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Investigating the Flow Dynamics at Ice Shelf Calving Fronts

Martin Wearing (1,2), Richard Hindmarsh (1), and Grae Worster (2)

(1) British Antarctic Survey, Cambridge, United Kingdom (marwe@bas.ac.uk), (2) DAMTP, University of Cambridge, Cambridge, United Kingdom

Ice-shelf calving-rates and the buttressing ice shelves provide to grounded ice are both difficult to model and quantify. An increased understanding of the mechanics of this process is imperative in determining the dynamics of marine ice sheets and consequently predicting their future extent, thickness and discharge.

Alley et al. (2008) proposed an empirically derived calving law, relating the calving rate to the strain rate at the calving front. However, Hindmarsh (2012) showed that a similar relationship could be deduced by considering the viscous flow of the ice shelf. We investigate the relationship between the ice shelf flow field and the strain rate field in the area close to the calving front.

Analysis is undertaken of ice surface velocity data for a range of Antarctic ice shelves (data from Rignot et al., 2011) and an inferred strain rate field produced from that data. These geophysical results are compared with a simple mathematical model for laterally confined ice shelf flow.

Correlations are calculated between the same variables as Alley et al. but using a new and larger data compilation, which gives a greater degree of scatter. Good agreement is observed between the expected theoretical scaling and geophysical data for the flow of ice near the calving front in the case of laterally confined ice shelves. This lateral confinement ensures flow is aligned in the along-shelf direction and resistance to flow is provided by near stationary ice in the grounded margins. In other cases, the velocity is greater than predicted, which we attribute on a case-by-case basis to marginal weakening or the presence of ice tongues. We develop statistical methodologies for identifying these outliers.