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Interactive comment on "Modelling environmental influences on calving at Helheim Glacier, East Greenland" *by* S. Cook et al.

Anonymous Referee #2

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General Comments: This manuscript describes a 2-D modeling study of calving events at Helheim Glacier, and reveals that calving is sensitive to crevasse water depth and basal water pressure, but insensitive to submarine melting and ice mélange. The topic and scope of this manuscript is appropriate for TC. However, I found many concepts not well presented in this manuscript and need to be explained more clearly. Most of the results come with NO numbers, which severely weaken the results as a scientific paper. I think there are some uncertainties in the external forcing and model results that are not discussed enough. I suggest not to accept the current version but to ask for a revised version addressing the following points.

Specific comments:

1. The calving phenomenon is studied using an ice flow model and a calving criterion.

The calving criterion is crucial in this study; it is helpful for readers if the equation of the calving criterion is given explicitly. This study only considers the case that surface crevasses pass the water line, i.e., calving from the surface. Is subaqueous calving impossible or unimportant? I have special concern on the importance of the subaqueous calving caused by submarine melting.

2. Basal water pressure seems to work on calving rates through adjusting glacier velocity. In this manuscript, I did not find how the authors build the relationship between basal water pressure and velocity. What is the equation? Did you tune the sliding parameters? If so, what are the values? Two additional questions: a) If the basal water pressure works through changing velocity, is it more direct to test the impact of ice velocity change on ice front calving? b) In this process, calving seems to be a passive response to velocity change; glacier terminus advanced at higher basal water pressure and higher ice velocity; do you have any assessment on the interaction between glacial velocity and calving?

3. The sensitivity experiments test cwd from 0 – 50 m, and use 30 m to represent a retreat scenario in other sensitivity experiments. Also, basal water pressure are either fixed or with 50 m seasonal variation (btw, the unit of dP is m or kPa in Table 1?). I understand these values are hard to derive from reality, is it possible to estimate any reasonable ranges, such as any possible upper limit? For example, from the surface crevasse width?

4. The authors compare the model results with observations at two places. The first is at the beginning of results section, where the "initial experiments" is compared with the observed front position. Here I don't understand if "initial experiment" is spin-up run or control run? What is the purpose of this comparison? If this is a spin-up run, does the comparison indicate that the actual glacier is relaxed to a stable status one year later, like what the modeled glacier does. If this is a control run, do you suggest that the model setup (i.e., no external forcing) is a representation of realistic condition? The second comparison is in subsection 3.5. I found the comparison of the calving event

size distribution sound. But I am curious how the comparison of the glacier's dynamic response to calving helps the topic of the study, which is "environment influence on calving"?

Technique comments:

p.4408 l.7: " produce a realistic representation of calving behavior" sounds a very strong statement?

p.4409 l.19: Xu et al (2012) is not a plume model, but an ocean gcm.

p.4410 l.10-14: Compared to Cook et al. (2012), this paper includes the consideration of channel width change and lateral drag through boundary condition, right? These changes are not explained here? Are these changes important to model results? Maybe this point could be discussed in the discussion section?

p. 4411 l.15: Equation(s) of the calving criterion would be helpful.

p. 4414 l.1-4: "This temperature profile gives temperature between . . .. . . never reaches the pressure melting point." I guess this is a description of the temperature profile found in Jakobshavn Isbrae. But I cannot find the exact description of the temperature profile used in this study.

l.9-12: These two sentences mention the summer melt. The model run include both summer and winter. What is the winter value of surface mass balance? Also, maybe the surface mass balance is not so important for the model result, but as long as it is mentioned here, there can be at least some simple description, e.g., overall ablation rate.

p.4417 Subsection 2.5: I like this part of error estimation. Maybe this section is more suitable in results section, after main results are given? Sentences here should be more specific, by giving numbers. For example, line 7: "Increased mesh resolution was found to cause a change of up to 0.2%" —- Mesh resolution is increased by how much? Line 10: "as smaller time steps allows small calving events to be resolved but

had a less than 1.0% effect on modelled terminus position" —- How much change of time steps causes this 1.0% of terminus position change? Line 17 "Minor changes in terminus behaviour were caused by changes in the inflow velocity boundary condition the shape of the basal water pressure profile and the mass. . ." Please identify "minor changes in terminus behaviour" "terminus behavior" (you mean terminus position or calving rate?) . . .. . . without numbers, this subsection look more like conclusion rather than results or model setup.

p. 4418 l. 15-19: Give numbers.

Figure 3a: This longitudinal deviatoric stress is from which experiment and at what time spot? Same question for Fig4a, 5a.

p.4419 3.2 Basal water pressure The first paragraph reviews the relationship between basal water pressure and ice velocity. Is it a bit deviated from the main topic of "environmental influences on calving"?

Figure 4 does not directly show the changes of calving, but only show the terminus position, which is a combined effect of velocity and calving.

It seems like basal water pressure affects calving through velocity field. It seems to me that in this process, calving is a passive response to the glacier dynamics (velocity). Ice front advances more with seasonal basal water pressure than without it.

p. 4420 l. 4-6: "with higher basal water pressures causing an increase in calving rates and hence a relative retreat of the terminus." —- This is not shown in Figure 4? Can you explain what is "relative retreat"? Because it seems to me that with seasonal varying basal water pressure (i.e., higher basal water pressure), terminus advances more than fixed basal water pressure.

Figure 6: I don't understand why the ice front is so stable when the subaqueous melt rate reaches 15km/a? Is the retreat caused by subaqueous melt compensated by glacier acceleration?

p.4421 l.17-20: need a citation for “The only study to measure the stress exerted on the calving face used a coincident change in velocity of 15% upon the break up of the ice mélange at Store Gletscher, West Greenland to estimate a backstress of 20 30–60 kPa over the full calving face, equivalent to a force of 1.8–3.6$\sim$107 Nm$-$1.”

Interactive comment on The Cryosphere Discuss., 7, 4407, 2013.