Overall Comments

This manuscript addresses a scientifically important question about the sensitivity of Antarctic ice sheet projections to different sub-ice shelf melt rate treatments during model initialization. The core finding that the method of initialization of sub-ice shelf melt rates can lead to a significant difference in projected sea-level contributions is valuable for the ice sheet modeling community, and relevant to the scope of the journal.

General Comments

The research article presents novel insights by isolating the effects of sub-ice shelf melt rate treatment while maintaining identical model configurations, which addresses limitations of previous intercomparison studies that combined models of varying numerical complexities and initialization methods. The experimental design is well-motivated, and the writing is generally clear and well-structured.

The conclusions that West Antarctica dominates in driving projection uncertainties are potentially significant and well supported by the results, as are the substantial differences reported from previous studies. The comparison with CMIP6 and ISMIP6 projections raises important questions about model setup differences and other contributors beyond the melt rate parameterization that warrant further investigation. However, several methodological components require more detailed description to facilitate reproducibility, particularly the forward projection methodology, and the discussion of divergences from previous studies needs expansion.

Specific Comments

Methodological Details:

Sub-grid interpolation:

p5, l107: *"… we conduct projection experiments, initiated in 2015, by employing "high" and "low" scenarios controlled by the sub-grid melt interpolation"*

This sub-grid melt interpolation requires clearer explanation. What constitutes this interpolation scheme, and why does activating it constitute a "high" scenario versus omitting it for "low" scenarios? Clarify the distinction between these scenarios.

Climate forcing implementation:

p5, l109-110: *“ These experiments used climate forcing derived from the CMIP5 IPSL-CM5A-MR (Barthel et al., 2020; Payne et al., 2021) and the CMIP6 CNRM-CM6-1 (Nowicki et al., 2016; Kamworapan et al., 2021) to assess …”*

I could also not find details on the implemented climate forcings, consider specifying:

- How are the forcing fields (temperature, salinity?) used/derived from these models?
- What is the temporal resolution of the forcing data?
- How are the CMIP5 or CMIP6 forcings interpolated or downscaled to the PISM grid? Describing this would be useful for reproducibility.

Model configuration:

p11, l226: “*consistent model configurations and climate forcings with LOW21.."*

It is not clear what consistent model configurations constitutes of, and the term is ambiguous. There is some clarification for this provided in Section 5, which would fit better in Section 2, where the experimental setup is first introduced. Consider establishing early on exactly which parameters remain identical between experiments and which differ.

Forward projection:

P12, l231: *“Prognostic simulations from 2015 to 2100 revealed divergent ice mass changes compared to LOW21, particularly in WAIS. Under various climate scenarios, …”*

The treatment of sub-ice shelf melt rates during the 2015-2100 projection period is unclear. Are the observational melt rates from Rignot et al. (2013) prescribed throughout the projections?

Projection uncertainties:

p14, Table 2:

The confidence intervals presented in Table 2 are not defined. Are these ranges derived from ensemble runs, sensitivity tests, or are a statistical treatment of the model output? Consider clarifying the source and methodology of these intervals and expand the table description/title accordingly.

Initialization results:

Grounding line migration:

p11, l225: *"...discrepancy can be attributed to the reversibility of grounding line migration on a retrograde-slope bedrock, which is characterized by oscillatory shifts"*

The differences presented among the three regions of retrograde bed slope (TB, WL, GVL) are interesting, and Section 3.3 provides a well written mechanistic understanding of the processes involved. In Section 3.4, the grounding line analysis mentions "reversibility of grounding line migration on retrograde-slope bedrock", raising an important point, but remains brief. Further, the phrasing of that sentence makes it unclear, as it seems to conflate the mechanism of oscillatory shifts in the grounding line with the bed geometry. A clearer explanation of the physical processes underlying these patterns in GL migration would be useful.

Projection results:

p12, l238-239: *"which is relative to the hysteretic response of ice sheet dynamics to climate forcing..."*

The lack of scenario dependence with significant overlap in the prediction ranges is consistent with the delayed/hysteretic response of ice sheet dynamics in that the current ice sheet state and near future (as during this 2015-2075 period) reflect historical forcing, but it is unclear from this sentence. Consider explaining/rephrasing.

p12, l244-246: *"...2100 trajectory extensions, persistent ice mass ....beyond 2100. "*

Are these extended projections beyond 2100 provided anywhere for this particular study, or does this statement refer existing literature? Consider expanding on this, particularly, which SSP scenario and which RCP simulations correspond to persistent ice mass and stabilizing trends.

p15, l295-300: *"... Compared to ISMIP6 (Ice Sheet Model Intercomparison for CMIP6) Antarctic projections under RCP 8.5 (Seroussi et al., 2020), our WAIS contribution exceeds it by approximately 0.15 m SLE, with AP showing a slight increase (~0.002 m SLE) and EAIS exhibiting a minor reduction (~0.02 m SLE..."*

The substantial differences from ISMIP6 projections raises important questions. To strengthen this section, please clarify whether the comparisons are made against the full ensemble or PISM-based runs alone. (e.g., from the description in LOW21, the model setup here would be most comparable to the VUW-PISM from ISMIP6). It would also be helpful to highlight and discuss any other model differences apart from the melt rate parameterization that could contribute to the divergences. If possible, a short comparison on the strengths/limitation of either this observationally constrained approach or the ISMIP6 approach would add significant value.

p16, l318-321: *"Compared to other prior studies, our sea level projections differ due to variations in ice sheet model configurations, including model resolution, ice dynamics (particularly stress balance schemes), represented physical processes (calving, hydrology, or bedrock uplift), and initialization methods (data assimilation or spin-up)"*

These lines address my above comment about detailing the potential reasons for the differences. Is there evidence to suggest which of these factors might be most important, and how it could be addressed in future work?

Technical Comments

p1, l30-31: This sentence on ice shelf susceptibility could be streamlined for clarity.

p3, l74: "(Rignot et al., 2013; Fig. 2; Table 1)" Should this reference be "Fig. 1"?

p3, l90: What is the depth of the ocean water temperature, T_s? Is it taken close to the bottom?

p3, l92: Define S_o (ocean salinity?) in Equation (3)

p8, l166-170: In Fig. 5 caption, clearly define ΔRMSE (Is it RMSE (current vs. obs.) – RMSE (LOW21 vs. obs.)?)

p9, l175: The percentages mentioned (0.5%, 0.2%) appear to conflict with the values presented in Table 1. Clarify whether these refer to overall ice volume biases or volume above flotation biases.

p9, l186: "enhanced oceanic forcing" needs a clearer definition in this context.

p9, l195: "elevated basal water consent": Should be "...content"

p11, l211-212: Line colors mentioned here are inconsistent with Fig. 7 description. (purple/orange in text vs. grey (dashed/solid) in figure)

p12, l243: "persistent ice mass": Should this be "ice mass loss"?

p12, l243-247: There seems to be a causal gap between the two sentences. Consider adding a brief description in between to establish the causal link between persistent ice mass (loss?) / stabilizing trends and "amplified ice-climate feedback" or modifying the sentence.

p12, l250: Fig. 8 caption should specify which RCP scenarios are used for panels (a) and (b).

Secondary comments:

The below comments are merely secondary suggestions for the authors, and I leave it to them whether to address these or not.

Use of Rignot et al., (2013) melt rates:

The reliance on Rignot et al., (2013) melt rate observations is understandable given their wide use in the modeling community. At the same time, this data now reflects conditions around a decade old, and more recent work, has further revealed interannual variability in ice shelf basal melt rates (Adusumilli et. al., 2020), and even slowdown in melt-driven thinning for certain sectors (Paolo et. al., 2023). I encourage the authors to briefly discuss and frame the use of this dataset within the context of more recent observational work.

Validation against observations:

p16, l321: *"...the present-day AIS may not have been in a steady-state during the observational period, and thus, some of the misfits could be attributed to uncertainties in the observational data used for validation"*

The authors note that the present-day AIS may not have been in steady state during the observational period. A brief discussion of the uncertainties and potential biases in the datasets used for validation would strengthen this argument.

Paolo et al., 2023, which constructed 3 km resolution datasets of ice thickness also revealed a **slowdown in thinning** from around 2008, specifically in the Amundsen, Bellingshausen and Wilkes sectors. Following from my earlier comment about melt rate observations, in addition to the citations in the introduction for accelerated thinning of ice shelves, this article may be worth including as a reference. The specific paper I'm referring to is:

Paolo, F. S., Gardner, A. S., Greene, C. A., Nilsson, J., Schodlok, M. P., Schlegel, N.-J., and Fricker, H. A.: Widespread slowdown in thinning rates of West Antarctic ice shelves, The Cryosphere, 17, 3409–3433, https://doi.org/10.5194/tc-17-3409-2023, 2023.