Editor's comments are in blue, our reply in black, quotes in the revised manuscript in red.

Public justification (visible to the public if the article is accepted and published):
Dear Ms. Yiliang Ma and Co-Authors,

thank you for submitting your revised manuscript. Please find below my remaining comments and a re-iteration of the comment of Reviewer 1 and myself on the necessity of a reference simulation to quantify model sensitivity. As soon as you have addressed the remaining comments and corrections we can proceed with the publication procedure.

With kind regards,

Johannes Sutter

L281-282: i think you are confusing Gt/yr and m/yr in Rignot et al 2013. Totten average melt rates in Rignot et al. 2013 are ~10 m/yr NOT 63.2 m/yr.
Reply: Yes. Sorry. We wrote the wrong unit. It is 63.2 Gt/yr, i.e., 10.5 m/yr. We corrected it.

L286-288: Same for Adusumilli et al., please be careful with the numbers you cite. The average basal melt rate for Adusumilli et al. 2020 is given as 11.5 m/a (see supplementary material table 1), thus very close to Rignot et al. and other publications. Please go through your manuscript carefully and double check any numbers you are citing from existing literature (e.g. line 327).
Reply: Yes, we agree. We double checked all the numbers we cite, and made sure the numbers are correct. We also find more papers and summarized earlier estimations based on satellite data, and updated it in the revision.
Flux gate calculations using satellite data have reported steady-state area-averaged basal melt rates of 10.5 ± 0.7 m yr^{-1} (2003-2008; Rignot et al., 2013), 9.89 ± 1.92 m yr^{-1} (2003-2009; Depoorter et al., 2013) and 11.5±2.0 m yr^{-1} (2010-2018; Adusumilli et al., 2020). Notably, Liu et al. (2015) used a similar method without assuming steady-state calving front, and derived a higher melt rate of 17.9±1.2 m yr^{-1} during the period 2003–2011. This elevated value aligns better with Rintoul et al.'s (2016) synoptic cavity water exchange estimates. In situ measurements by Vaňková et al. (2023) using autonomous phase-sensitive radar along grounding lines revealed large spatial melt variability, correlating with water column thickness gradients.

References:
Depoorter M. A., Bamber, J. L., Griggs, J. A., Lenaerts, J. T. M., Ligtenberg, S. R. M., van den Broeke, M. R., Moholdt, G., Calving fluxes and basal melt rates of Antarctic ice shelves. Nature, 502, 89-92, 2013.

Rintoul, S. R., Alessandro Silvano, Beatriz Pena-Molino, Esmee van Wijk, Mark Rosenberg, Jamin Stevens Greenbaum, Donald D. Blankenship, Ocean heat drives rapid basal melt of the Totten Ice Shelf. Sci. Adv. 2, e1601610, 2016.

Given the remarks above, I'm unsure whether you assumed too high melt rates in your melt parameterization in general. Thus, please quantify average/bulk melt rates in the sub-shelf melt rate fields shown in figure 3 so a comparison with the literature is made easier for the reader.

Reply: The area-averaged melt rates for our modelled sub-shelf melt rate with the maximum value of 20, 40 and 80 m yr^{-1} are 7.8, 14.0 and 26.6 m yr^{-1}. Therefore, the area-averaged melt rates for modelled sub-shelf melt rate with the maximum value of 40 m yr^{-1} is closest to the satellite-based estimates in literature. We add in the revision Our model simulations for sub-shelf melt rate with the maximum value of 20, 40, 80 and 160 m yr^{-1} (Fig. 3) yield area-averaged melt rates of 7.8, 14.0, 26.6 and 51.6 m yr^{-1} respectively for the present day ice shelf geometry.

Since the modelled sub-shelf melt rate with the maximum value of 40 m yr^{-1} is closest to the satellite-based estimates (Section 3.3), the experiment C_m_{40} (which belongs to the Melt rate group) was selected as the control experiment to evaluate the model drift, and was done from 2015 to 2100.

L330 The sentence "and the sensitivity of Totten glacier dynamics to sub-shelf melt rate has been revealed in 35 years period." is unclear. What do you mean by "has been revealed in a 35 years period"?

Reply: The 35 years period is the simulation period 2015-2050 of Melt rate group experiments. We change the sentence to "and the sensitivity of Totten glacier dynamics to sub-shelf melt rate has been shown from 2015 to 2050"

Quantifying the drift of the reference-control run. You have dismissed the comments of the reviewer and my own comments regarding a quantification of the drift/trend in your reference simulation/control simulation. I agree with Reviewer 1 that such an assessment is still missing in your study, and that the simulation would be relatively easy to run in a reasonable amount of time. The comment on the trend of Reviewer 1 might be motivated by your Figure 9, in which even for C_m0 the model responds with a linear and steady ice loss right from the beginning of the simulation implying model drift. This is fine but needs to be quantified and put into perspective with current trends in ice thickness changes in the region. If your thinning rates are higher(lower) than observations (e.g. Smith et al., 2020 or Nilsson et al., 2022 ESSD) suggest you can infer higher(lower) model sensitivity and quantify the trend.

Reply: We agree with the editor and the referee. After quantifying the area-averaged melt rates of our modelled sub-shelf melt rate with the maximum value of 20, 40, 80 and 160 m yr^{-1}, we found the modelled sub-shelf melt rate with the maximum value of 40 m yr^{-1} is closest to the satellite-based estimates. Therefore, we took the simulation

C_m_{40} using the modelled sub-shelf melt rate with the maximum value of 40 m yr^{-1} as the drift control experiment and extended it from 2050 to 2100.

We compared the modelled thinning rates from 2015 to 2020 with the observed (Nilsson et al., 2023). We found the observed and modelled annual mean thinning rates from 2015 to 2020 are −0.02 m/yr and −0.03 m/yr. We add in the revision that "In the drift control experiment C_m_{40}, the modelled annual mean thinning rate from 2015 to 2020 is −0.03 m yr^{-1}, larger than the observed thinning rate of −0.02 m yr^{-1} (Nilsson et al., 2023) , indicating higher model sensitivity to the present day climate forcing."

We quantify the model drift in the Results, section 4.2 of the revision as below. We add the C_m_{40} result in Table 4. We also updated Figures 6, 7, 8 and 9 by adding the curve of C_m_{40} result. Additionally, we polished the language in section 4.2 and adjusted some paragraphs according to the order in which the figures appeared.

Along the main trunk FL1 both the regularized Coulomb (C_m_{80}) and linear Weertman (LW_m_{80}) sliding parameterizations produce comparable grounding line retreat rates of 0.14 km yr^{-1} over 2015-2100 (Fig. 7). By 2050, this results in 8.08 km of retreat, increasing to 12.20 km by 2100. In contrast, with nonlinear Weertman sliding, retreats are 5.94 km by 2050 along FL1 followed by then stabilization (Fig. 6). Meanwhile, the drift control experiment (C_m_{40}) shows a grounding line retreat of 8.08 km along FL1 by 2100.

Along FL2, the retreat rates differ significantly across parameterizations (Fig. 8): approximately 0.42 km yr^{-1} using linear Weertman (LW_m_{80}), 0.27 km yr^{-1} using regularised Coulomb (C_m_{80}) from 2015 to 2100, (Fig. 8), 0.04 km yr^{-1} from 2015 to 2050 followed by near-stabilization using non-linear Weertman sliding parameterization (NW_m_{80}). Along FL2, the grounding line retreats 12.09 km by 2050 and 35.85 km by 2100 using linear Weertman; 10.83 km by 2050 and 23.29 km by 2100 using regularised Coulomb; and only 1.32 km by 2050 followed by near-stabilization using nonlinear Weertman sliding parameterizations (Fig. 6). Meanwhile, the drift control experiment (C_m_{40}) shows a grounding line retreat of 12.33 km along FL2 by 2100.

The modelled grounded ice thinning rate in the reference run (C_m_{80}) near the projected 2100 grounding line is double that of the drift control run (C_m_{40}). Furthermore, surface ice velocity acceleration in C_m_{80} at the projected 2100 grounding line position along the main trunk FL1 exceeds that in the drift control run by a factor of three over the 2015-2100 period (Table 4).

...The grounded area loss in LW_m_{80} and C_m_{80} experiments by 2100 significantly exceed the 3 413 km^2 from the drift control experiment....

The modelled VAF loss of the TG sub-basin from the Sliding parameterization group experiments is equivalent to global sea level rise of 5.67 mm, 5.48 mm and 3.29 mm over the period 2015-2050 (Fig. 9d) and 16.35 mm, 15.97 mm and 7.34 mm over the period 2015-2100 using linear Weertman, regularised Coulomb and non-linear Weertman sliding parameterizations, respectively, compared with 11.29 mm in the drift control experiment (Fig. 9c).

Table 4. Surface ice speed change, Δv, and ice thickness change rate, Δh, from the year 2015 to 2100 (2100 minus 2015) at the projected 2100 grounding line position and 15 km further upstream, along FL1 and FL2 from the drift control experiment and experiments in the sliding parameterization group.

		Along FL1		Along FL2	
	Experiment	Grounding Line 2100	15 km Upstream	Grounding Line 2100	15 km Upstream
Δv ($m\ yr^{-1}$)	C_m40 (drift control)	87	21	210	145
	C_m80	262	195	265	272
	LW_m80	240	165	537	200
	NW_m80	18	−32	−34	−39
Δh ($m\ yr^{-1}$)	C_m40 (drift control)	−1.19	−1.10	−3.36	−2.79
	C_m80	−2.35	−2.14	−5.06	−2.88
	LW_m80	−2.65	−2.29	−6.42	−2.83
	NW_m80	−0.91	−0.59	−0.79	−0.70

Reference:

Nilsson, J., Gardner, A. S. & Paolo, F.: MEaSUREs ITS_LIVE Antarctic Grounded Ice Sheet Elevation Change. (NSIDC-0782, Version 1). [Data Set]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/L3LSVDZS15ZV, 2023.

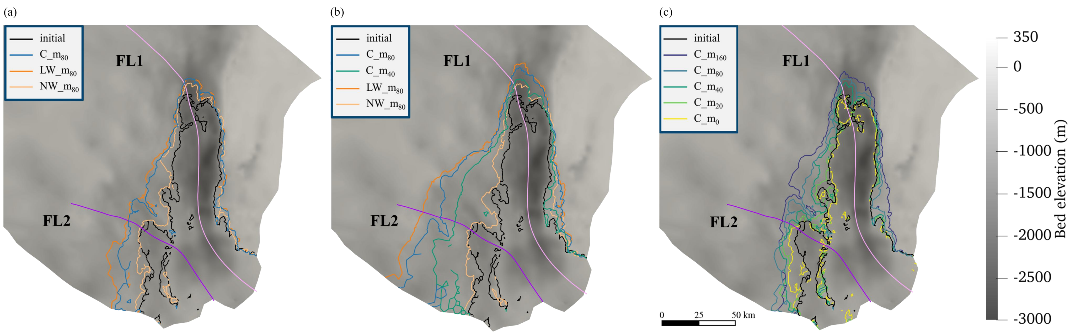

Figure 6. Grounding line positions (coloured curves) at the year 2050 from experiments in the sliding parameterization group **(a)**, at the year 2100 from experiments in the sliding parameterization group and drift control experiment **(b)**, at the year 2050 from experiments in the melt rate group **(c)**. The solid black line represents the initial grounding line position in the year 2015. The pink and purple solid lines are FL1 and FL2, respectively. The grey background shows

the bed elevation.

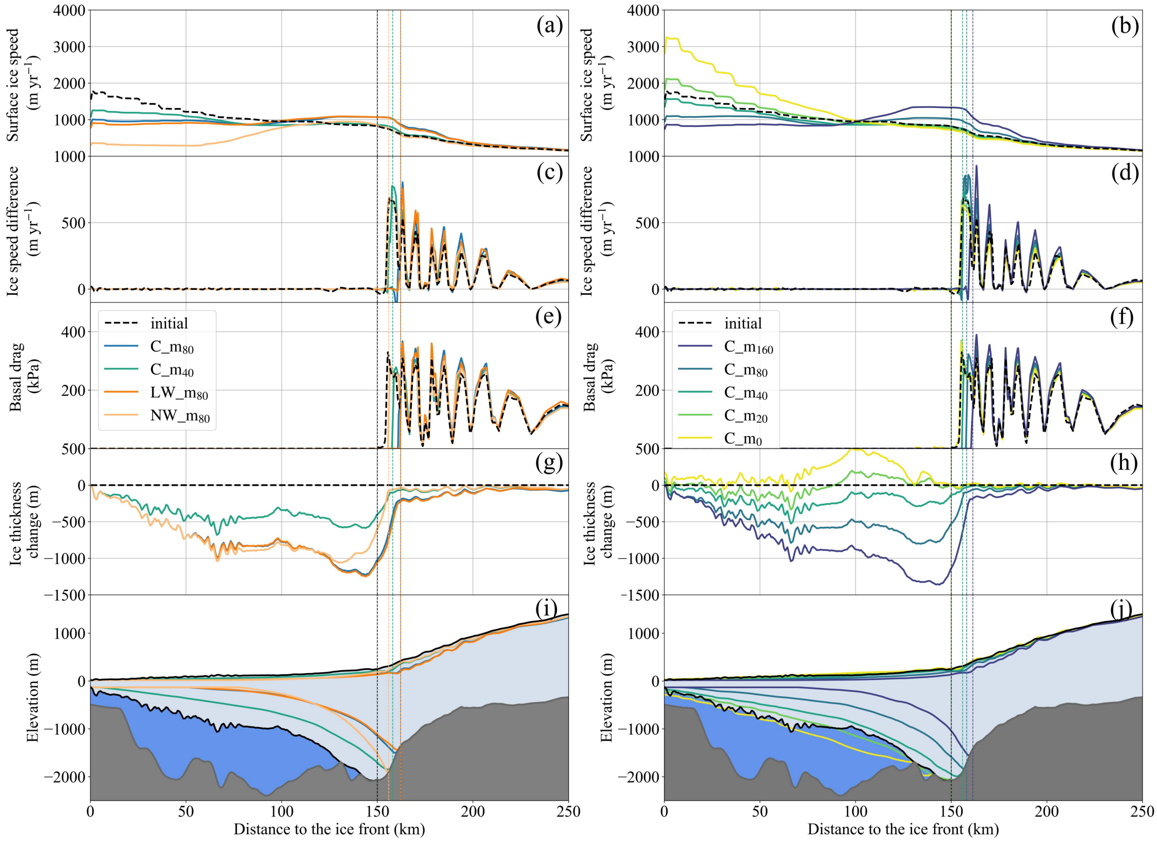

Figure 7. Surface ice speed **(a, b)**, ice speed difference **(c, d**; surface minus basal**)**, basal drag (e, f) ice thickness change **(g, h)**, and ice-sheet profiles **(i, j)** along FL1 in the initial year 2015 (black solid line) and the year 2100 (coloured solid line) from experiments (Table 3) in the sliding parameterization group and drift control experiment **(left column)** and the year 2050 (coloured solid line) in the melt rate group **(right column)**. Grounding line positions are marked with black vertical dashed line for the year 2015 and coloured vertical dashed line for the year 2100 in the Sliding parameterization group **(left column)** and the year 2050 (coloured solid line) in the melt rate group **(right column)** . The figure is shaded to show the geometry of the TG along the flow line in 2015, where dark grey is the bedrock, light blue the ice shelf and dark blue seawater. The elevations are exaggerated by a factor of 25.

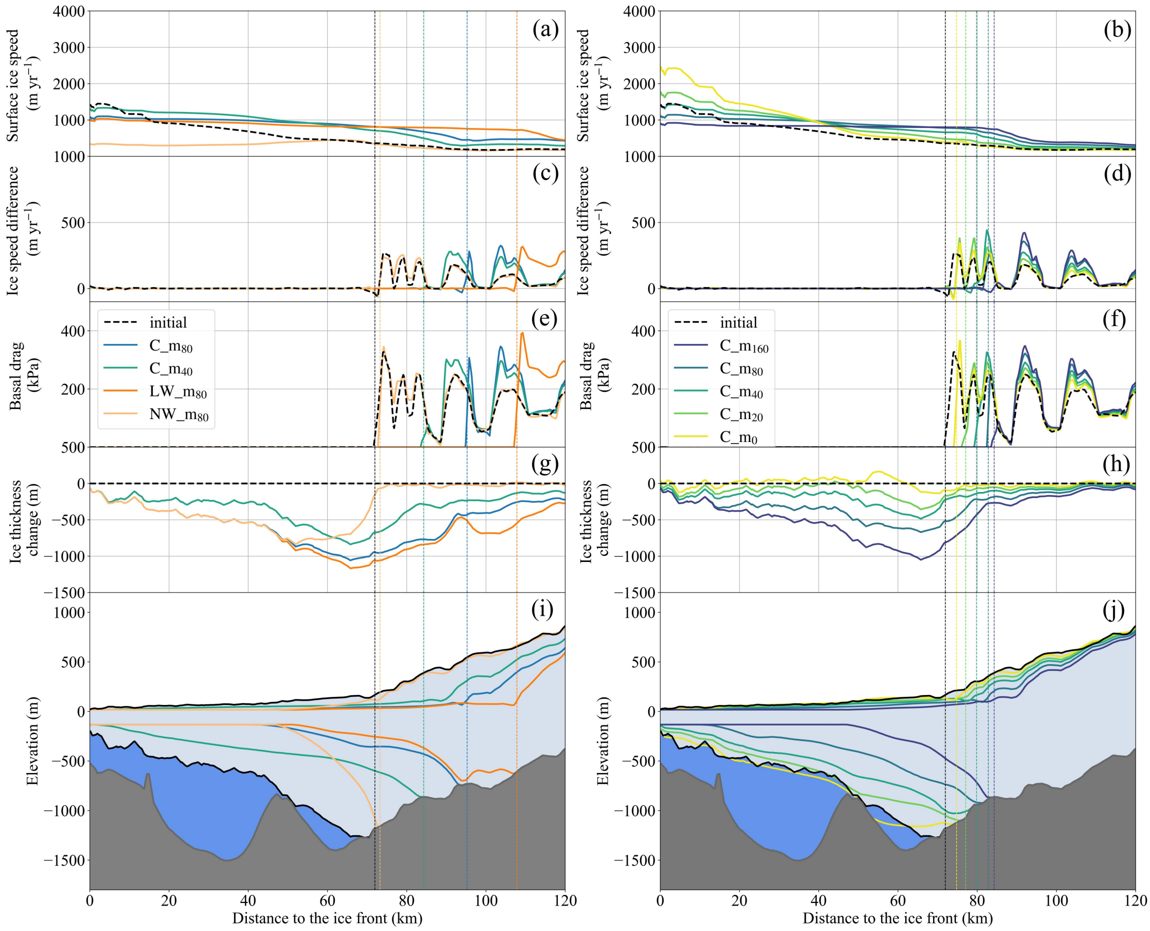

Figure 8. The same as Figure 7 but for FL2.

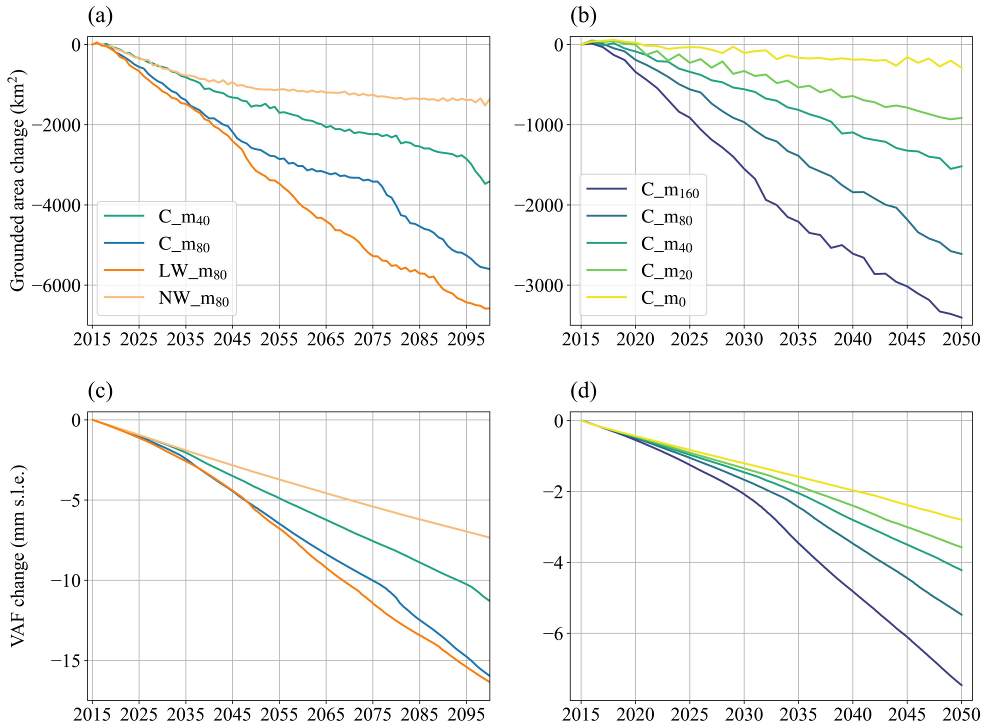

Figure 9. Grounded area change (a, b) and VAF change (c, d) of sliding parameterization group experiments and drift control experiment (a, c) over the period 2015-2100 and melt rate group experiments (b, d) over the period 2015-2050.

I want to point out here, that it is a usual and useful procedure in both model projection studies as well as sensitivity studies (such as yours) to define a baseline/reference/control simulation in which you simulate the evolution of the glacier/ice-sheet assuming no change in forcing (e.g. fixed CESM2 + present day ocean forcing e.g. similar to the ISMIP6 ocean reference field.). The response of your model against such a control scenario then provides an idea of the sensitivity of the model setup against which you can compare the perturbations in melt rate and SMB. This important aspect is still missing in your study. So far it is not possible to differentiate between already ongoing non-linearities in the ice sheet response vs. differences in the response triggered by different assumptions of basal sliding etc. Your study would be much more impactful if such an assessment where possible. As you employ an inversion in your model initialization, one useful simulation to quantify model behavior and sensitivity is to simulate (reg. Coulomb) the response of the catchment to present day constant forcing (with a bulk basal melt rate field optimally fitted to present day bulk melt rates, i.e. ~10 m/yr from Rignot et al., 2013 or Adusumilli et al., 2020) and compare the ice sheet thinning rates with satellite observations

So to re-iterate: please provide an additional reference run (reg. Coulomb) in which you prescribe a sub-shelf basal melt rate with an average rate similar to what the literature suggests (seems to be in the ballpark of 10 m/a) and present-day reference

SMB and surface air temperatures (e.g. in your case a historical or present day mean of CESM2). You can include this run in figure 9 as e.g. "present day reference simulation".

Reply: Agreed. So, we took the simulation C_m_{40} having the modelled sub-shelf melt rate with the maximum value of 40 m yr^{-1} which best matches the area-averaged observed rates, as the present-day reference experiment, and extended it from 2050 to 2100. We also compared the modelled and observed thinning rates from 2015 to 2020. We found the observed and modelled annual mean thinning rates from 2015 to 2020 are −0.02 m/yr and −0.03 m/yr, respectively. We also include the C_m_{40} result in Figure 9.

It would be also interesting to see how different the CESM2 SMB field looks like for present day compared to tailored regional climate models such as RACMO as often in ice sheet modelling studies the climate forcing is constructed with climate anomalies from a GCM added to a regional climate model to alleviate any regional model biases in globally tuned circulation models.

Additionally, please provide a time series (supplementary material) of CESM2 SSP5-85 SMB over the Totten catchment from 2015–2100, otherwise it is not possible to assess the influence of changing accumulation in the region. While you mention that CESM2 SMB does not vary much over the period from 2015–2100 it would be better to quantify this via the time series plot over both floating and grounded ice.

Reply: We double checked the SMB data we used. For the period 2015-2100, the applied SMB consists of repeated 1995-2030 CESM2 output under SSP585 scenario, which represents the present day atmospheric forcing conditions. We clarify this in the manuscript as

The surface mass balance (SMB) data applied for the period 2015-2100 consists of repeated 1995-2030 time-varying output of the Community Earth System Model Version 2 (CESM2) of the Coupled Model Intercomparison Project Phase 6 (CMIP6) under the SSP5-8.5 scenario at 32 km resolution (Nowicki et al., 2016; Fig. S1), which is close to the RACMO2.4p1 SMB data (Van Dalum et al., 2024).

We made a time series plot of SMB we used over the floating and grounded ice and compared it with RACMO2.4p1 as below. We add it in the supplementary material.

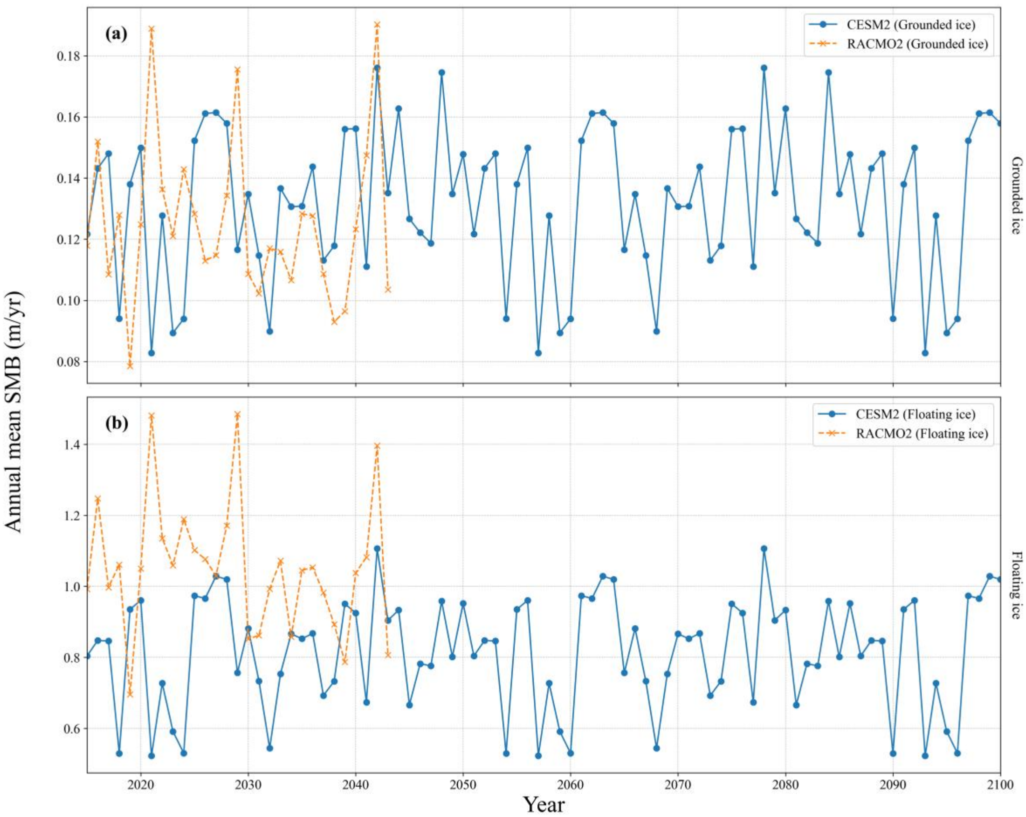

Figure S1. The SMB time series (blue curve) used for the period 2015-2100 in our experiments, consisting of repeated 1995-2030 CESM2 output, which is compared with the 1995-2023 SMB from RACMO2.4p1 data (orange dashed curve; Van Dalum et al., 2024).

Reference:

Van Dalum, C., Van de Berg, W. J., and Van den Broeke, M.: Monthly RACMO2.4p1 data for Antarctica (11 km) for SMB, SEB and near-surface variables (1979-2023), https://doi.org/10.5281/zenodo.14217232, Zenodo [data set], 2024.

Please rephrase the second sentence in the abstract

"It has the third highest annual ice discharge, 71.4±2.6 Gt yr^{-1}, among East Antarctic outlet glaciers" as you cannot cite literature in the abstract and the number you give is probably from a specific study while there is a range of estimates. You could e.g. write something along the lines of

"It features very large discharge rates among the highest for East Antarctic outlet glaciers and has been losing mass over recent decades."

Reply: Thank you. We rephrase that sentence with the one you suggested.