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The Cryosphere Discussions

Interactive comment on "Boundary layer models for calving marine outlet glaciers" *by* Christian Schoof et al.

Anonymous Referee #3

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The manuscript applies some fairly sophisticated analysis to a simple but widely applied model of a laterally confined glacier subject to one of two calving rules: a 'calving at flotation' model and a crevasse depth calving model (CD) a la Nick 2010. CD turns out to be turns out to be essentially a minimum thickness criterion because of the relationship between calving front thickness, stress and crevasse depth. I think this is fairly well known, but this paper makes good use of that fact to write down an expression for the free boundary condition. The problem is first examined with an unusual (but well described) numerical model, and then with an a analytic boundary layer model, similar to the well known Schoof 2007 model for laterally unconfined flow. Both models feature an interesting result for the CD model: a flux which can decrease with bedrock depth at the grounding line, which in turn allows for stable equilibria on retrograde slopes

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Discussion paper

and the like. Note that this mechanism is not (quite) the same as in e.g Gudmundsson 2012, but rather arises from the interaction between the calving model and the stress balance, e.g flux increases when bedrock depth decreases for a grounded terminus because the first order change is a taller cliff and greater extensional stress.

Overall this is a very strong paper, both in terms of the analysis and the explanation. I'm sure it will be well cited.

Minor comments

If the Nick et al crevasse depth calving model is ro be referred to as 'CD' (as in Nick et al 2010 IIRC) then why not have a similar acronym for the other model (I think Nick called it 'FL'?)

P5-6, eqns 1h,1i: Although the derivations of these expression is in the supplement, would it not make sense to say at this point that the arise from combining the relationship between stress and thickness at the calving front and the relationship between 'dry' crevasse depth and stress.

P6, L15: I don't dispute that sensitivity to d_w (and the requirement that $d_w \sim h$) is a problem for CD: in fact I would go further and say it that in current applications it might be standing in for physics that has nothing to do with hydrology at all.

P9, L24: 'Our aim in what follows. . . ' rather than a single sentence, it might be helpful to quickly sketch out the line of thought. It was not until about P15 that I got the sense of that.

P12,L15: 'Despite working at leading order in ϵ we have retained two terms that contain factors of ϵ in (9) '. Slightly odd phrasing, which might give the impression that the terms are retained even though they are $< O(1)$? Both factors are (for the case $n - 3, m = 1/3$) $\epsilon^{-9/16}$ so $> O(1)$. In the next paragraph that requires γ and $\lambda < O(1)$

for all terms to appear at the same order.

P13, eq 9g. Does the factor $|h_x|^1/m - 1$ arise in general? Or just because $m = 1/n$? Perhaps I missed a trick here, but if γ and b_x are small in (7a), the flux expression just depends on the wall drag and driving stress (so m does not enter).

P19: typo? $H'_{f0} -> H'_f$ in expressions above (14)

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