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Inverse modelling of basal velocity using a 2D higher-order ice-flow model

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The basal boundary condition remains one of the least understood aspects of ice dynamics. This lack of knowledge hampers the credibility of current ice-flow modelling efforts. For this reason, much attention recently goes to the inverse modelling of basal parameters from surface velocity observations. We present and test the limits of such an inverse methodology.

The innovative aspect of our method is that it takes into account both vertical shear and longitudinal stress gradient aspects of ice flow, which makes it suited for both valley glaciers, ice sheets and ice streams. The forward model is a 2D time-independent isothermal higher-order finite-element ice-flow model. We use a dirichlet boundary condition at the base in the form of a basal velocity. This way, we avoid the hypothesis of a sliding law which may not hold in practice.

The limits of the method are explored with synthetic glacier data. We then apply the method to Pine Island Glacier, West-Antarctica and McCall Glacier, Alaska. For McCall Glacier, we investigate changes in the annual and seasonal sliding patterns during the period 1970-2006. We discuss the usefulness of basal reflection power data from radio-echo soundings in the detection of sliding zones. We show there is an intimate link between basal topography, basal drag and basal velocity. We discuss the importance of higher-order flow aspects in this type of inversions.