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Digital landscapes and Late Pleistocene environments of deglaciation: The use of LiDAR data to test outburst flood hypotheses of lowland river gorge formation

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We report on the quantitative interrogation of DEMs developed from airborne LiDAR data for the identification and reconstruction of Late Pleistocene glacial lake outburst floods (GLOFs). There is much importance attached to the quantification of geomorphic processes associated with deglaciation given global warming and current observations of rapidly melting glaciers and ice caps (e.g. Greenland). Given the period of direct observation is short, recourse can be made to the study of past ice sheets and associated landforms in order to reconstruct the rates and magnitudes of change during deglaciation. Meltwater channels, lakes and outflow channels are examples of landforms that can be used to identify the position, timing and retreat of former ice margins. With regards lake drainage there is a need to distinguish 'instantaneous' outburst floods from long term downcutting in order to improve our interpretations on the rates and magnitudes of geomorphic processes. There has been success in this regards at the megaflood scale but less attention has been paid to low magnitude outburst floods that can nevertheless have important regional implications for geomorphic processes. Here we use 5m DEMs and 2m resolution LiDAR data using ArcMap10, in combination with fieldwork, to investigate outflow channels in lowland environments of northern England, and develop methodological guidelines to aid the identification of GLOF events in previously glaciated landscapes. We identified a suite of distinguishing landforms from the 2m LiDAR data, not always identifiable in the 5m DEM, that indicate rapid erosion as opposed to long-term incision: 1) abandoned head cuts; 2) spillways representing sudden incision events once a downstream blockage has failed; 3) headcut extension of incised gorges upstream of the breach site; and 4) sedimentary deposits of 'chaotic' poorly sorted, water-lain sediments mapped at low elevations in the gorge; and run-up bars at higher elevations. All of these features are present in the River Till gorge, previously thought to be the outflow of Glacial Lake Milfield in northern England but here interpreted as a new drainage pathway resulting from an outburst event. Our reconstruction of the Till flood shows complex initial flow hydraulics with water flooding over undulating drumlin terrain. However once the gorge has incised we quantify palaeodischarges of between 2000-4000 m3/s, based on hydraulic modelling using the DEM-derived topography, with floodwater elevations delimited by terrace levels associated with incision phases (caused by the sudden failure of downstream blockages). This suggests that the 1.27 km3 lake took less than one week to drain, during this time eroding approximately 0.04 km3 of material from the gorge. We also briefly report on results from another UK site, the River Derwent outflow gorge of Glacial Lake Pickering.