The Cryosphere Discuss., 6, C2318–C2320, 2012
www.the-cryosphere-discuss.net/6/C2318/2012/

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

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Received and published: 29 November 2012

We would first like to thank Jason Amundson for his comments regarding this work.

Regarding rheology of the mélange: We agree that this model is not well adapted for predictively forecasting the seasonal advance of the ice front or seasonal variation of calving. In the revised paper we will make clear that such an attempt would require a system that captures a myriad of important factors such as ocean-induced melt, strain history, hydrofracturing, and glacier geometry. Our work here seeks an upper bound on the ability of mélange to reduce longitudinal-strain rate and calving. In seeking an upper

bound, we make a couple assumptions about the rheology of mélange. First, we assume that bergs fill the embayment and, taken to the limit, replace any space that might be filled by relatively thin sea-ice. This could conceivably occur through a combination of below-freezing atmospheric temperatures, sea-ice stabilization of bergs, growth in iceberg size through accretion, and compression of mélange as the front advances. Second, we assume that the material strength of the mélange is the strongest it can possibly be. In this effort, we assume there is no failure along grain boundaries and that the mélange is connected strongly enough that the stress equilibrium equations are applicable.

Regarding thickness of the mélange: Our original assessment that mélange thickness values exceed that of a few meters is based on figure 2 provided in Amundson et al. (2010). We also note measurements of mélange thickness in crevasses by Fricker et al. (2005) in the Amery ice-shelf that show mélange thickness of $60\ m$ for a shelf that is roughly $300\ m$ thick, a 20% ratio. Per the referees suggestion, we have run experiments for a mélange thickness that nears full thickness at the front and linearly decreases over a transition distance to $100\ m$ thickness for the rest of the embayment. Results indicate that calving drops 24% relative to the summer mélange-free calving rate. This means that for a transition length of one kilometer or $3\ km$ the impact on calving is roughly half, or equals, that of a constant $220\ m$ thickness. Our result still holds, that mélange can, under certain conditions, affect the force balance of the near-terminus glacier, calling into question assumptions made by Reeh et al. (2001) and Joughin et al. (2008) that the glacier force balance will not be affected by the presence of mélange.

Regarding application of the Alley et al. (2005) calving parameterization: The Alley calving parameterization is based on a broad array of ice-shelf calving data including several data points from Jakobshavn Isbræ. It is heuristic in nature and gives us a sense of how calving will behave for a given scenario. While the calving parameterization is derived by assuming the calving rate matches the ice-front velocity, there is no reason to assume the calving rate is not applicable for other glacier geometries. Furthermore, the parameterization depends on thickness, width, and longitudinal strain-rate to ease implementation into existing models and other factors such as ocean melt, wave energy, and strain history, are incorporated implicitly via the coefficient and exponent of the power-law fit. Upon publication of Hindmarsh (2012), we compared output from the Hindmarsh parameterization with that produced by the Alley calving rate. The result is that the Hindmarsh parameterization accurately produces velocities at the terminus matching those of the numerical model but does not capture the character of the Alley parameterization. In other words, the Alley parameterization is not strictly a consequence of mass balance at the front.

Interactive comment on The Cryosphere Discuss., 6, 4123, 2012.