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Greenland wide terminus change from 1984-2017: linear climate responses, and application of machine learning

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Greenlandic tidewater glaciers (TWGs) have been undergoing widespread retreat since the mid-1990s and contribute up to 50% of mass loss from the Greenland Ice Sheet (GrIS), though a comprehensive annual record of their retreat during the satellite age is currently lacking.

Here we present a Greenland-wide dataset of annual terminus positions for 220 TWGs for the period 1984-2017 based on Landsat 4-8 and Sentinel 2 imagery (n = 3833). These were manually digitised using the cloud-computing based Google Earth Engine Digitisation Tool (GEEDiT), and their changes quantified using the curvilinear box method within the Margin Change Quantification Tool (MaQiT; Lea, 2018). Results were analysed alongside regional climate data (including air and sea surface temperatures), and with the supervised machine learning tree ensemble method Random Forests to determine the existence of threshold-type behaviour that may influence terminus stability.

After normalising terminus behaviour of all glaciers, our analysis highlights distinct linear trends in the regional response of TWG termini. The south-east, south-west and north-west regions are all found to behave comparably (advance/stability until the mid-1990s followed by sustained retreat until 2017). However, in the north-east sustained retreat occurred since the mid-1980s, which then accelerated in 2008/2009.

The multi-decadal timescale data set generated by this study enables the identification of a regional linear trend of TWG behaviour for the first time, and has allowed the application of Random Forests to determine the relative influence of climate forcings on termini positions. We anticipate that the results of this study hold a potential for creating new, empirically based predictive models of TWG change.