

We would like to thank the reviewer for their comments, suggestions, and feedback. This response aims to address any comments raised by the reviewer. Our responses are embedded below and are shown in orange.

## Response to referee comments #1

### General comments

After having read the revised manuscript, I must say its quality and readability have drastically improved. Combined with the revisions, having access to the model description pre-print was very helpful in addressing the main questions related to technical aspects of the model and was sufficient for appropriately conducting this review process. Whereas I am not a reviewer of the modelling description paper, nor will I make any comments on the manuscript content itself, I could not help but get stuck on the author's statement "*Depending on community interest and involvement, a github for the model may eventually be setup.*". I rather believe that, if the model is not available in a standard way like GitHub, with some documentation, it will be much harder to get traction in the community. This is of course just an encouragement from my end for the authors to seek to expand the group of users of their glacial systems model, which this paper highlights to be extremely useful for the paleo ice sheet modelling community.

This is the intention of this upcoming publication, to detail all of the GSM's components, advertise it, make it publically available to other research groups, and with an expanded community, build out version control and comprehensive documentation.

My only remaining concern about this manuscript is regarding some of the citations. As per TC's manuscript submission guidelines, citing a pre-print posted on a personal webpage is not allowed for publication (i.e., no "in prep", "in review", or "submitted" references are allowed, only those that were given a DOI). Thus, the pre-print should be available in GMD Discussions with a citeable DOI before I can recommend this manuscript to be published. I have been checking GMD's website daily to make sure I did not miss it being out until the last day I could delay sending my review, but so far it has not appeared. If the manuscript has already been submitted and is waiting on an Editor to open the discussion, I would suggest liaising with GMD so its process can be expedited and a citable GMDD version of the model description can be made available. Similarly, it would be highly beneficial if the accompanying "Part 2" paper would be available for the reader as a pre-print, so its citation can be kept. On a similar note, I could not find the reference "Tarasov & Goldstein (2019)" as per the author's rebuttal letter. Assuming it was meant to be "Tarasov & Goldstein (2021)", in GMDD, I am unsure what TC's policy is regarding citing pre-prints that did not have their revised version accepted. This is beyond my role as a reviewer, but I found it to me my job to highlight this to the Editor and the authors.

The GSM description paper was submitted on Sept 20<sup>th</sup> 2024, a pre-print should be made available shortly upon making the code available with a permanent DOI. A pre-print for part 2 can be found at: <https://doi.org/10.5194/egusphere-2024-3268>. The Tarasov & Goldstein (2021) study can be found at: <https://doi.org/10.5194/cp-2021-145>.

Citation problems apart, I am happy that the introduction is much improved and the reading flows really well throughout the entire manuscript despite its considerable length. I think this manuscript is a good contribution, showcasing the power of data constraints in paleo ice sheet models. My remaining points are rather minor, mostly editorial.

## Specific comments

L10: Are citations in the abstract allowed? It should not be necessary, and the mention of AntICE2 (including its full name) should be sufficient

Addressed.

L90: I think there's an "If" missing at the beginning of the sentence

Addressed.

L132: "can quantify" reads better and is more appropriate for the middle of an introduction than "will quantify"

Addressed.

L168-171: not quite framed as "research questions". It might be worth rewording or calling them "research problems/goals".

Addressed.

L240: the reference Morlighem et al. (2024; SciAdv, doi:10.1126/sciadv.ado7794) would be good to support your approach to treat ice-cliff failure in a more conservative way

Added.

L251: "temperoral" -> temporal

Corrected.

L253-255: Does the first scheme then just adds an uniform anomaly based on the glacial index, which is further modified by the lapse rate? Please clarify

Effectively yes, a scalar glacial index forcing plus 10°C forcing per pCO<sub>2</sub> doubling and lapse rate vertical temperature adjustment is applied to the PD climatology (GSM description paper; Tarasov et al., submitted to GMD). This is a similar scheme found in Pollard and DeConto, (2012). This is one of the several schemes applied to produce a wide envelop of possible climate scenarios.

L255: just "van Wessem et al."

Corrected.

L372: Please define that this sum is the quadrature, so you can appropriately use the term in L378

Addressed.

L385: It might be worth reiterating that the evaluation of the mentioned consequences is presented in the "part II" paper

Addressed.

L438: the proper way of writing isotopes is <sup>14</sup>C and <sup>10</sup>Be

Corrected.

L500-505: It is not clear what the criteria were for picking those 18 runs for the HVSS, neither how exactly RefSims 1 to 3 were deemed to "collectively represent the best-fitting simulation (or simulations?)". Do you just mean the top 3 performing simulations when evaluating their score against the data? Please clarify

Added:

"The simulations that make up the HVSS were selected based on maximizing the normalized multi-dimensional distance between metrics and scores for simulations in the NROY sub-ensemble. A few reference simulations with minimized scores for key data types were also included in the HVSS, such as the best overall scoring simulation, best scoring simulation against ice core data, and best scoring simulation to marine paleo extent data."

L508: "necessarely" -> necessarily

Corrected.

L523-524: Whereas I think I understand this sentence after reading it 3 times, it could be rewritten for better readability

"Ice dynamics then perturb the temprature profile of the ice by displacing colder ice from the surface deeper into the ice column"

L526: It might be worth saying "larger spread" or something similar instead since, as far as I understand, you are not showing their variance, nor testing whether it is statistically significant. Whereas I do not personally think this is a problem, I can see some readers getting stuck in this sentence because they expected something different to be shown/discussed

Addressed.

L538: either "on a magnetic and a seismic inference" or "on magnetic and seismic inferences" would read better

Corrected.

L544: I would start the sentence with "Particularly" to avoid repetition (two instances of "especially" are four words apart), and change "are" for "is", unless "overlap" was meant to be plural

Addressed.

L589: I believe an "and" is missing before "open"

Corrected.

L677: This sentence feels odd, as it implies that this is not the norm. It could be rephrased as "Cosmogenic exposure ages taken from PD ice free regions scattered across Antarctica (can) constrain past ice thickness"

Corrected.

L820: "across West Antarctica", without "the"

Corrected.

L839: "data constraints", no need for hyphenation

Corrected.

L869: I'd emphasise that you are still talking about the "continental shelf" here, even if it is not strictly necessary

Addressed.

Table 1: Is it correct that the first two EOFs are used for temperature, but only the first for precipitation?

Yes, a sensitivity analysis showed that the second precipitation EOF had effectively no impact on the simulation output. For this reason it was dropped as an ensemble parameter.

Figure 2: please explain in the caption to what the lighter blue shading refers

Caption was revised. It is showing the raw and gaussian filtered record.

Figure 3: should it be "full ensemble statistics" or "full ensemble spread" in the caption?

Revised the caption to simply say: "...where the grey shading represents the min/max,  $1\sigma$  and  $2\sigma$  ranges of the full ensemble."

Figures 4 and 6: There is no explanation why some sites have their ID in grey or black. Please add it to their caption.

It is to more easily delineate data in different Antarctic sectors. The caption was revised to include: "The data ID transition in colour to demarcate the data located in different Antarctic sectors."

Figure S9: Is there any particular reason why the HVSS markers are grey in the plot, but black in the legend?

Updated the figure legend to be consistent with the figure.