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A hydrologically inspired approach to predicting fjord bedrock elevation at the ice-ocean interface of the Greenland Ice Sheet

Chris Williams (1), Jonathan Bamber (1), James Cochran (2), Stephen Cornford (1), Julian Dowdeswell (3), Tom Jordan (1), Mathieu Morlighem (4), Steven Palmer (5), Martin Siegert (6), Kirsty Tinto (2), and John Paden (7)

(1) School of Geographical Sciences, University of Bristol, Bristol, UK, (2) Lamont-Doherty Earth Observatory, Colombia University, New York, USA, (3) Scott Polar Research Institute, University of Cambridge, Cambridge, UK, (4) Earth System Science, University of California, Irvine, USA, (5) Geography, University of Exeter, Exeter, UK, (6) The Grantham Institute for Climate Change, Imperial College London, London, UK, (7) Center for Remote Sensing of Ice Sheets, University of Kansas, Lawrence, USA

Measurements of ice sheet basal topography provide vital boundary conditions for numerical modelling of ice sheet evolution and are key to understanding observations of ice sheet dynamics. A consistent issue with existing bed topography products for the Greenland Ice Sheet – developed using ice thickness observations from ice penetrating radar, interpolation, and mass conservation (Bamber et al., 2013, Morlighem et al., 2014) – is the poor quantification of near coastal bathymetry. Accurate mapping of bedrock elevation in these areas is important as glaciers local to these regions have been observed to have the largest velocities, greatest associated mass changes, and are therefore most sensitive to uncertainties in basal boundary conditions when modelling ice motion (e.g. Nick et al., 2013). Sparse data availability and resultant coarse rendering of digital elevation products at the edges of existing ice sheet bed elevation products poses issues, particularly when integrating models over longer periods of time (e.g. Vieli and Nick, 2011). Improving data coverage in these regions is a further priority as fjord bathymetry is known to provide a strong control on ocean circulation and ice-ocean forcing (e.g. Straneo et al., 2011) which have been related to changes observed in tidewater glacier systems (e.g. Murray et al., 2010).

We have developed a method that improves existing products of the Greenland Ice Sheet bed rock and surrounding bathymetry through [1] the addition of new bathymetric and ice thickness data where available and [2] the integration of generalised fjord structures in data sparse regions to better inform interpolation routines.

Following the release of the last Greenland bed topography-bathymetry product (Bamber et al., 2013), new data acquired through gravity inversion as well as single and multi-beam echo sounding are included, improving bed elevation data density and coverage. In fjords which remain data sparse, idealised fjord geometry is implemented through the development of synthetic data, based on a procedure previously used for developing river channel morphology (Goff and Nordfjord, 2004, Merwade et al., 2005). Data are created by defining fjord centrelines using a medial axis image skeletonisation approach which is based on land classification masks developed from remote sensing imagery. Cross-profile geometry along a given fjord is calculated normal to the fjord centreline with elevations being calculated relative to nearest bedrock elevation observations and elevation trends.

This approach is being applied to the entire Greenland coast, and will result in the development and public release of a new, vastly improved and topographically representative Greenland Ice Sheet bed geometry product. We will present the aforementioned fjord geometry method coupled with results of its application.