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Automating the implementation of an equilibrium profile model for glacier reconstruction in a GIS environment

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Reconstruction of glacier equilibrium line altitudes (ELAs) associated with advance stages of former ice masses is widely used as a tool for palaeoclimatic reconstruction. This requires an accurate reconstruction of palaeo-glacier surface hypsometry, based on mapping of available ice-marginal landform evidence. Classically, the approach used to define ice-surface elevations, using such evidence, follows the 'cartographic method', whereby contours are estimated based on an 'understanding' of the typical surface form of contemporary ice masses. This method introduces inherent uncertainties in the palaeoclimatic interpretation of reconstructed ELAs, especially where the upper limits of glaciation are less well constrained and/or the age of such features in relation to terminal moraine sequences is unknown. An alternative approach is to use equilibrium profile models to define ice surface elevations. Such models are tuned, generally using basal shear stress, in order to generate an ice surface that reaches 'target elevations' defined by geomorphology. In areas where there are no geomorphological constraints for the former ice surface, the reconstruction is undertaken using glaciologiaclly representative values for basal shear stress. Numerical reconstructions have been shown to produce glaciologically "realistic" ice surface geometries, allowing for more objective and robust comparative studies at local to regional scales.
User-friendly tools for the calculation of equilibrium profiles are presently available in the literature. Despite this, their use is not yet widespread, perhaps owing to the difficult and time consuming nature of acquiring the necessary inputs from contour maps or digital elevation models. Here we describe a tool for automatically reconstructing palaeo-glacier surface geometry using an equilibrium profile equation implemented in ArcGIS. The only necessary inputs for this tool are 1) a suitable digital elevation model and 2) mapped outlines of the former glacier terminus position (usually a frontal moraine system) and any relevant geomorphological constraints on ice surface elevation (e.g. lateral moraines, trimlines etc.). This provides a standardised method for glacier reconstruction that can be applied rapidly and systematically to large geomorphological datasets.