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Basal topographic controls on the rapid retreat of Humboldt Glacier, northern Greenland

Rachel Carr (1), Andreas Vieli (2), and Chris Stokes (3)

(1) Aberystwyth University, Geography and Earth Sciences, Aberystwyth, United Kingdom (rac31@aber.ac.uk), (2) Department of Geography, University of Zurich, Zurich, Switzerland, (3) Department of Geography, Durham University, Durham, UK

The Greenland Ice Sheet has rapidly lost mass in the past decade, through a combination of negative surface mass balance and accelerated discharge from marine-terminating outlet glaciers. However, the factors driving changes in ice dynamics are poorly understood. Here, we assess the impact of climatic/oceanic and basal topographic controls on the behaviour of Humboldt Glacier, one of the largest marine-terminating outlet glaciers in Greenland. We use a combination of ESA SAR image Mode data and Landsat imagery to demonstrate that Humboldt Glacier retreated rapidly between 1999 and 2012 (162 ma-1), following decades of gradual retreat between 1975 and 1999 (37 ma-1). Comparison of frontal positions with climatic/oceanic forcing data suggests that the primary driver of retreat was increased summer air temperatures, which warmed by almost 3°c between 1999 and 2012, with a secondary contribution from reduced summer sea ice concentrations. Retreat rates at Humboldt Glacier were an order of magnitude greater on the northern portion of the terminus, which we attribute to the presence of a large basal trough beneath this section. We suggest that this overdeepening brought the northern section close to floatation and increased its sensitivity to climatic/oceanic forcing, thus promoting rapid retreat. The basal trough continues up to 40 km inland and may facilitate sustained and substantial mass loss from Humboldt Glacier throughout the 21st Century. Our results imply that basal topography is likely to be a critical control on the magnitude and rate of mass loss from Humboldt Glacier in the near-future and highlights the potential for overdeepenings to influence contemporary Arctic outlet glacier behaviour.