Reply to Referee #2

April 4th, 2015

Before all, we would like to thank Martin Truffer for reviewing carefully our article and making suggestions which improved the quality of the manuscript. We took them into account and our point-by-point answer is given below, in red. When a remark deserved a specific revision in the manuscript, we modified it accordingly (using red color).

General comments

1) The geometry chosen is one with a positive bed slope, when it is well known that many of the interesting phenomena on tidewater glaciers occur on negatively sloped beds. What motivates this choice? Will the model simply lead to too many instabilities?

The objective of this article is to test the robustness of our modelling (melting and ice mélange forcings) onto many different geometries. To do so, setup have to exhibit a quasi stable position, which was only possible when dealing with prograde slopes. Studying the behaviour of retrograde sloped glacier would be interesting, but it would require case-by-case approach on specifics glacier configurations, which is out of the scope of the present study.

We add a specific sentence in the manuscript that motivates our choice. (Sect. 3.1)

2) I think floating tongues are not properly treated here. On temperate glaciers they are rarely observed. The reason, I believe, is hinted at in the paper: under floating tongues the melt rates are so high that it would quickly become unstable and fall apart. If near-glacier fjord circulation is driven by subglacial freshwater discharge, as seems reasonable, then the near grounding line melt rates would have to be very large. I therefore question the choice of a floating-tongue glacier as the control run; it is likely not a good representation of reality.

In our experiments, there is one Control Run (CR) per geometry. The CR is not forced by any mélange or melting (see Table 2 and Sect. 3.2)

Fig. 4 is not a Control Run, but an illustrative example only. This point was added in its caption. We chose this geometry in order to define the grounding line position X_G.

The absence of submarine melting in our modelling is a limitation (as we wrote at the end of Sect. 3.2.1), but this choice was motivated by the fact that the objective was to compare the different simulations. A deep analysis of the submarine distribution would have introduced supplementary differences between glaciers and would have make their comparison harder.

3) The basal boundary condition should be explicitly stated, rather than just via reference to Krug et al. (2014) (The flip side is that it made me go look at that paper, which is

impressive work!). Again, a lot of interesting tidewater glacier behavior is tied to sliding laws that are effective pressure dependent and thus lead to acceleration upon thinning (e.g. Pfeffer, 2007, JGR). Perhaps it is not so relevant in the positive bed slope, but it is important enough to clearly state in the paper.

Thank you for your appreciation of Krug et al. (2014).
This comment is similar to the one of reviewer n°1. We expanded the description of the damage and calving model in Sect. 2.2.
The basal friction is kept linearly decreasing along-flow, and it is the same for each simulation. We did not study the feedbacks on basal friction arising from changes in front position. Studying its effect would be interesting, but in this case, we should focus toward a realistic approach, rather than a global and theoretic approach.
We explained the formalism of the friction coefficient in Sect. 3.1.

4) Is it important that the upstream flux is fixed? I am wondering whether the glacier can be 'supply starved', i.e. higher terminus fluxes would occur if the glacier could supply them? This is perhaps outside the scope of this paper, but is an important question for ice sheet evolution.

We made several tests for this boundary condition (with constant velocities and constant fluxes). We did not observed any sensitivity in our conclusions related to these tests. Thus, for sake of simplicity, we chose to keep the inlet flux constant.

Line-by-Line Comments

Below is a list of detailed comments in order of occurrence:
p.184, l.16: heaviest -> strongest
Done

p.184, l.21: delete the second 'pathways'
Done

p.185, l.13: what do you mean by 'unavoidable mechanism'?
We meant significant. The word has been changed.

p.185, l.15: there is no force imbalance, is there? Forces are always balanced. What are feedbacks between ice discharge and ice flow, isn't that the same thing?
We meant the feedbacks between the calving processes and ice dynamics. We changed our sentence.

p.189, l.16: Can you specify exactly how calving happens? If a crevasse penetrates to full depth, that ice becomes part of the melange and the glacier boundary jumps back, correct? This might be nice to clarify in light of the discussion 5.1 where a comparison with Amundson et al's results are made. Those authors calculated a force balance on an ice berg that is fully separated from the glacier, but prevented to rotate by the ice melange.

We expanded calving model description, as stated before.
Calving processes and ice mélange are completely independent. When an iceberg calves, the

boundary “jumps” back. The new iceberg does not contributes to the mélange. This is why the comparison with Amundson was limited to the order of magnitudes only. We do not compare our processes. The manuscript was modified to improve the explanation (see Sect. 5.1).

p.190, l.7: It might be worth mentioning shortly what LHS is or give a reference.
Done

p.190, l.19: This sentence is hard to understand. Are you simply stating that the up-stream boundary is that of a constant flux?
Yes. We clarified it.

p.192, l.6: Motyka et al. (2013, GRL) is also a good reference for showing the depen-dence of melting on subglacial discharge
You are right.

p.194, eqn (5): The onset of freezing on Jan. 1 seems rather late, no?
Yes. In fact, as there is no dependancy between melting experiments and mélange experiment, the starting date of each forcing does not really matter. But for clarity, we changed the Fig. 2. Of course, it does not impact our results.

p.197, l.10: ’do not’ -> ’does not’
Done.

p.199, l.8: I don’t understand that sentence (’when the glacier undergoes the melange layer’)
It just mean: “when a mélange layer is present”. The sentence was changed accordingly.

Fig. 6 and 8: What is the daily normalization you refer to?
The length of the forcing period (mélange or melting) is always shorter than the rest of the year (4-5 months compared to 8-7 months). Thus, in order to compare the ice losses, we divided the quantity of ice lost by the length of the corresponding period. This is why we called it a daily normalized period.
For mélange experiment, Winter = 5 months and 20 days; Summer = 6 months and 10 days
For melting experiment, Winter = 8 months; Summer = 4 months

However, we simplified the descriptions of these captions:
Fig. 6: “Daily average ice loss over the winter and summer seasons for the five years of the simulation for the setups listed in Tab. 2 (experiment U2).”
Fig. 8: “Daily average ice loss over the winter and summer seasons for the five years of the simulation for the setups listed in Tab. 2 (experiment M2).”

Fig. 10: why the strange upside down order? What does ’undergoing an ice melange’ mean?
We inverted panels (a) and (c). The upside down order had no reason for being.
“undergoing an ice melange” just means: “when a mélange layer is present”. The caption was modified into “a glacier forced by an ice mélange”.

Fig. 11: the caption could be clarified a bit. Currently it only becomes understandable together with the text. What is a ’ratio between summer and winter events’ or ’the mean length of the front retreat ratios’?

“The ratio between summer and winter events” corresponds to the ratio between the frequency of calving event occurring during summer and the frequency of calving events occurring during winter time.

“The mean length of the front retreat ratios” corresponds to the ratio between the length of calving front retreat occurring during summer and the length of calving front retreat occurring during winter time.

We changed the caption accordingly to your and reviewer #1 comments.