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Modelling tidewater glacier dynamics: the case of Columbia Glacier, Alaska

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Recent rapid dynamic changes in Greenland tidewater outlet glaciers such as flow acceleration, retreat and thinning demonstrate the importance of the calving process on the mass budget of large ice sheets. The availability of data on the time-dependent behaviour of outlet glaciers is however very limited but crucial for the development and testing of numerical ice-flow models of such marine-based glaciers.
Columbia Glacier in Alaska provides probably the best documented example of rapid tidewater glacier retreat in the world and includes extensive time series data of front retreat, surface velocities and elevation change that span over more three decades. In the early 1980s, Columbia Glacier started to retreat rapidly from its initial stable position on a shallow moraine bank into deeper water with average retreat rates of almost 2km/y, while the ice speed at its terminus increased from 3km/y to up to 20km/y.
We use this extensive dataset as an opportunity for developing and testing dynamic numerical ice-flow models for tidewater glaciers and the parameterization of the calving process. Using a 3d-higher order ice flow model we compute the velocity and stress field of Columbia Glacier for a time slice and constrain it by the observed flow. We use these results to assess the representation of velocities and stresses of a reduced 1d flowband model that also includes a physically based parameterization of calving. This 1D-model is then used to simulate the retreat history of Columbia glacier from its stable state in the 1980s to the present and to assess different parameterizations for calving.