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The Cryosphere Discussions

# *Interactive comment on* "Mechanical effect of mélange-induced buttressing on embayment-terminating glacier dynamics" *by* D. Seneca Lindsey and T. K. Dupont

**J. Amundson (Referee)**

jason.amundson@uas.alaska.edu

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This paper uses a numerical model to attempt to determine the impact that ice mélange (a dense pack of icebergs and sea ice) has on calving rate and glacier flow. The authors conclude that mélange can account for some ($\sim$10%) of the seasonal variability in terminus position observed at some outlet glaciers. However, I have several major concerns about this study that make me question its relevance:

1. Data published on ice mélange suggests that it is a granular material: many of the icebergs are large relative to the domain and a lot of the motion occurs along discrete shear bands (failure along grain boundaries). I therefore see no reason why



it would be appropriate to model the mélange using the shallow shelf approximation. This approach needs to be justified by comparison to data, such as satellite-derived velocity fields (Joughin et al., 2008). The authors admit that they may be missing important bridging effects and that other rheologies may be necessary. Why not try other rheologies? Or at least use a larger exponent in the constitutive relation so as to better approximate the shear bands?

2. The authors state that a conservative estimate of the ice mélange thickness is 20% of the glacier thickness. A quick glance at altimetry data would have shown that this is not conservative. The average mélange freeboard at Jakobshavn is something like 10 m, so the mélange has an average thickness of 100 m, or 10% of the glacier thickness. This raises another issue with the continuum model that the authors adopted – ice mélange has a highly irregular geometry and in some places will be much thinner than 100 m.

3. The calving parameterization used in the study was determined by analyzing glaciers that are near steady-state and assuming that calving rate equals terminus velocity. In fact, the calving parameterization can be shown to simply be a consequence of mass conservation (Amundson and Truffer, 2010; Hindmarsh, 2012) when the terms in the parameterization are evaluated at the glacier terminus. By selecting values that are slightly up glacier from the terminus, as the authors did in this study, you under-predict terminus velocity and therefore under-predict the steady-state calving rate, causing the glacier to slowly advance. The Alley et al. calving rate is useful in that it suggests what parameters might be important for calving, but I don't think its appropriate to apply it to glaciers that are evolving with time – at least not without some significant modifications.

What this paper tells me is that if ice mélange does indeed significantly affect calving and glacier flow (directly or indirectly) on seasonal time scales, than its rheology cannot be adequately described with the shallow shelf approximation.

-J. Amundson, 14 November 2012

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