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Modelling last glacial cycle ice dynamics in the Alps

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The European Alps, cradle of pioneer glacial studies, are one of the regions where geological markers of past glaciations are most abundant and well-studied. Such conditions make the region ideal for testing numerical glacier models based on approximated ice flow physics against field-based reconstructions, and vice-versa.

Here, we use the Parallel Ice Sheet Model (PISM) to model the entire last glacial cycle (120–0 ka) in the Alps, with a horizontal resolution of 1 km. Climate forcing is derived using present-day climate data from WorldClim and the ERA-Interim reanalysis, and time-dependent temperature offsets from multiple paleo-climate proxies, among which only the EPICA ice core record yields glacial extent during marine oxygen isotope stages 4 (69–62 ka) and 2 (34–18 ka) in agreement to geological reconstructions.

Despite the low variability of this Antarctic-based climate forcing, our simulation depicts a highly dynamic ice cap, showing that alpine glaciers may have advanced many times over the foreland during the last glacial cycle. Cumulative basal sliding, a proxy for glacial erosion, is modelled to be highest in the deep valleys of the western Alps. Finally, the Last Glacial Maximum advance, often considered synchronous, is here modelled as a time-transgressive event, with some glacier lobes reaching their maximum as early as 27 ka, and some as late as 21 ka. Modelled ice thickness is about 900 m higher than observed trimline elevations, yet our simulation predicts little erosion at high elevation due to cold ice conditions.