In the following, the reviewer's comments are in blue, and our response is in black.

General comments

The paper by Hoang et al. describes the implementation of the simple surface energy and mass balance model BESSI into the iLOVECLIM Earth system model. First, the performance of BESSI for the simulation of the present-day SMB over Greenland and Antarctica is compared with results of the regional climate model MAR. Then BESSI is driven by climate forcing from iLOVECLIM simulations to show how climate model biases affect the SMB and how the results compare to the insolation-temperature-melt (ITM) method used previously in iLOVECLIM. Finally, transient iLOVECLIM simulations of the last interglacial period are performed and climate fields are used to drive BESSI and estimate the evolution of the SMB and its different components over the time interval from 135 to 115 kyrBP. The results indicate that BESSI and the ITM produce different SMB evolutions for the Greenland ice sheet over this period of time. I have some major comments that should be addressed before this paper can be published in Climate of the Past.

We thank the reviewer for the useful comments. These comments are taken into account in the paper's revised version. Detailed answers to specific comments are provided in the following section.

Here are the main adjustments to the revised manuscript:

- The title of the paper has been changed to make it less technical.
- The description of the BESSI model is shortened in the main text and moved to Appendix A.
- ITM stand-alone replaces the previous version, which runs with the iLOVECLIM time step (4-hourly) and includes the impact of iLOVECLIM temperature biases on the parameter crad of the ITM equation (Quiquet et al., 2024). In the revised version, BESSI is compared to ITM stand-alone, which uses the same input and runs in the same time step. This provides a cleaner comparison and insights into the two models' behavior, as suggested by Reviewer 2.
- As both reviewers suggested, the bias correction of iLOVECLIM is now included in the main text.
- To put more weight on the Last Interglacial (LIG), as both reviewers suggested, we shortened the part of calibration/validation of BESSI and ITM (stand-alone) with only important results. The climate simulated by iLOVECLIM for the LIG is also evaluated based on existing knowledge.

The paper is rather technical, with a large part being dedicated to the description of the BESSI model (which is already described in detail in Born et al. 2018) and model evaluation for the present-day Greenland and Antarctic ice sheets. This part of the paper would actually better fit the scope of a journal like Geoscientific Model Development.

In order to make the manuscript less technical, we have reshaped the new version to focus more on the differences between BESSI and ITM, as well as the effects of using BESSI for paleo studies. We have also changed the paper's title to "Using a multi-layer snow model for transient paleo studies: surface mass balance evolution during the Last Interglacial." The description of the BESSI model has now been moved to an appendix.

However, I think that there is the potential to make the more scientific part of the paper more prominent to make the publication generally more interesting for readers of Climate of the Past. To make the paper more suitable for Climate of the Past, I would suggest a few changes:

- generally shift the focus of the paper towards the simulations of the LIG

  In the revised version, the paper focuses more on the LIG by comparing the climate simulated by iLOVECLIM with proxy and previous work, as well as the results of BESSI and ITM (stand-alone).

- expand the Introduction with some background information about what is known about the climate and ice sheet evolution (in particular Greenland) over the LIG, both from modeling studies and reconstructions (e.g. sea level)

  The revised version of the Introduction now includes climate and ice sheet evolution information from reconstruction, proxy, and modeling studies (CMIP6/PMIP4) during the LIG.
- add a discussion of the implications of the simulated SMB for the Greenland ice sheet evolution over the LIG

  In the revised version, the paper now includes a part discussing the SMB simulated by BESSI and ITM stand-alone during the LIG.

  In the original version of the manuscript, we used the ITM model that is embedded in iLOVECLIM. This version runs with a 4-hourly time step and includes local "crad" modifications based on the temperature bias of iLOVECLIM with respect to ERA-Interim. Details of this modification are presented in Quiquet et al., 2024. Following reviewer 2's suggestion, we now use a stand-alone version of the ITM so that we can use exactly the same inputs for the ITM and for BESSI, with the same time frequency. It makes the comparison of the two models cleaner. In doing so, discussing the two models' behaviors is also more robust. The description of ITM stand-alone is provided in Section 2.1.3.
- possibly move the Appendix B into the main paper, as the sensitivity analysis is scientifically interesting

  We have replaced the old ITM results with new results from ITM stand-alone to provide a better comparison between ITM and BESSI. The bias correction part is now included in the main text of the paper. The sensitivity of ITM with different crad and albedo values is discussed in the Discussion section with Supplement Fig. S12.

BESSI is certainly more physically-based than the original ITM model, but as also acknowledged by the authors, this does not necessarily imply a more realistic representation of the SMB. Nevertheless, at several places in the text the authors make claims like:

- 'The model also captures well the variation of SMB and its components during the LIG.'
- 'For long-term simulations in paleo studies, BESSI has proved to be able to provide reliable data in a short time as it has a physical model setup and is computationally inexpensive. Particularly, in this work, BESSI-iLOVECLIM simulates well the SMB evolution during the LIG, following the change of the orbital configuration and carbon dioxide concentration.'

To justify statements like these, at the very least the simulated SMB should be compared with previous modelling studies (e.g. Sommers et al. 2021 but also some of the previous work by the authors themselves).

BESSI represents the SMB change in a more physical way than the ITM. However, it is true that we cannot firmly validate the model behaviors in the past, given the lack of solid paleo constraints. We have moderated our statements in the new version of the manuscript and more explicitly compared our results with the existing literature (Plach et al., 2018; Sommers et al., 2021).

Simulated temperature (or more generally climate) changes over Greenland during the early phase of the LIG at a time when the GIS was probably similar to its present-day state could be compared with previous modelling studies (e.g. CMIP6 lig127k) and proxy data.

We agree that the simulated LIG climate of iLOVECLIM was not described in the previous version. In the revised version, the paper now includes a part of the climate of iLOVECLIM for both present-day and LIG. In the LIG climate part, the simulated global mean temperature changes with respect to the pre-industrial and the sea ice extent are compared to the results of CMIP6 models (Otto-Bliesner et al., 2021). The simulated temperature over the ice sheets is compared to proxy data from ice core NGRIP (for Greenland) and EPICA Dome (for Antarctica) (Andersen et al., 2004; Jouzel et al., 2007; Lemieux-Dudon et al., 2010). The results of these comparisons show that the LIG climate simulated by iLOVECLIM is in the range of previous modeling works and in a reasonably good agreement with the proxy data.

Finally, the English usage in this manuscript must be substantial improved to make the text easier to follow.

We have fixed all the errors the reviewer mentioned. However, as the paper's content has changed a lot, some of the sentences have been removed.

Minor comments

L. 1: 'retreat-advanced' -> 'retreat-advance'

Fixed

L. 8: ‘an’ -> ‘the’

Fixed

L. 11: ITM not defined

We are sorry about this. ITM is now correctly defined before using an abbreviation.

L. 16: MaBP is not really a standard abbreviation, possibly use Myr BP or Ma instead?

Ma is now used.

L. 16: I wouldn't call glacial cycles' events'

Corrected.

L. 36-39: maybe worth mentioning that some EMICs are using more sophisticated SMB schemes (e.g. Calov et al. 2005 and Willeit et al. 2024)

Thanks for pointing this out. These models are now included in the Introduction.

L. 44: 'physically key' -> 'key physical'

Fixed.

L. 57: ‘a’ -> ‘the’

Corrected.

L. 66-67: repetition of 'annual global mean temperature'

Fixed.

L. 67-68: the cited references do not support the statement that the LIG was globally 2°C warmer than the pre-industrial. Actually, I believe there is an agreement now that the global temperature change was small, with models indicating no significant change (Otto-Bliesner et al., 2021).

This part has been rewritten following this comment.

The estimation of the global mean temperature change during the LIG with respect to the pre-industrial ranges from almost no change (Capron et al., 2014; Hoffman et al., 2017; Otto-Bliesner et al., 2021) to a 1 to 2°C warming (Turney and Jones, 2010; McKay et al., 2011; Fischer et al., 2018). A warming in the high-latitude regions is nonetheless reported by both proxy data and model outputs

L. 68: retreat of glaciers has certainly little to do with global mean temperature changes

The text has been corrected.

L. 127: 'air temperature is transported to the surface': I would rather say that it is assumed that the temperature of the snow/rain corresponds to the air temperature, right? Considering that precipitation is formed at higher altitudes above the ground where it is usually colder, is this a good approximation? Maybe also provide some details on how large this flux is under typical conditions.

We agree with the reviewer. When falling, snow/rain brings energy to the top layer of the snow model due to the temperature differences. The temperature of snow/rain is assumed to be equal to the air temperature, which is a common approximation (e.g., Greulle and Genthon, 2004; Bougamont et al., 2005; Vizcaíno et al., 2010). This assumption neglects some specific cases, such as the high altitude precipitation, as the reviewer mentioned. However, this assumption is acceptable because BESSI's goal is to be compatible with the low-resolution Earth System Models. Sensible heat from rain is reported to be around 2% of the total energy (Hay and Fitzharris, 1988). Hence, it can be neglected in the energy calculation (Greulle and Genthon, 2004; Krapp et al., 2017; Willeit et al., 2024).

L. 129-130: please specify the units for precip, particularly because it seems to be expressed in non-SI units of m(water equivalent)/s.

The unit for precipitation is $kg/m^2/day$. This information is now provided in the main text. We have also rewritten this part to make it easier to follow.

L. 130: why is 273.15 used here and not Ts as for snowfall?

As the rain falls when the snow condition is not satisfied ($T_{air} > 273.15$ K), BESSI uses the freezing temperature of the water, similar to Vizcaíno et al., 2010. This assumption is acceptable for a large-time step of BESSI (daily).

L. 140-148: If I understand this correctly, as long as the mass of the top layer is below 500 kg/m2, BESSI includes only a single layer. Why is that? Considering that for typical snow densities of ~350 kg/m3 this means that a single layer can be ~1.5 meter thick, this implies that the model is not really resolving vertical gradients and processes in the snow pack.

The splitting mass threshold of 500kg/m2 is to be sure that the mass after the split of the two layers (new and old) is appropriate considering the value of the mass after the splitting. After the split, the new layer is 300 kg/m2, around 1m thick. The old layer now has 200 kg/m2, which is enough so the merging process does not happen soon after splitting and, at the same time, gives enough room for the new accumulation.

We agree that this results in a relatively thick layer at the top, which may not be ideal but is coherent with the time step of one day. Thinner layers would require a much shorter time step, which contradicts one of the primary design goals of BESSI. The model's improvement to have thinner layers is currently under development.

L. 158: Eq. 12 doesn't consider changes in the liquid water/snow storage in the layers, why?

The equation did consider the change of the liquid water/snow storage among the layers. The change in liquid water/snow is considered as follows: the snow melts from the top, and the resulting water percolates through the snow column. The water that reaches the bottom layer is then treated as runoff. The water inside the snow column can be frozen again, adding mass to the snowpack. When the whole snow column melts, the refreezing is zero, and all the water from rain and melt is runoff.

L. 196: (missing

Fixed.

L. 286: And how do you deal with the grid cells that are not covered by the iLOVECLIM land domain?

These grid cells are masked out in the simulation. To illustrate the mask used in the different experiments, we now include the topography map for each simulation in the models' description (Fig. 2 and 3).

L. 291: 'climate major pattern' -> 'major climate patterns'

Fixed.

L. 327-328: ITM is equally unrealistic, as it completely ignores the sublimation

The results of this part have changed.

However, the revised manuscript mentions and discusses the missing sublimation/evaporation processes in ITM.

L. 339-340: sentence unclear

As the results have changed, this sentence is removed.

L. 398: remove 'possibly'

Done

Why not integrate Fig. S1 into Fig. 2?

In the revised version, the SMB differences of BESSI-MAR and ITM-MAR are included with absolute SMB from MAR (Fig.4 and 6). The absolute SMB results are in the Supplement (Fig. S1).

Fig. 6: Maybe worth specifying that ITM is also driven by iLOVECLIM climate output?

We apologize for the confusion. ITM forced by iLOVECLIM is now denoted as ITM-iLOVECLIM.

Fig. 6, 8, 11, 12: The colormap for the SMB is not color-blind-friendly.

The colormap for the SMB is fixed, using the colormap recommended by the publisher (Crameri, 2018).

Fig. 12: wrong units in caption

Fixed (now is Fig.15). The captions of all the figures are double-checked.

Table 2: The Melt from the ITM should rather be compared to the runoff, as refreezing is implicitly accounted for in the ITM model.

In the revised version of the paper, melt from ITM stand-alone is considered as runoff.

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