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Geoscientific Model Development Discussions

Interactive comment on "Coupling the Glacial Systems Model (GSM) to LOVECLIM: description, sensitivities, and validation" *by* Taimaz Bahadory and Lev Tarasov

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Review by Irina Rogozhina, MARUM, University of Bremen

The manuscript of Bahadory and Tarasov presents a new coupled climate-ice sheet model, which is capable of time-efficient simulations of entire glacial-interglacial cycles. In order to bridge the low-resolution of the climate model (T21 for the atmosphere) with the higher resolution of the ice sheet model (0.5° x 0.25°) the authors have introduced important tools for the downscaling of climate fields, which are most relevant to the calculation of the ice sheet surface mass balance (i.e., precipitation and near-surface temperature). In addition, the paper presents a self-consistent treatment

of the ocean-driven ice shelf melting, daily temperature standard deviation (DTSD) in the temperature-index method, dynamic routing of supraglacial hydrology and spatially distributed freshwater fluxes and tests the impacts of these model developments in coupled simulations of the glacial inception during Marine Isotope Stage (MIS) 5. Taken together this is a solid contribution to the ongoing work towards the development of comprehensive models for multimillennial climate simulations, and I recommend it for publication after moderate revisions.

I agree with reviewer 1 that the paper will benefit from some restructuring. Indeed, it would make sense to first present the model validation and calibration over the observational period and then move to the evaluation of the impacts of new tools on the modelled climate and ice sheets during MIS5. In addition to the presented analyses it would be interesting to see how the implemented dynamic lapse rate corrections and DTSD improve the model performance compared to the commonly used lapse rates of 6.5 – 7°C/km and uniform DTSD values of 4 - 5°C. In particular, in the light of studies of Erokhina et al. (2017) and Wake and Marshall (2014) it is important to assess, whether these previously inferred dependences of lapse rates and DTSD on background climate are confirmed by long-term transient climate simulations.

I also agree with reviewer 1 that the paper needs a more detailed description of the newly implemented tools. Referring for details to a manuscript, which is not even submitted, is not commonplace. Even though this is a technical paper and thus does not have an appropriate format for extensive discussion and interpretation of the results, some aspects of the development presented in this study require further analysis in order to put these model developments and the resulting model sensitivities into the context of the past climate/ice sheet evolution. For example, the study finds that during MIS5 the Cordilleran ice sheet extended significantly beyond its southernmost marginal positions documented for the later stages of the last glacial cycle (MIS4 and MIS2). If this result is meaningful, glacial imprints of this earlier ice sheet advance should have been preserved until now. Is there any geomorphological/geochronological evidence

confirming such extensive glaciations in North America during MIS5 or it is merely a model artefact? If this is the latter, the impact of dynamic runoff routing seems to amplify an unrealistic ice sheet buildup (Figure 5b) and thus as opposed to one's expectations gives a poor credit to the inclusion of such model development. Could the authors reflect upon this result in the context of the model validation for the glacial inception period?

Minor suggestions:

Page 5, lines 7 – 8: Do the authors mean "ice streams" instead of "ice shelves"?

Page 9, Figure 3: It would be useful to include an absolute ice sheet thickness from the reference experiment in this figure.

Page 13, line 18: distribute → distributed

Page 13, line 26: trigger → are triggered

Page 19, first paragraph: Why are the authors talking about 3 North American ice sheets in the context of the 20th century simulations?

Please, consider including a table with the main model parameters in different sensitivity experiments relative to the reference experiment.

Please, describe in detail how the ice sheet model was initialized.

References

Erokhina, O., Rogozhina, I., Prange, M., Bakker, P., Bernales, J., Paul, A., and Schulz, M. (2017): Dependence of slope lapse rate over the Greenland ice sheet on background climate. Journal of Glaciology, 63, 568-572. Wake L and Marshall S (2015) Assessment of current methods of positive degree-day calculation using in situ observations from glaciated regions. J. Glaciol., 61(226), 329–344 (doi: 10.3189/2015JoG14J116)

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