Rapid grounding line migration induced by internal variability of a marine-terminating ice stream

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Numerous studies have found significant variability in the velocity of ice streams to be a prominent feature of geomorphologic records in the Siple Coast (Catania et al. 2012) and other regions in West Antarctica (Dowdeswell et al. 2008). Observations indicate that grounding line position is strongly influenced by ice stream variability, producing rapid grounding line migration in the recent past (Catania et al. 2006) and the modern (Joughin & Tulaczyk 2002).

We analyze the interaction of grounding line mass flux and position in a marine-terminating ice stream using a stretch-coordinate flowline model. This model is based on that described in Schoof (2007), with a mesh refined near the grounding line to ensure accurate resolution of the mechanical transition zone. Here we have added lateral shear stress (Dupont & Alley 2005) and an undrained plastic bed (Tulaczyk et al. 2000). The parameter dependence of ice stream variability seen in this model compares favorably to both simpler (Robel et al. 2013) and more complex (van der Wel et al. 2013) models, though with some key differences.

We find that thermally-induced internal ice stream variability can cause very rapid grounding line migration even in the absence of retrograde bed slopes or external forcing. Activation waves propagate along the ice stream length and trigger periods of rapid grounding line migration. We compare the behavior of the grounding line due to internal ice stream variability to changes triggered externally at the grounding line such as the rapid disintegration of buttressing ice shelves. Implications for the Marine Ice Sheet Instability are discussed.