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Acceleration of land- and marine-terminating catchments of the Greenland Ice Sheet in contrasting melt-seasons

Douglas Mair (1), Andrew Sole (2), Peter Nienow (2), Ian Bartholomew (2), Tom Cowton (2), Matthew King (3), and Matthew Burke (4)

(1) University of Aberdeen, School of Geosciences, Aberdeen, United Kingdom (d.mair@abdn.ac.uk, +44 1224 272331), (2) University of Edinburgh, School of Geoscience, Edinburgh, United Kingdom, (3) Newcastle University, School of Civil Engineering and Geosciences, Newcastle, United Kingdom, (4) Simon Fraser University, Department of Geography, Burnaby, Canada

One of the key uncertainties affecting attempts to model the response of the Greenland Ice Sheet (GrIS) to a warming climate is how to parameterise the relationship between surface melt and ice velocity. Seasonal ice acceleration is initiated when surface meltwater reaches the ice sheet bed and lubricates flow. At land-terminating margins, these changes in ice velocity occur nearest the margin first, in response to the onset of surface melting, and propagate inland. Each summer, an increase in the efficiency of the subglacial drainage system under the ablation zone suggests that subglacial water pressures (and hence basal sliding) decrease over time for a given meltwater input at a particular site. Marine-terminating outlet glaciers generally display less sensitivity to variations in surface meltwater availability. However, far inland from the calving front, recent measurements on the GrIS have shown that seasonal variations in ice velocity are principally related to surface melt induced changes in subglacial hydrology rather than changes at the calving front. The net effect of complex air temperature-ice velocity relationships on GrIS mass balance depends on whether inland expansion of the area experiencing acceleration, due to increased melt extent, outweighs potential reductions in more marginal ice velocity due to earlier establishment of efficient subglacial drainage systems.

Here we present two years (2009 and 2010) of GPS-derived ice velocity, air temperature and surface melt data from two transects (land- and marine-terminating) in West Greenland. The land-terminating Leverett Glacier transect, with seven GPS sites, extends from the ice sheet margin to ~200 m above the equilibrium line (at 1716 m elevation ~115 km inland). The marine-terminating Kangiata Nunata Sermia (KNS) transect, with four GPS sites, ranges from 1280 m to 1840 m elevation, and extends from 32 to 76 km from the calving front. At both transects, in 2010, surface melting started ~3 weeks earlier than in 2009 and melt was substantially greater throughout the 2010 melt-season. Our data is analysed to show clear evidence for greater ice acceleration in the warmer year. This has implications for the future behaviour of the GrIS if present warming continues and provides a framework for the development of an empirically-based parameterization of the relationship between atmospheric warming and ice sheet velocity.