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Long-term evolution of a small ice cap in Greenland: a dynamic perspective from numerical flow modelling

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Small ice caps at the periphery of the Greenland ice sheet are often close to the limit of existence and are therefore expected to respond more sensitively to climate change than the land-margin of the neighboring ice sheet. However, their past evolution and dynamic behavior is poorly understood and their use as climate indicators therefore remains so far limited.
We here aim to provide a long-term dynamic reconstruction of Lyngmarksbraeen, a small (32km2) ice cap on Disko Island in West Greenland, with a particular focus on the little ice age (LIA, since 1200AD). We use a 2-dim. time-dependent numerical flow model (SIA) and a PDD-mass balance model in combination with historical observations, geomorphological mapping and exposure dating to simulate its long-term evolution and dynamic behaviour. We specifically focus on retreat since the LIA, which is well constrained by geomorphological evidence and historical maps and length records of several small outlet glaciers and data from local and regional climate stations (Qeqertarssuaq and Ilulisat). We also explore aspects related to flow dynamics and find that the dynamic state of this ice cap is, at any time, far from being balanced and is highly sensitive to the surface elevation mass balance feedback and results in an asynchronous response of the different outlets and hysteresis-type behaviour.
The modelling is able to reproduce the observed LIA-extent and the almost continuous retreat over the last hundred years well. It further indicates that the ice cap was already dynamically inert since the 1960s. Today, the ice cap has lost almost its entire accumulation area and even without any further warming in the future, the ice cap is expected to vanish within a couple of decades.