Impact of spatial resolution on large-scale ice cover modeling of mountainous regions

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For reconstructing paleoclimate or studying glacial isostatic effects on the Earth's lithosphere, increasingly more studies focus on modeling the large-scale ice cover in mountainous regions over long time scales. However, balancing model complexity and the spatial extent with computational costs is challenging. Previous studies of large-scale ice cover simulation in mountain areas such as the European Alps, New Zealand, and the Tibetan Plateau, typically used 1-2 km spatial resolution. However, mountains are characterized by high peaks and steep slopes - topographic features that are crucial for glacier mass balance and dynamics, but poorly resolved in coarse resolution topography.

The *Instructed Glacier Model* (IGM) is a novel 3D ice model equipped with a physics-informed neural network to simulate ice flow. This results in a significant acceleration of run times, and thereby opening the possibility of higher spatial resolution runs. We use IGM to model the glaciation of the European Alps with different resolutions (2 km and 200 m) over a time period of 160,000 years. We apply a linear cooling rate to present-day climate until 6 °C colder to mimic ice age conditions.

Preliminary results indicate systematic, resolution-related differences: At the beginning of cooling the 2 km resolution yields slightly more ice volume. However, this trend reverses when ice flows together from high elevations and fill large valleys with thick ice. When the Alps are fully ice covered, we find up to 14% more ice volume in the higher resolution models which, however, is not uniformly distributed in space.