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An automated workflow for reconstructing 3D glacier thickness and volume

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There is a pressing need to constrain the volume and distributed ice thickness of both former and contemporary mountain glaciers. The availability of high resolution digital elevation models (DEMs), contemporary glacier outlines and former terminus positions has opened up the possibility of rapidly reconstructing former ice surfaces and estimating current bed topographies in a GIS environment. Whilst it has been proven that 'perfect plasticity' based models can be used to estimate ice thickness values along a central flow line in a 2D manner, there is potential to expand such models further by automating the entire process and interpolating full 3D surface/bed topographies.

This presentation firstly introduces the VOLTA (Volume and Topography Automation) model, which is a GIS based tool for estimating contemporary ice thickness distribution and volume. Novel algorithms for automatic centreline production and branch delineation are employed to automate the entire process, requiring just a DEM and glacier outline as inputs, running as a standard geoprocessing tool in ArcGIS. VOLTA is shown to perform well when tested on glaciers where the bed topography is known from field measurements and initial model results for the New Zealand Southern Alps are presented.

By removing the distributed ice thickness calculated by VOLTA from the contemporary DEM, an "ice-free" surface can be created. This is the initial input required for reconstructing former ice-surfaces using a perfect plasticity approach. An additional workflow is presented for automatically removing postglacial sediment infill, a step which is often overlooked but can improve the accuracy of reconstruction models. By applying these tools to the Southern Alps of New Zealand, preliminary reconstructions of the LGM will be discussed.