A landform-driven simulation of deglaciation of the Scandinavian Ice Sheet and the PalGlac project's progress on data-modelling integration

Chris D. Clark[a], Jeremy C. Ely[a], Anna, L.C. Hughes, Rosie, E. Archer[a], Ben M. Boyes[a], Frances, E. Butcher[a], Nico Dewald[c], Chris R. Diemont[a], Helen, E. Dulfer[a], Tim J. Heaton[d], Sarah L. Bradley[a]

[a]Department of Geography, University of Sheffield, Sheffield, UK, [b]Department of Geogrpahy, University of Manchester, Manchester, UK. [c]British Geological Survey, The Lyell Centre, Edinburgh, UK. [d]School of Mathematics, University of Leeds, Leeds, UK.

The field of palaeo-glaciology has evolved from inquisitiveness about glaciated landscapes - how they came into being - into the wider role of improving glaciological understanding and more recently, into testing or improving the fidelity of ice sheet modelling approaches. Such endeavors are crucial for improving forecasts of today's diminishing polar ice sheets and for predicting sea-level rise. The PalGlac project (2018 to 2024) is using glacial landform mapping and analysis to advance our understanding of ice sheets, and in this talk, we will focus on the demise of the Scandinavian Ice Sheet and how landform data is used to either test or calibrate (nudge) ice sheet modelling simulations.

Glacial landforms such as drumlins, moraines, meltwater channels and eskers record spatially extensive components of ice sheet activity, namely 1) ice flow geometry and thermal regime, 2) the pattern of ice-marginal recession, and 3) the subglacial flow of meltwater that likely modulated the first two. High-resolution (metres) digital elevation models (DEMs) are revolutionising the mapping and understanding of glacial landforms (Johnson et al. 2015). They permit detailed investigation across areas so large as to have been unimaginable decades ago. We here report on a multi-person mapping investigation of glacial landforms across the land areas of Fennoscandia, northern Europe, and parts of Russia, and which have yielded over 350,000 individual features recording ice flow (250,000), ice margins (70,000), and meltwater routing (30,000). All data, held in a GIS, are used to build a first-order reconstruction of the pattern of ice flow changes and ice margin retreat. Much of these data reveal a useful confirmation and replication of prior studies, which we now know with improved robustness, and with many new aspects being revealed, notably in ice divide positions.

Our ultimate aim is to build a simulation of whole ice sheet growth and decay incorporating changes in ice thickness and flow geometry and tracking successive ice-marginal positions. This is being achieved using the mapped landform data along with chronological data (Hughes et al. 2016), glacio-isostatic constraints and other constraints from the literature and comparing them with ice sheet modelling simulations using PISM (Winkelmann et al. 2011). We focus on using identified empirical changes in ice flow geometry (from the landforms) to choose between dozens of alternate ensemble ice sheet model simulations. The challenge is to build a three-dimensional simulation of ice sheet evolution that is physically well-founded that satisfies most of the flow geometry changes, and fits within empirically defined ice marginal positions.

References

Johnson, M.D., Fredin, O., Ojala, A.E.K., Peterson, G., 2015: Unraveling Scandinavian geomorphology: the LiDAR revolution. *GFF 137,* 245-251.

Hughes, A.L.C., Gyllencreutz, R., Lohne, Ø.S., Mangerud, J., Svendsen, J.I., 2016: The last Eurasian ice sheets--a chronological database and time-slice reconstruction, DATED-1. *Boreas 45,* 1–45.

Winkelmann, R., Martin, M.A., Haseloff, M., Albrecht, T., Bueler, E., Khroulev, C., Levermann, A., 2011: The Potsdam parallel ice sheet model (PISM-PIK)--Part 1: Model description. *The Cryosphere 5*, 715–726.