EGU23-5510, updated on 25 Apr 2024
https://doi.org/10.5194/egusphere-egu23-5510
EGU General Assembly 2023

A 3D glacier dynamics-line plume model to estimate the frontal ablation of Hansbreen, Svalbard

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Frontal ablation is responsible for a large fraction of the mass loss from marine-terminating glaciers. The main contributors to frontal ablation are iceberg calving and submarine melting, being calving the largest one. However, submarine melting, in addition to its direct contribution to mass loss, also promotes calving through the changes induced in the stress field at the glacier terminus, so both processes should be jointly analysed. Among the factors influencing submarine melting, the formation of a buoyant plume due to the emergence of fresh subglacial water at the glacier grounding line plays a key role.

In this study we use Elmer/Ice, an open-source, parallel, finite-element software which solves the full-Stokes system, to develop a 3D glacier dynamics model including calving and subglacial hydrology coupled with a line-plume model fed by the subglacial discharge that accounts for the submarine melting at the calving front. The ice flow model provides the calving front position at every time-step.

We apply this model to the Hansbreen–Hansbukta glacier–fjord system in Southern Spitsbergen, Svalbard, where a large set of data are available for both glacier and fjord. The evolution of the modelled front positions are in agreement in terms of advance and retreatment with those observed from time-lapse images of the glacier front, and, in general, the modelled is always ahead of the observed due to an underestimation of calving.