Review of a manuscript "The stability of present-day Antarctic grounding lines Part A: No indication of marine ice sheet instability in the current geometry" by Hill et al.

This manuscript had two rounds of reviews. I would like to thank the authors for their genuine efforts to address my comments. The manuscript is substantially improved. Considering its high-profile, it would be better to make it clear as possible. It appears that the authors continue to treat the ice-sheet geometry as the only characteristic of the ice sheet behaviour (*e.g.*, line 439 "As our experiments aimed to assess the stability of the observed grounding lines in their current geometry. . . "), yet the state of an ice sheet and its behaviour depends on the forcing in the equal measure.

My comments are of editorial nature and their purpose is to clarify remaining inconsistencies, and not to criticize the authors. The comments are not separated in "major" or "minor"; they just follow the text. By no means I want to put words in the authors' mouth. They should take the suggested text as suggestions and modify it in a way they find appropriate. On the other hand, I have no objections if they decide to use it verbatim.

Title: it'd be clearer if you add "... under steady-state climate conditions..." so it reads

"The stability of present-day Antarctic grounding lines *under steady-state [present-day] climate conditions* Part A: ~~No indication of marine ice sheet instability in the current geometry~~".

My suggestion would be either to remove "marine ice-sheet instability" from the title; if your prefer to keep it, then have something like

"The stability of present-day Antarctic grounding lines Part A: No indication of marine ice sheet instability in the current geometry *under steady-state [present-day] climate conditions*"

because that's the experiments your performed. Though in your response you state that there are different versions of interpretation of marine ice-sheet instability, my understanding is that in your study you consider stability of a steady state, or something close to it, because for PISM simulations the forcing is the same - RACMO and PICO fields that do not change in time, apart from the periods when perturbations are applied and removed.

Abstract requires more clarifications and a brief but clear description what has been done in a study it could be something along the lines:

"Theoretical and numerical work has shown that under certain circumstances grounding lines of marine-type ice sheets can enter phases of irreversible advance and retreat – a process typically described as the marine ice sheet instability (MISI). Instances of such irreversible retreat have been found in several simulations of the Antarctic Ice Sheet under atmospheric and oceanic forcing that were meant to represent past or future climate conditions. However, it has not been assessed whether the currently observed ice-sheet geometry can maintain a steady state configuration, if the climate forcing similar to the present-day would remain constant, and whether such a steady state is stable. Here, we conduct a systematic numerical stability analysis of the present-day Antarctic Ice Sheet configuration using climate conditions that are similar to the observed ones with three state-of-the-art ice-sheet models, Úa, Elmer/Ice, and PISM. For the first two models, we construct steady-state configurations by modifying the surface accumulation simulated with RACMO and sub-ice-shelf melt rates parametrized with PICO and in such a way that if the modified fields kept constant in time, the simulated grounding lines remain at the observed present-day positions. The third model, PISM, uses spin-up procedure and historical forcing such that its transient state is close to the observed one. To assess the stability of these simulated states, we apply short-term perturbations to submarine melting that causes the grounding-line migration, which is reversed after the perturbations are removed. Our results indicate that were these climate conditions remained constant in time the grounding line positions would remain at or very close to their present-day positions. Our results suggest that the simulated grounding-line retreat under drastically different climate conditions used in previous studies is not an indication of the marine ice-sheet instability.".

The last sentence of the current version – "However, our accompanying paper (Part B, Reese et al., 2022) shows that if the grounding-lines retreat further inland, under present-day climate forcing, it may lead to the eventual irreversible collapse of some marine regions of West Antarctica."– is confusing because it contradicts the rest of the abstract. In my view, it is unnecessary, and the two parts of your study, A and B, could stand on their own.

Introduction:
Though the rebuttal states that "We however only use "stable/unstable" when referring to a steady state..." the first sentence of Introduction states "Retreat of the Antarctic grounding lines, i.e. the zones where the grounded ice sheet becomes so thin that it floats, could destabilise large marine regions of the ice sheet..." (emphasis is mine). Both sentences in the first paragraph need to be modified. Also references to Weertman (1974) and Schoof (2007) in the context of these sentences are incorrect – they considered idealized configurations, and had nothing (apart from a motivation) to do with Antarctic grounding lines and their retreats.

The first sentence of the second paragraph (line 18) is incorrect, because " instability" is not a mechanism, it's a property either of a steady state or a time-variant trajectory (*i.e.,* a limit cycle). Weertman (1974) and Schoof (2012) discussed it specifically as a property of a steady state, and not in "the sense of having a self-enhancing, irreversible grounding line retreat due to a positive feedback mechanism related to the ice dynamics " as you describe in the rebuttal. (It is not until line 36 that you mention the "positive feedback"sense.) The Introduction sentences up to one in line 23 (starting with "For marine, laterally uniform ice sheets with constant conditions... ") could say that the results of numerical studies with climate forcings (either varying in time or constant) that are substantially different than observed today show irreversible retreat of the grounding lines.

Line 27: the sentence "However, in the case of laterally confined ice shelves that buttress the inland grounded ice, the MISI mechanism becomes more complex." is incorrect for the same reason as above – the MISI is not a mechanism. A simple modification for it could be to replace "the MISI mechanism" with "the situation" or something similar.

Line 33: the sentensce “Critically, this means…”is disconnected from the sentences above it, because they describe steady-state studies, and this sentence refers to “observed retreat”– an unsteady behaviour.

Line 36: It would be helpful if you describe how this “self-reinforcing, positive feedback” operates. I suspect that it is based on the Schoof’s (2007) formula of the ice flux at grounding line. If that is the case, then that refers back to the use of the MISI in the sense of stability of steady states. Also, studies referenced in lines 28-33 show that this formula is valid only for laterally unconfined marine ice sheets.

Lines 39: the sentence “For example Rosier et al. (2021)…” is very similar to those in lines 20-23. It is better to remove/modify those and keep this one.

Lines 44-54: the second sentences of these two “However, to date there has not been a systematic analysis to determine whether the currently observed changes in grounding line position are reversible. In this paper we use a systematic modelling approach to assess whether the current retreat of the Antarctic grounding lines is due to an ongoing positive feedback mechanism related to MISI.” is incorrect. This is because you do not assess whether the observed changes are reversible or not: you have created alternative, steady, states and assessed the reversibility of small perturbations from them. As you correctly point out later (lines 140-143), the present day ice sheet (and not only its geometry) is not in a steady state; and its current behaviour is not a perturbation from the steady state, or at the very least, you do not have evidence that indicates that it is a perturbation. The last sentence of this paragraph is incorrect as well for the same reason. This paragraph could state something like:

> “Previous studies have argued that sections of the West Antarctic Ice Sheet may already be undergoing self-sustained unstable retreat (Joughin et al., 2014; Favier et al., 2014; Rignot et al., 2014). However, to date there has not been a systematic analysis whether, if the climate conditions close to the present-day ones kept constant, (1) the present day ice-sheet configuration could attain a steady state and (2) is stable or unstable. Our modelling approach is outlined at the beginning of Sect. 2. Briefly, we perform numerical experiments using three state-of-the-art ice sheet models, Elmer/Ice (Gagliardini et al., 2013), òa (Gudmundsson, 2020) and the Parallel Ice Sheet Model (PISM; Bueler and Brown, 2009; Winkelmann et al., 2011), by applying a perturbation to our initial model forcing, that all closely replicate the current geometry and velocity of the Antarctic Ice Sheet. Our results indicate that (1) there exist climate conditions, such that were they held constant in time, the present-day ice-sheet geometry is in (or close to) a steady state with respect to them; and (2) this steady state is stable with respect to small perturbations in the model forcing.”

Line 55: the first sentence is factually incorrect for the reasons described above. This paragraph can mention the companion paper and a different approach/forcing used in it.

Methods

Lines 92-103: your results are still conditioned on steady states: in the case of the PISM simulations, it is forcing that is steady.

Line 158: My suggestion would be to move figs S1-S3 to the main text. Fig. S1 does not have units.

Discussion:
Lines 404-415: The last sentence of the first paragraph is over interpretation of the results for the reasons discussed in the comments to Introduction section. In contrast to the first sentence of the second paragraph stating that the obtained results are surprising, in my view they are not. This is because the mentioned studies use very different forcings compared to those used in your study, and also their experiments were very different from yours. Rosier et al. (2021) used forcing which is equivalent to extremely large submarine meltrates. Though you are right that conclusions of other studies that current retreat of the Pine Island Glacier is an indication of the MISI are incorrect, this is not a direct conclusion of your study.

Line 429: the first sentence of this paragraph is not correct. The use of three models does not eliminate structural uncertainties of the individual models. Because you have created steady state or initial conditions that are very specific to these models. The only common procedure is application of submarine melt perturbations. Considering that all the models use the same vertically integrated momentum balance, solve the same set of equations (more or less) and use the same perturbations, it is not surprising that they produce fairly similar behaviour. But once again, that does not imply that their structural uncertainties are eliminated.

Lines 448-452: The comparison with idealized simulations of Robel et al (2022) is not relevant for many reasons, including their experiment design and a specific choice of the bed topography.

Lines 453-470: Your assessment that the dynamic calving front would not change your results (I paraphrase) is most likely overstatement. Acknowledging that your results are valid in this particular configuration with a fixed calving front and that simulations with a moving calving front might produce different results would be better.

An additional limitation of your study that you do not consider any feedbacks between the ice-sheet geometry, *e.g.*, surface elevation, the ice-shelf draft) and the climate forcing,*e.g.*, surface accumulation and submarine melting (Sergienko, 2022; https://doi.org/10.1038/s41467-022-29892-3).

Conclusions: The first sentence is absolutely correct. The following sentences unfortunately not so for the reasons already mentioned above – a state of an ice sheet (its geometry and surface velocity) and its forcing cannot be considered separately. As you demonstrated, it is possible to have almost identical steady-state configurations of the Antarctic Ice Sheet with slightly different climate forcings (one for Elmer/Ice another for Úa), and a transient state, which is close to the observed one with PISM. However, your results do not tell what is the cause of the present-day grounding line migration. They tell that it is not the MISI that caused them, which is a slightly different conclusion. Lines 480-481 state "Here, we have argued that the currently observed changes of the Antarctic Ice Sheet are not a manifestation of an ongoing positive-feedback related to MISI." However, the manuscript does not have a clear description of this positive feedback and, consequently a clear demonstration that this feedback does not operate in both your simulations and the real ice sheet. Here is a suggestion of Conclusions based on the results of your study:

"In this study, we have investigated the existence of a steady-state configuration of the Antarctic Ice Sheet which closely resembles the observed present-day configuration and the climate conditions that can maintain this steady state if kept constant in time. Our results show that it is indeed possible to construct such climate conditions for two different ice-sheet models Elmer/Ice and Úa that produce the geometry and surface velocities that are very close to those of the present-day Antarctic Ice Sheet. A transient state, which is close to the present-day ice sheet was obtained with PISM model. We find that the in all models the grounding line retreat caused by increasing sub-ice-shelf melting for a short period of time of twenty years is reversible. These results indicate that if the climate conditions would be the same as we have constructed and remain constant in time, the present-day Antarctic Ice Sheet would be in steady state, and this steady state would be stable. They also suggest that the grounding-line retreat obtained in simulations with drastically different climate conditions are not indications of the marine ice-sheet instability, and is externally forced retreat."