Review of: Relative importance of the mechanisms triggering the Eurasian ice sheet deglaciation in the GRISLI2.0 ice sheet model by van Aalderen *et al.*

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van Aalderen et al present the results of a number of ice sheet model simulations with GRISLI2.0 for the Eurasian Ice Sheet Complex. Their main goal is to identify which primary factor, out of surface temperature, subshelf temperature and sea level rise, is most important for triggering the deglaciation of the Eurasian Ice Sheet Complex after the Last Glacial Maximum. Their main conclusion is that surface temperature warming is the dominant control on initiating deglaciation, and unlike previous experiments with the GRISLI model, subshelf melting is not so important. They emphasize that this could be a model dependent conclusion.

This paper has already gone through a cycle of reviews, where the main comments were that the results could be model dependent. I agree with this, and the authors have changed the text to reflect this possibility. In my opinion, this study does what I consider to be the ideal way to test ice sheet models. By changing the variables in a controlled way, they understand what causes the change of model behaviour. The conclusion of a surface temperature control is similar to an experiment we conducted using PISM (Niu *et al.*, 2019), though in that study our experiment design was different. In some ways, I ponder if the sensitivity to temperature is a product of the fact that it is uniformly changing the climate in a way that is probably not realistic, as the forcing does not react to the changes in ice sheet configuration. This issue is somewhat mooted by the fact that the authors are only looking at a short time window after inducing the change in forcing. However, the Eurasian Ice Sheets react dominantly to insolation forcing (at least during the last glacial cycle), so this conclusion is probably not wrong. Do note that there is some evidence of rapid marine ice sheet collapse in Norway (Batchelor *et al.*, 2023).

Another possible weakness to the experiments here are that they do a 100,000 year spinup. In reality, the Eurasian Ice Sheet completely retreated during MIS 3 at about 55,000 years ago (Mangerud *et al.*, 2023), and did not start advancing from mountain based ice caps until about 15,000 years before the LGM (Hughes *et al.*, 2016). The authors have mitigated this contradiction by doing an index run, which eliminated one of the climate models from consideration. In the context of the experiments presented in this paper (building up an ice sheet complex similar to the LGM extent), the 100,000 year spinup is a good strategy. I would propose the authors consider a followup study to test a shorter 15,000 year spinup. I would be interested to see what it takes to build up the ice sheet complex in such a short period of time.

I have a few minor comments that the authors can address if they choose, but otherwise am happy with the paper as it is.

Minor comments

- Section 4.1 - That the CNRM-CM5 PMIP3 climate forcing failed to build up an ice sheet is not a surprise. When I investigated that forcing, it looks very much like they ran the LGM simulation without including the ice sheet topography (check the temperature anomaly in Antarctica versus the preindustrial, for instance). However, I am surprised about MRI-CGM3 and MIROC-ES2L. Is

there any indication that they might have also forgot to include the ice sheet topography in those simulations? I personally have not checked these simulations.

- Section 4.3 - What is the index used for the climate index experiments?
- EXP2 needs to be introduced better in the text.
- EXP5 - it should be noted that the local sea level change is a result of glacial isostatic adjustment. The local sea level is higher than the global average because of the combination of Earth deformation and gravitational attraction of water towards the ice sheets. Though the simplistic GIA model used in the GRISLI model will not precisely calculate these changes compared the model we used in Gowan et al (2021), I would assume using a eustatic rise in sea level in combination with this is sufficient to simulate the impacts of sea level change. There is no harm in trying these experiments, though.
- Figure 11 - please include explanations of the different symbols in the caption
- Figure 12 - please say what Kt is in the caption

Best Regards,
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References

Batchelor, C.L., Christie, F.D.W., Ottesen, D., Montelli, A., Evans, J., Dowdeswell, E.K., Bjarnadóttir, L.R., Dowdeswell, J.A. 2023. Rapid, buoyancy-driven ice-sheet retreat of hundreds of metres per day. Nature **617**, 105–110. https://doi.org/10.1038/s41586-023-05876-1.

Hughes, A.L., Gyllencreutz, R., Lohne, Ø.S., Mangerud, J., Svendsen, J.I. 2016. The last Eurasian ice sheets–a chronological database and time-slice reconstruction, DATED-1. Boreas **45**, 1–45. https://doi.org/10.1111/bor.12142.

Mangerud, J., Alexanderson, H., Birks, H.H., Paus, A., Perić, Z.M., Svendsen, J.I. 2023. Did the Eurasian ice sheets melt completely in early Marine Isotope Stage 3? New evidence from Norway and a synthesis for Eurasia. Quaternary Science Reviews **311**, 108136. https://doi.org/10.1016/j.quascirev.2023.108136.

Niu, L., Lohmann, G., Hinck, S., Gowan, E.J., Krebs-Kanzow, U. 2019. The sensitivity of Northern Hemisphere ice sheets to atmospheric forcing during the last glacial cycle using PMIP3 models. Journal of Glaciology **65**, 645–661. https://doi.org/10.1017/jog.2019.42.