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Flow Characteristics and Basal Boundary Condition for Daugaard-Jensen Gletscher, East Greenland

Thomas Perry (1), Poul Christoffersen (1), Julian Dowdeswell (1), Steven Palmer (2), and Duncan Young (3)

(1) Scott Polar Research Institute, University of Cambridge, Cambridge, UK (tp378@cam.ac.uk), (2) College of Life and Environmental Sciences, University of Exeter, Exeter, UK, (3) Institute for Geophysics, University of Texas, Austin, TX, USA

The recent acceleration of mass loss from the Greenland Ice Sheet can in part be attributed to the dynamic thinning and acceleration of its tidewater outlet glaciers. Many of these glaciers have been shown to exhibit sensitivity to conditions at their marine termini, where warm ocean currents promote ice front melting and retreat. However, these currents are confined to a northerly extent of 69N, and whilst remarkable change is seen to the south of this latitude, glaciers to the north are considerably more stable in terms of terminus position. Different environmental variables may thus control the flow characteristics of glaciers north of this well-defined geographical boundary. During 2011, high-resolution ice data was collected for Daugaard-Jensen Gletscher (71N) as part of the Greenland Outlet Glacier Geophysics (GrOGG) project. Remote sensing has confirmed its stability but few, if any, have applied an ice flow model to examine its ice dynamics in more detail. Here, the numerical Elmer-ICE model is applied to a new bed DEM in order to analyse flow characteristics and basal boundary conditions for Daugaard-Jensen Gletscher.

The bed elevation of the inland part of the catchment was derived from Operation Icebridge and GrOGG ice thickness data, whilst the main glacier trunk was inferred through mass conservation calculations at a resolution of 100 m using TerraSAR-X velocity data. The latter was also used for 3D inverse modelling with Elmer-ICE, to analyse basal boundary conditions such as basal traction, sliding speed, frictional heating, and the basal melt rate. This is critical in accurately reproducing velocities and flow characteristics for the glacier, which is not always successful with a simple parameterisation in pure forward modelling.

The new DEM offers considerable improvements in vertical accuracy and horizontal resolution compared to previous bed datasets created at the ice-sheet scale. Preliminary results indicate that two deep channels within the main fjord trough guide ice flow, and velocity increases rapidly and substantially close to the terminus, suggesting that basal boundary conditions are variable along the longitudinal profile of the glacier. Finally, we compare the setting, flow and basal conditions obtained for Daugaard-Jensen Gletscher with conditions found at other tidewater outlet glaciers in northern Greenland. This approach offers high-resolution results that can be used to refine regional mass loss estimates and to predict the future stability of those glaciers more isolated from strong ocean forcing.