Review of manuscript:

Large ensemble simulations of the North American and Greenland ice sheets at the Last Glacial Maximum with a coupled atmospheric general circulation-ice sheet model

The authors have presented a comprehensive paper tackling an ongoing issue in climate-ice sheet modelling which is the uncertainty in parameter space within the model. Focusing on the ice sheet southern margin extent, which as the authors state is an ongoing problem to achieve was a very original approach. I enjoyed reading the paper but have several main points that I would like the authors to provide more information for or make small changes in the manuscript.

Main points:

Model evaluation metrics:

LGM temperature. I found the paragraph describing the uncertainty calculation hard to comprehend. There has been several specific publications which have estimate LGM global temperature with an uncertainty range (Tierney, 2o022, Osman). What was the authors reasoning for this approach?

Ice sheet volume:

Lower limit:50m The reference the authors have chosen to define their LGM NAIS and GrIS ice sheet volume is old. A lower limit, which the authors use of 60m is from ICE4G, which has been preceded by ICE6G and ICE7G. Both these latter two studies have a larger total ice volume, ~ 76m. Therefore, I do not think a lower limit of 50m is a good value to use. Tarasov et al., 2012 Table1, has published a study exploring a range of LGM NAIS volumes., but there are others. I am not sure how much this lower limit influences the authors parameter space, as from Figure 8, the minimum volume of the 16 parameters > 80m.

Upper limit: Have the author considered using an 'upper limit' for the total ice sheet volume. From the Figure 8; some of the best 16 members, (black dots) have total volumes of ~ 110m. Given that this number does not include the Antarctic ice sheet (~10m) or the Eurasian ice sheet (~24m; number from the authors paper), this would produce a total global sea level at this time would be too large, 144m. (rough calculations). This may reduce the possible parameter space, but it will also rule out ice sheet volume that do not appear viable.

Southern margin extent

Including the southern margin as a metric to evaluate the ice sheet-climate simulation is an original approach. The extent of the box the authors have used (Figure 2), from my understanding consider a margin that has retreated up to Hudson Bay as reasonable?

Parameter testing procedure

The authors have taken the temperature as the primary criteria and then adding ice volume and southern margin extent. I am interested to know if the authors started with a 'ice

volume' if this would have impacted on their results? As this is to some extent, a study focused on the ice sheets.

Spin up procedure.
What was the authors reasoning for ice-sheet spin up and then adding in the climate parameters? I understand that running the climate model is computationally expensive, however from the SOM figure including the climate parameters seemed to feedback onto the ice sheet?

Comments about figures:
Figure 11: I really liked this figure to try and understand how the different criteria used in the study relate. Is this all 200 ensemble members
What I find interesting, which I hope the authors can comment on is in panel (a) the same ice sheet volume, ~ 70m is produced for a GMST between 5C and 12C. Has the ice sheet not thicken? Changed in extent? I am trying to understand the 3 factors together. In terms o the southern margin, about ~ 11 C the southern margin has undergone a large retreat. Perhaps if the authors plot North American volume vs ice sheet margin this will become apparent.

Figure S3:
This is an interesting figure and from my understanding this is after the spin-up procedure (ice sheet only parameters)? If this is the case, the ice volume can reduce by up to 40m? Given than in the ice sheet-only stage (Fig S1) the volume in some simulation increases by ~ 20m, does this climate influence (feedbacks?) reduce this? This possible relates to my above question about spin-up, why not spin up with the climate feedbacks?

Figures changes:
The figures with multiple panels are small for the reader to see. This might be the typesetting of the manuscript but can the authors try to increase.

Figure1: I would suggest changing the title to a more general phrase.
I am confused how there are SST across the land region? Is it SAT?

Figure2:
Can you add a key onto the figure to state: light blue = GMST; dark blue ...

Figure 3:
Can you highlight the edge of the actual simulated ice sheet? It is hard to identify where the edge of the ice sheet is (panelsb,c,d,e) without guessing in reference to the ablation area. Does this figure only show grounded ice?

Figures 4 and 7:

For these graphs can you add on the limit of GMST and ice volume as you have, for example on Figure 5.

Minor comments

Line 217: Laurentide> this is one ice sheet which makes up the LGM North American ice sheet: change to North American

Terminology: Can the author clarify from the beginning the difference between FAMOUS-ICE (is this with always an ice sheet? Or just the climate component): FAMOUS-Ice (Gandy et al., 2023) - this is when it is coupled to Glimmer, and FAMOUS-ICE, which then is referred to in the abstract as FAMOUS-BISICLES.

GMT - this is a very common abbreviation for other things: please change to GMST, Sat or something else.