat of the BSIS. Also possibly (Ivanovic et al., 2018) in terms of HS 1.

P3L17: And Patton et al. (2017).

P3L30: Missing section 4.

P4L12: What is the basis for these thresholds for SSA activation?

P4L14: criterium->criterion

P4L15: citation needed for the typical observed Hcalv.

P4L21: “Initial” topographic conditions infers GIA is accounted for, but is not described in the model description.

P4L26: It does not appear that any account has been taken for the contribution of insolation-induced melt during MIS 3 (e.g., Robinson and Goelzer, 2014).

P5L4: SMB not defined

P5L23: AMOC not defined

P6L8,9: Some citations here would be useful.

P6L18: The submarine melt rate for ice shelves appears somewhat arbitrary and does not appear to consider possible refreezing associated with supercooling (e.g., Jenkins and Doake, 1991). While Bgl is undoubtedly more important in terms of the glacial response, will modifying this coefficient of 0.1 likely introduce any major differences on the results?

P7L15: This statement on the agreement with previous reconstructions appears confusing – neither study cited shows reconstructed margins during MIS 3 at 40 ka BP. Are the authors instead referring to the glacial maximum of the Mid Weichselian (MIS 4/3) at $\sim$60 ka?

P8L5: wrong section cited.

P8L25: It would be useful to see this value in relation to total ice volume of the ice sheet.

P9L31: ‘British-Irish’

P10L23: ‘of all the other’

P12L3-5: The reason for linking these two statements is not clear unless it’s mentioned also the susceptibility of the WAIS to oceanic warming.

P12L32: This is a useful section that discusses the major limitations of the present study and where future work is needed. The authors however do not mention the limitation of the grid resolution at the grounding line within the context of insights into the EIS responses across sub-millenial timescales. The use of an index to track grounding line dynamics is interesting and a very useful tool, although some mention of the simplifications on grounding line migration would be appropriate to mention given the main conclusions e.g., response time to abrupt forcing.

P12L15: Along the southwest EIS (Irish/Scottish margin) at least. This effect of increased IRD during stadials is not observed by Becker (2017) further north along the mid Norwegian margin during MIS3.

P12L17: Citation

P13L18: citation needed.

P13L34: Should mention here in the conclusions the anti-phase effects of the subsurface warming.

Figures: Bjørnøyrenna is misspelled among figure captions. Missing figure lettering on Fig 2 & 9.

Figure 6: It appears from the OCNsrf timeslices that the Baltic region of the FIS is dramatically affected by ocean surface temperature forcing even though this area was disconnected from the North Atlantic. Is there any provision in the model to distinguish freshwater vs. ocean?

Figure 9: Mean/max ice thickness?

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