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The Cryosphere Discussions

Interactive comment on "The stability of grounding lines on retrograde slopes" *by* G. H. Gudmundsson et al.

Anonymous Referee #2

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General Statement

The paper investigates the stability of marine ice sheets by presenting examples of steady state grounding lines on a retrograde bed, using two distinct models, Elmer/Ice and Ua. The problem considered is a two horizontal dimension marine ice sheet, flowing over a complex bedrock configuration. Traditionally, the question of marine ice sheet instability has mainly been investigated in one horizontal dimension, or by parameterization of the second horizontal dimension. To my knowledge, the only other currently published two horizontal dimension investigation of marine ice sheet instability, is by Goldberg et al., which used a simpler bedrock configuration, so studies such as this present work are important and thus should be published after addressing the comments described below.

Specific comments

My major concern is the use of the word "stable" instead of "steady state". The grounding line would be stable if a steady state grounding had been perturbed by a change in accumulation, sea-level etc and reached a new steady state or equilibrium configuration. The paper has successfully shown that steady state configurations on retrograde slopes are possible, but not that they are stable.

The other concern is the presentation of the current work in context to what has already been done. A simple way around this, is to describe a bite in more details the other works and how they differ from your approach. In addition, the references to other previous work are not numerous: steady state grounding lines have been found on retrograde slopes for example by Parizek and Walker (2010). Like Dupont and Alley, Parizek and Walker parameterizes the second horizontal dimension so are simpler models than your models, but these works do also indicate that the 2D problem is different than the unstable 1D problem for freely floating ice shelves considered by Schoof, Weertman etc.

The paper would be stronger with a few more sentences on how the findings differ with previous work, and a few more sentences on your actual results. For example, the only steady state of Goldberg et al. (in their Fig 12) which is obtained with parameters similar to Dupont and Alley, has a width which is similar to some of your experiments, and bed slope of 0.3. Thus, what is the bottom slope of your steady states? The other experiments of Goldberg et al. where no steady states on a retrograde slopes where obtained had a smaller bed slope and larger width than Dupont and Alley. . . Do you have a feeling whether it is the bed slope that is more important compared to the width? What is the shape of your grounding lines for all of your steady states? A simple map-plane view of your grounding lines for the different half-width could be placed in your figure 5.

Technical comments

P2600, L2-4: “It is unclear what three-dimensional geometrical configuration, if any, . . . used by Dupont and Alley (2005) in their example.”. I would remove this sentence as it does not add anything to your text, especially since Goldberg et al have managed to reproduce a similar configuration (their figure 12).

P2601, L6-8: “For x=0, both horizontal velocity components are set to zero . . .”, since you are describing a boundary condition, you might want to consider moving this to section 3, where you describe your other boundary conditions. Also, is there really just one condition along the sides y = +-120 km? (it could be that the 2nd conditions is a stress free condition, or a free slip, but this should be stated)? Maybe, a small diagram depicting the problem that you are solving (i.e. the BC), will help the reader to quickly identify how different your setup is to other works such as Goldberg et al.

P 2601, equation (2): The notation used for your fractions has a missing bracket: written as $(x/750 \times 10^3)$ implies that $(x \times 10^3/750)$ when I think that you actually mean $(x/(750 \times 10^3))$.

P2604, L25: change “ELMER/Ice” to “Elmer/Ice” to be consistent with the rest of your text

P2606, L22 and caption of Fig 2: Change “cyan” to “pink” or change the pink lines in the figure to be cyan.

P2606, L23: consider “steady state” instead of “stable”

P2607, L19: remove “stable”

P2607, L23: either change “within the approximate of 35 to 55 km” to “within the range of 40 to 50km” or carry out a few more simulations with wc that are closer to the range that you suggest (i.e. just 2 more will do: 35 and 55 km).

P2608, L1-5 are confusing. I think that you are saying that in the unconfined portion of your ice shelf, far from the grounding line, the ice shelf thickness can become very thin over some small region/patches before thickening again? Maybe a figure would help

illustrate what you are describing?

P2609, L19-23: see specific comments, namely that you have not shown that the grounding line is stable. A way around would be to write instead: “By providing a numerical example of a marine-type ice sheet in a steady-state configuration with the grounding line located on a retrograde slope we have shown that marine ice sheets could potentially be conditionally stable. Our findings are fully compatible with . . ..

P2609, L26: change “stable” to “steady state”

P2610, L18: Also add reference to Walker et al., 2008

P2610, L24: change “stable” to “steady state”

P2611, L21: change “usu full” to “useful”

Fig 1 caption L2: add “for a channel half-width of wc = 50km”

Fig 3: using the same colourscale for your three distinct surfaces makes the figure really hard to see. Maybe a different colourscale per surface can help, or make 2 plots with different view angles? Also, add “y (km)” on your 3rd axis.

Fig 5: The use of solid lines between your discrete steady state grounding line position, suggest the assumption of continuity and that you expect to have steady grounding lines position on your solid lines. The figure would be better with only the points.

Fig 5 caption: Change “stable” to “steady state”

Reference: Walker, R.T., Dupont, T.K., Parizek, B.R., Alley, R.B., 2008. Effects of basal-melting distribution on the retreat of ice-shelf grounding lines. Geophys. Res. Lett. 35.

Parizek, B.R. and R.T. Walker, 2010, Implications of initial conditions and ice–ocean coupling for grounding-line evolution, Earth and Planetary Science Letters, 300, 351-358.

Interactive comment on The Cryosphere Discuss., 6, 2597, 2012.