Review of

“A model study of Abrahamsenbreen, a surging glacier in northern Spitsbergen”

By J. Oerlemans and W. J. J. van Pelt

General impression

This paper describes the application of a simple glacier model to a surging glacier in Svalbard. The authors nicely outline the capabilities (and limitations) of simple glaciers models, and argue coherently why their method is appropriate. The main points of the paper are that the model captures the feedback between a surge (and the subsequent lowering of surface elevation) and glacier length, and reproduces the limited observations of the glacier behaviour. Abrahamsenbreen is found to be very sensitive to changes in equilibrium line altitude, and has the potential to retreat or advance substantially depending on the climate forcing.

I only have a few major comments (see below). I have also included a list of minor comments, which should improve the readability of the manuscript.

Once these changes have been implemented, I would be happy to recommend the manuscript for publication in The Cryosphere.

Major comments

I am surprised the abstract makes no mention of the sensitivity tests done in this study. The tests strengthen the conclusion of the paper and would be of interest in themselves.

The authors chose a set of parameters based on observations from Abrahamsenbreen and from other glaciers on Svalbard. While this is a reasonable approach given the limited amount of information available from Abrahamsenbreen, readers unfamiliar with the glaciers on Svalbard, such as myself, will need a better justification of why these glaciers are relevant to Abrahamsenbreen. For example:

- (p. 5695) A previous study of Hansbreen have found the necessary parameters for the simple glacier model, but the authors assert that this glacier is in a different geological setting and therefore use parameters from Kongsvegen. It is, however, never made clear how Hansbreen differ geologically and how Kongsvegen is similar to Abrahamsenbreen. Is it purely because Hansbreen is not a surging glacier?
- (p. 5697) A study by Hagen et al. (1993) found that “annual precipitation decreases significantly when going in northwesterly direction from the Holtedahlfonna”. This leaves the reader wondering if Abrahamsenbreen lies northwest of Holtedahlfonna. Fig. 5 shows balance profiles from four glaciers. Where are the other glaciers situated? Is it reasonable to use the mean value of β if these glaciers are, for example, far south of Abrahamsenbreen?

- (p. 5698) It is also unclear where the values of 100 – 150 m increase in equilibrium line altitude come from. Is this taken directly from the aforementioned study, is it an extrapolation of their results?

The last two points might be addressed by making it clear exactly what purpose Eq. 12 serves. Is it a way to avoid that β becomes dependent on *x*?

Minor comments

p. 5688

Lines 15-16: The way this sentence is phrased, it could imply that the direct effect of a surge is to increase the ablation area, but I assume this happens indirectly due to the lowering of the surface elevation. I suggest moving "thereby" so the sentence reads "… to lower the mean surface elevation and thereby to increase the ablation area, causing…"

Line 17: What is meant by "stronger retreat"? Faster?

Line 20: It would be nice to remind the reader that a decrease of *E* means a lowering in altitude.

p. 5689

Line 2: "a.s.l." is undefined.

Line 9: "BP" is undefined.

Lines 16-29: Somewhere in this paragraph one or two sentences could be included, that describe what processes are thought to trigger glacier surges, e.g., increasing surface temperatures, mass balance etc.

p. 5690

Lines 15-16: If the net balance includes the period when the surge happened, does this imply that the net balance at present is likely to be higher or lower?

p. 5691

Line 9: Typo: "topography"

Line 15: There is either a word missing or a typo here.

p. 5692

Lines 6-10: This velocity calculation is unclear. The way I understand it, the velocity is calculated as v = 0.5*(4500+4700)m/(1990-1969) = 219m/yr, but it is stated that the velocity is 241m/yr.

Line 22: Is it a flowline in the sense that it follows the steepest surface gradient? Judging from Fig. 1 that does not seem to be the case, rather the flowline is defined as the central line on the glacier.

p. 5693

Line 12: Typo: “positive”

p. 5695

Line 4: It is never specifically stated that *L* is glacier length.

p. 5696

Lines 1-2: Please mention here that the value of α_m is investigated later.

p. 5697

Line 9: Is there a word missing here?

p. 5699

L. 13-14: It is a bit unclear how this basin correction is applied. Is it directly derived from Eq. 12? I.e. *E* in Eqs. 15-16 is taken as a constant?

p. 5700

L. 12: Reference to Eq. 4 is incorrect?

L. 21: Typo “difference”

p. 5701

L. 3: Typo “surge” not “surges”

p. 5703

L.27: I assume it should say “the surging mechanism” not “the searching mechanism”?

p. 5704

L. 19: Typo “An”

L. 24: Is equilibrium length in this context the same as steady state length?

p. 5707

L. 5: Typo “grows” instead of the second “growth”.

p. 5708

L. 8: Is contribution from the tributaries zero because the glacier has retreated so far upstream that it is no longer connected to them?

Line 13: This section reads more like a conclusion than a discussion. Consider changing the section title or expanding the section into a longer discussion.

Figures

Figure 1:

Typo in caption: “… and T6 to T10 (right).”

Figure 2:

A scale indicating the distances would be nice. Also, if possible, please indicate the location of Fig. 2 on Fig. 1.

Figure 8:

It would improve the readability of the figure if the labels on the y-axes either were coloured (similar to Fig. 6) or if the figure had a legend (similar to Fig. 7).

Figure 9:

Please consider changing the colour for some of the lines. It is very difficult to distinguish the individual tributaries from each other.

Figure 11:

In Fig. 10 the reference simulation is shown as a black line, is this identical to the red line in Fig. 11? Please consider making the reference simulation black in Fig. 11 too if that is the case.