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Towards coupled ice flow - surface mass balance modelling of all glaciers in the European Alps

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The retreat of glaciers in the European Alps has severe implications related to the availability of water resources, natural hazards and the human perception of mountains as a recreational environment. To date, studies on the future evolution of glaciers rely on parameterizations, in which ice dynamics are not explicitly accounted for. A few coupled ice flow – surface mass balance studies have been realized, but these focus on individual glaciers and cannot be used to predict the evolution of all glaciers in the European Alps.

Here, we attempt to model the time evolution of all glaciers in the European Alps, accounting for both surface mass balance and ice dynamics. For this we use the Global Glacier Evolution Model (GloGEM) and include an ice flow component. Glacier outlines from the Randolph Glacier Inventory are utilized, while a physically based approach is used to reconstruct the ice thickness. For model validation and calibration, we rely on a vast dataset, consisting among others of surface mass balance measurements (including field measurements and geodetic mass balances), glacier length changes and surface velocity measurements.

The climatic data for the validation and the historical period is drawn from simulations from the Euro-Cordex ensemble (ca. 11 km resolution). For future climatic conditions, Euro-Cordex simulations under different Representative Concentration Pathways (RCPs) are considered. In our analysis, we pay particular attention to the committed ice loss (i.e. the ice loss that would occur if the climate would stabilize at present) and analyse the role that the current climate-geometry imbalance and ice dynamics have on the future evolution of the glaciers. We also show that under an intermediate to extreme warming (RCP4.5 and more), the European Alps will be largely ice-free by the end of the 21st century.