Responses of marine ice sheet to basal melting of ice shelves

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Integrated study of combining climate models and ice sheet models are required to understand the response of Antarctic ice sheet to climate changes, and basal melting beneath ice shelves is a key player (Mengel et al. 2015; Deconto and Pollard 2016; Kusahara 2016). Simulations by high-resolution ocean models that resolves ice shelf cavity circulations show that basal melt rate of ice shelves increase drastically in a warm climates (Timmermann et al. 2013; Obase et al. in press), and could cause collapse of marine ice sheet.
Previous studies investigated the model dependency on the response of marine ice sheet to changing ice accumulation, ice temperature, and basal sliding, but not for changing basal mass balance (Vieli and Payne 2005; Pattyn et al. 2012; Pattyn et al. 2013). Recent study with explicit treatment of basal melt rate suggests that careful treatment of basal melt rate near grounding line and higher horizontal resolution are required for simulating grounding line retreat because of abrupt change in basal mass balance near grounding lines (Gladstone et al. 2017).
In this study, we investigate the responses of marine ice sheet to basal melt rate beneath ice shelves under an idealized flow-line system. We use a numerical ice sheet-shelf model IcIES for flow-line calculation. Ice flow is approximated by Shallow Ice Approximation for grounded ice and Shallow Shelf Approximation for floating ice, and sub-grid scale grounding line migration is parameterized with ice flux at the grounding line (Schoof 2007). In the flow-line calculation, ice flux that is orthogonal to ice flow and lateral resistive stress are set to zero. The ice sheet and ice shelf are assumed to be isothermal, therefore thermodynamics is not included. Bedrock topography is taken from several ice sheet drainages from Antarctic ice sheet. We systematically simulate steady-states of ice sheet shape under a given basal melt rate and bedrock topography. We discuss the determining factors of changing basal melt rate, changing sea level, and bedrock topography on the stability of marine ice sheet.

