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Alpine-wide LIA glacier reconstruction and ELA patterns using glacier modelling

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The maximum extent of the glaciers in the European Alps during the Little Ice Age (LIA) is relatively well known. However, the ice surface geometry and related ice volume are still poorly constrained. We provide an Alpine-wide reconstruction of glacier thickness using the novel Instructed Glacier Model (IGM). The IGM uses the innovative approach based on deep-learning and GPU to accelerate the solving of computationally expensive 3D physics of glacier flow, which is key to work in high-resolution at the Alpine scale. The mass-balance model is tuned to fit each glacier of the Alps to its known maximum LIA extent resulting in ice-surface geometries and volumes that are consistent with glacier physics and the principles of mass conservation. In addition, our approach provides the corresponding equilibrium-line altitudes (ELAs) for individual glaciers and thereby reveals regional ELA patterns. Comparing these patterns with pre-industrial climate model data permits to analyse the relationship between ELA and climate factors such as temperature, precipitation, aspect, and solar radiation. In conclusion, our approach not only contributes to the estimates of LIA glacier shapes and geometries, but also permits to infer first-order relationships between glacier dynamics and climate conditions.