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 Urruty et al.

The manuscript describes results of a multi-model study aiming to assess sensitivity of the current Antarctic grounding line positions to short-term perturbations in the submarine melting. The authors demonstrate that simulated grounding line position reverts to its initial state after the perturbations are removed. The study represents a substantial group effort, and simulations produced many results that can be useful for other kinds of analyses. The current version of the manuscript, however, requires significant modifications, because it has several misconceptions and self-contradictions.

General comments

The authors conclude "This suggests that present-day grounding-line retreat is driven by external climate forcing alone. Hence, if the currently observed mass imbalance were to be removed, the grounding-line retreat would likely stop." The first part of these conclusions – the "present-day grounding-line retreat is driven by external climate forcing"– is absolutely correct. However, this is an observational evidence, rather than conclusions of this study. As the authors indicate on line 60 "... it is not realistic to assume the Antarctic Ice Sheet is in a steady state today", it is equally unrealistic to assume the Antarctic Ice Sheet has ever been or will be in a steady state. A state of an ice sheet cannot be considered in isolation from its environmental conditions – atmospheric and oceanic, at least. An ice sheet can be in a steady state only with respect to a specific set of these conditions that are constant in time. If these conditions change, the ice-sheet configuration, and its grounding line position change as well. The Earth atmospheric and oceanic conditions always vary, and they do so on a wide range of temporal scales (e.g. Jouzel, et al. (2007); Thomas et al. (2013)). Consequently, it is the variability of these conditions (that are in their turn are affected by the ice-sheet conditions) that drive variability in the ice sheets.

The abstracts starts with the sentence "Theoretical and numerical work has firmly established that grounding lines of marine-type ice sheets can enter phases of irreversible advance and retreat driven by the marine ice sheet instability (MISI).". The marine ice-sheet instability hypothesis was proposed by Weertman (1974) who was interested in "the steady-state size of a two-dimensional [unconfined] ice sheet ... that rests on a flat bed (flat before the ice sheet was placed on it) situated below sea-level". No part of the Antarctic (or Greenland) Ice Sheet has this configuration. While the authors acknowledge that the presence of the lateral confinement complicates the original Weertman's (1974) and later Schoof's (2007, 2012) conclusions that the bed slopes determine stability of the grounding line (lines 30-35), they seem to continue to use the bed slope as an indicator of stability throughout the introduction section. In addition to the ice-shelf lateral confinement, non-negligible bed topography found, for instance, under Thwaites Glacier, and very weak beds, such as under Siple Coast ice streams complicate stability conditions (Sergienko and Wingham, 2019, 2022). In the presence of feedbacks between the ice sheet characteristics (*e.g.*, the surface elevation) and environmental conditions (*e.g.*, surface accumulation) there are no general stability conditions at all (Sergienko, 2022).

Although it is true that the marine ice-sheet instability hypothesis is widely used to interpret the observed grounding line retreat, there is no need to promote this misconception, or more accurately, misapplication of a concept of stability (or instability). These concepts can be applied only to a steady state. Even though the authors point out (line 75) that "Although stability cannot strictly be defined for non-steady states" they continue "we find that even with transient forcing included, the current grounding-line positions do not show self-sustained retreat." These kinds of statements are confusing, and to some extent, self-contradictory. A possible interpretation of the finding that the grounding line positions do not show self-sustained retreat is that the grounding-line advance and retreat does not correlate with the immediate forcing it is experiencing. For instance, Robel et al. (2022) point out that in places with the appreciable bed topography, the grounding lines can persist at bed peaks under substantial changes in the environmental conditions.

It may appear that it is just a matter of semantics whether to call the present-day ice-sheet configuration "stable" or "close to stable" (either with or without quotation marks) or to have sentences like "Note that in this manuscript we refer to grounding lines as 'unstable' if they are engaged in MISI-driven retreat, and 'stable' otherwise, even if the grounding lines are not in steady state." However, the words matter (especially those in the abstract and conclusion sections), and the basic assumptions of the study should not contradict observational evidences. As currently framed, the manuscript gives a strong impression of misapprehension, despite already mentioned "bracketing sentences".

Technical Comments

Presumably the calving front position was held constant during all simulations. It is unlikely that during 100 years no icebergs would calve. As Haseloff and Sergienko (2022) show, the calving front conditions have stronger effects on the grounding line stability than melting.

Lines 103 and 167-168 state that PISM uses 8 km horizontal resolution (no need to repeat that twice). Seroussi et al. (2014) find that the accurate representation of the grounding line dynamics requires the horizontal resolution of 2 km or higher. I appreciate that running a spin-up for 400 kyr with such a high uniform resolution is computationally expensive, but at least some comments have to be made in that regard.

Lines 117-119 PICO is hardly a realistic representation of submarine melting. As studies that used ocean circulation models to compute melt rates show over and over again, melt rates do not correlate with the ice-shelf thickness or the ocean depth (e.g .Goldberg and Holland, 2022). Once again some justification is needed for the use of PICO (an alternative could have been melt rates inferred from observations, *e.g.* by Adusumill et al., 2020).

Lines 150-165 This section about mass-balance correction is opaque. It seems that the results whether the grounding line retreats or not depend on this correction. It also appears that the obtained 'steady-state' is contrived, *i.e.* the configuration is essentially artificially held in this state by means of this correction. If this is not the case then tthis should be illustrated. With the used approach, making any connections to the actual ice-sheet state is a stretch.

Lines 223-247 What is used as the surface mass balance during the perturbation experiment? Is the mass-balance correction applied as well?

Line 253 “An increase in ice shelf melt, and thus reduced buttressing, will lead to an increased ice flux. ”This is an unsupported statement. It could potentially be verified by computing buttressing and demonstrating that it was reduced. If the calving front position is indeed fixed, then the retreat of the grounding line caused by increased melting, leads to the increase of the horizontal extent of the ice shelves, and hence increase in buttressing (Haseloff and Sergienko, 2018, 2022).

Lines 258-259 “When the grounding line does not retreat further, it means that it has found a new stable position very close of the previous one.”As already mentioned, an alternative could be a non-linear response of the grounding line to the applied forcing (Robel et al., 2022).

Lines 262-265 and eqn(2) It is unclear what is meant by “the recovery of the ice flux” ΔQ, and how it is computed. Presumably the $e-$ folding time could be estimated for the grounding line as well (*e.g.*, Sergienko and Wingham, 2019).

Summary

The manuscript requires significant modifications in terms of the presentation and of the framing of the problem as well. Also, the main conclusion that the observed grounding line migration is driven by the atmospheric and oceanic (and lithostatic) forcing is based on observations, and not an outcome of this study. Taken at its face value, the study contradicts the observational evidence that the Antarctic Ice Sheet is not in a steady state. This is hardly a good starting point if modeling studies are to be taken seriously. As mentioned above, this study is a collaborative effort of a large group of people, undoubtedly they can find less equivocal ways to use these results.

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