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Calving laws and strain rates: a comparison between modelled relationships and observations from InSAR velocity maps from across Greenland.

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Calving is a major mechanism of cryospheric ice mass loss and a significant contributor to global sea level change, though it is currently poorly understood as a process. Longitudinal strain rate is often cited as a first order control on calving, however multiple different calving laws (not always including the strain rate) have been used to represent this in numerical models of ice sheets. This study seeks to investigate how (1) different calving laws within a 1D flowline model predict strain rate will evolve within increasing terminus thickness for steady state and transient simulations, and (2) how these relationships compare with observed strains (derived from MEaSUREs Greenland InSAR velocity maps; Joughin et al., 2010 [updated 2016]) and depths (from BedMachine v.2 subglacial topography data; Morlighem et al., 2014).

We identify that systematic relationships with terminus thickness exist for height above buoyancy, water-line and full-depth crevasse calving laws amongst others for both steady state and transient simulations. However, analysis of observed near-terminus strain rates for multiple Greenlandic glaciers using a variety of metrics (with a range of bed depths predicted by BedMachine) does not reproduce the shape or magnitude of any of these modelled relationships.

Relationships between strain rate and depth derived from simple 1D model simulations therefore cannot be realistically compared to current real-world observations. This suggests that the magnitude of observed strain rates at an individual point, or area-averaged conditions near a real-world terminus are not meaningful in determining the potential for calving when taken in isolation. To improve understanding of first/second order calving processes, future modelling work should therefore look to analyse how/if the distribution of strain across the terminus region impacts calving as part of 2D-planform/3D models.