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Advancing land-terminating ice cliffs in Northwest Greenland

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Land-terminating ice cliffs are intriguing features that occur in various ice-covered regions around the world both in high and low latitudes. Over flat terrain land-terminating ice cliffs can only persist under a complex interplay between certain climatic and ice dynamic conditions with "cold" and "dry" being the common pillars for their occurrence. In North Greenland, dry calving ice cliffs are an abundant feature, however, to our knowledge, detailed investigations are limited to studies more than six decades ago in the Thule area. Rough estimates state that approximately 45% of the ice sheet in Northwest Greenland terminate as cliffs on land.
The ice cliff position and its change with time is a combined signal of the ice flow and mass balance at the cliff. The ice flow is triggered by a mass imbalance upstream the ice cliff integrating a potentially long response time, basal sliding and ice deformation, whereas the mass balance of the ice cliff is determined by the sum of the energy fluxes at the cliff face and the calving flux. Studies during the 1950s and 1960s report counterintuitive results with a generally negative mass balance and a reduction of ice cliff height versus a net advance of the cliff. This intriguing evolvement warrants closer attention as it remained unstudied thereafter even though it is likely relevant for a large portion of cold and dry North Greenland. Thus, the purpose of this contribution is to build a relevant basis for future process studies by (i) determining the occurrence of ice cliffs in Northern Greenland, (ii) classifying them by obvious morphological distinctions such as height and steepness and (iii) give a first-order estimate on percentage of advancing vs retreating areas.
Repeating the past study above using recent space-borne earth observation data (digital elevation models from 1985, 2007 and 2015) we mapped the evolution of the ice sheet margin. Results at the same cliff and at another independent location in Northwest Greenland show that, on a decadal time scale, despite a generally negative surface mass balance and a reduction of ice cliff height, parts of these ice cliffs either remained stagnant or advanced at an average speed of 0.5 m/year.