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The Cryosphere Discussions

Interactive comment on "Calving on tidewater glaciers amplified by submarine frontal melting" *by* M. O'Leary and P. Christoffersen

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This is an interesting paper that makes some progress towards understanding the important problem of how subaqueous melting affects the stress pattern and calving behaviour of tidewater glaciers. The subject is important enough and of a wide enough interest for publication in The Cryosphere. On the whole the text is very clearløy written and the scientifica case is sound. In the introductory sections, however, some minor revisions may be advisable to make the paper more accessible to those not already deeply involved with the calving problem.

A very brief 'menu' of the paper is given in the final paragraph of section 1, but then the paper leaps straight into a discussion of continuum mechanics. For many readers, I think it would be useful to have a clearer statement of the aims and approach of the

paper at this early stage. I.e., it should be made clear that the paper investigates the effects of undercutting on glacier stress regimes, by comparing the static stress fields for a series of specified subaqueous geometries. The stress fields are then used as a basis for investigating the implications for calving. The points made in the existing précis can be introduced as part of this more explicit statement of intent.

Similarly, section 3 could benefit from some revision. In section 3.1, it is argued that the stresses near the waterline can be used to characterize conditions for calving, based on similar reasoning to that put forward by Benn et al 2007a. I think this needs to be explained in a bit more detail, as at present it may appear a bit obscure to someone not already immersed in the problem. The key ideas here are: calving occurs due to penetration of crevasses, which reflect the state of stress in the ice; first-order crevasse-depth calving models assume that calving occurs when crevasses reach some critical depth; Benn et al., 2007 chose the waterline as that critical depth because of the water-filling argument, but a full-depth variant was also proposed by Nick et al 2010. My present view of the calving criterion is that the waterline threshold is applicable for many glaciers, but not necessarily for the original reasons put forward in the 2007 papers. In a lot of cases, what happens is that the subaerial part of the front calves, followed sometime later by buoyant calving of any subaqueous part (which of course does not exist in your simulations). On other glaciers, the waterline threshold may not be so appropriate. For simplicity, I think it is OK to use the waterline as the reference level for your stress comparisons, though I'd go easy on the water-filling argument – in my experience this has acted as an unnecessary obstacle to people's acceptance of the model.

The following sections are clearly explained, and a convincing case is made that stress retreat transfers the effects of front melting upglacier, and hence scales calving rate to melt rate. The authors quite rightly state that their interpretations should be used with care, due to the links between calving events and glacier dynamics. To investigate this further will require solving the harder problem of a fully coupled time-evolving model

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with changing front geometry due to melt and ice flow, as well as application of a calving criterion. Perhaps this could be mentioned in the text.

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