Review of "Hysteretic evolution of ice rises and ice rumples in response to variations in sea level" by Henry et al.

General comments

This paper presents modelling experiments designed to test the responses of ice rises and rumples to perturbations in sea level under different basal friction conditions. It demonstrates hysteretic behaviour in velocities and profiles of ice rises, with two distinct possible steady states. Repeated tests in one case show that one of these steady states is stable, with further perturbations to sea level responding in a closed hysteretic loop. Additionally, comparisons are made between results using full Stokes model and an SIA approximation, showing minimal difference with a high friction case, but a large mismatch when greater basal sliding is allowed.

I found the majority of the manuscript to be well written and easy to follow. However, in some places the paper in its current form lacks clarity and precision. Some more attention needs to be given to the presentation of the equations in the early sections, where there are cases of conflicting notation and variables which are not defined. Part of the experimental setup described in the text is contradicted by some of the figures, namely whether the sea level is reduced back to its original state, or in fact lowered beyond the initial value. Another aspect I was unclear on is the presentation of "equilibrium states" on some figures, which did not appear to be addressed in the text (perhaps I somehow missed it, in which case it should be made clearer). Specific comments are listed below.

Overall, I found this to be an interesting study, with novel and useful results. The methodology is rigorous, and the manuscript is well structured. It is certainly worthy of publication in the Cryosphere subject to revisions which address the issues of clarity.

Specific comments

Line 21 – I think you start off with "Great progress in ice flow modelling" or similar, just to make it entirely clear right at the start.

Line 49 – Maybe you should briefly explain what a Vialov profile is. Just a short phrase such as "the solution to an idealised analytical problem".

Figure 1 – In panel (c) I would suggest labelling the cross sections as 1-3 and labelling the dome using a letter to differentiate it. I was also confused a little upon first glace by the arrow pointing to the ice dome being the same line type as the cross sections.

Line 61 – Should the gravity term be negative, since your z-axis point upwards?

Line 73 – I'd put the trace operation in non-italic font, to distinguish from variables.

Line 76 – You should probably use $u_{s,b}$ to be entirely clear.

Line 96 – M needs to be defined in the text.

Line 104 – This should be added to the reference list and cited as usual.

Line 115 – You've introduced h here when you already have z_s defined. If this is a different quantity (eg. the reference plane isn't the same as z=0) this should be made clear. If not, you should be consistent with notation.

Line 118 – The standard and subscript h are the wrong way round in the first instance on this line.

Line 120 – This equation is quite confusing within the context of this paper. It's written in quite a convoluted way, and it would be far clearer if it were formulated in the same way as equation 8, especially as it is directly related by the following equation. Also, p and q are not defined.

Line 130 – The variables Q, R and Q_R in this equation need to be defined in the text.

Line 132 – Same as above for L.

Figure 3 – I'm not clear about what the "equilibrium simulations" are. These don't seem to be referred to in section 2.5. More explanation is needed so that this can be understood. They are also referred to as "steady state branches". Does this mean that new experiments branch off from these points in which the sea level is kept the same until a steady state is reached?

Line 150 – The green line in Figure 3 shows this $0.02ma^{-1}$ decrease continuing until it reaches -40m, rather than the last 2000 years being flat. I assume this is an error in the plot?

Line 152 – Why was a second cycle only done for one friction case?

Line 159 – This should probably be specified as being analysis of the *initial* steady states for clarity, since there are also different final steady states and the branches referenced in the caption of Fig. 3.

Line 160 – Is this referring to full Stokes or SIA? I assume full Stokes, but you should be clear.

Line 189 – "and" rather than "as well as".

Figure 5 – I assume these are the initial steady states? This should be stated in the caption, perhaps specifying the time (t=2000, if I'm correctly interpreting this?).

Figures 6 & 7 – Again, specify in the captions what time these velocities and cross sections are for.

Line 222-3 – I think what you're saying here is that from the final steady state obtained after one full perturbation cycle, further perturbations in sea level do not cause changes to the steady state position? Figure 8 is very clear in this regard, but I think there's probably a better way of wording it. Do you know if the same would be true of the intermediate and high friction cases?

Figure 8 – Are panels (b) and (d) really needed? I suppose the transition points are in slightly different places? It's still unclear to me what the "equilibrium states" are, as noted for Fig. 3 above.

Figure 10 – I notice the sea level goes below 0 at the end again here. I assumed it was a mistake in Fig. 3, as I don't think this decrease in sea level was mentioned in the text. Was it actually part of the experiment and if so why has it not been mentioned?

Figure 11 – I think you mean "solid" rather than "blue".

Figure 12 - Specifying the time would be nice here.

Appendix A – It seems a little odd to have a single figure with no text as an appendix. Can this figure not just be included within the main text, or is there some appendix text missing?