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Modelling the dynamics and future evolution of Alpine glaciers under the EURO-CORDEX RCM ensemble

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Glaciers in the European Alps play an important role for the runoff regime of mountainous drainage catchments, act as a source for hydroelectricity and have a large touristic importance. To date, studies on the future evolution of these ice masses typically rely on parameterizations, in which ice dynamics are not explicitly accounted for. So far, only few studies have explicitly coupled ice flow and surface mass balance processes, and these have focused on individual glaciers, rather than on the regional scale.

Here, we model the future evolution of glaciers in the European Alps with GloGEMflow, an extended version of the Global Glacier Evolution Model (GloGEM), accounting for both surface mass balance and ice flow. Glaciers are identified through the outlines from the Randolph Glacier Inventory, and an inversion approach is utilized to estimate the initial glacier thickness. For model calibration and evaluation, we rely on an extensive dataset, including amongst others in-situ and geodetic mass balance measurements, glacier length changes, and surface velocity measurements. This allows for a novel, glacier-specific initiliaztion and calibration procedure. The climatic data for the historical period is drawn from the ENSEMBLES daily gridded observational dataset (E-OBS), while for future climatic conditions we rely on EURO-CORDEX Regional Climate Model simulations.

The evolution of the total glacier volume in the coming decades is relatively similar under various representative concentrations pathways (RCPs), and about half of the present-day (2017) ice volume is lost by 2050. We find that under RCP2.6, the ice loss in the second part of the 21st century is relatively limited and that about one-third of the present-day ice volume will still present in 2100. Under a strong warming scenario (RCP8.5) the future evolution of the glaciers is determined by a substantial increase in surface melt, and glaciers are projected to largely disappear by 2100 (>90% volume and area loss vs. 2017). For a given RCP, differences in future changes are mainly determined by the driving global climate model, rather than the RCM that is coupled to it, and these differences are larger than those linked to various model parameters. We find that including ice dynamics reduces the projected mass loss under a limited warming, and that this effect increases with the glacier elevation range. Our results suggest that including ice dynamics will be important for future global glacier evolution simulations.