Deriving the response of glaciers from an ice-dynamic model

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Glaciers respond to changing climatic conditions by adapting their geometry. This adaptation is slow and occurs over time scales ranging from years to decades, referred to as the 'glacier response time'. As a consequence of this slow response, most glaciers are too large for present-day climatic conditions and will lose a considerable part of their mass in the future, even for cases without additional warming ('the committed loss').

In the literature, various analyses of glacier response time have been performed based on theoretical considerations, by utilising observed glacier changes, and by relying on numerical model simulations of idealized glacier geometries and individual glaciers. In this contribution, we aim at better characterising the response time of all glaciers in the European Alps through numerical modelling. For this, we use the regional glacier evolution model GloGEMflow, which is a recently developed coupled surface mass balance – ice flow model that was calibrated and extensively evaluated against ground-truth data and used to simulate the future evolution of glaciers in the European Alps (Figure 1).

With this regional setup, we examine the glacier characteristics (e.g. length, area, surface slope,…) that best describe the glacier response time by considering the e-folding time scales over which glacier characteristics evolve in numerical steady state simulations. We furthermore analyse the imbalance between the glacier geometry and the climatic conditions ('the climate-geometry imbalance'), and examine how this relationship has evolved over the past two decades. To characterise the evolution of the climate-geometry imbalance, we among others consider how the committed loss has recently evolved and determine which climatic forcing is needed for preserving certain glacier characteristics (e.g. its volume) at a given moment in time.

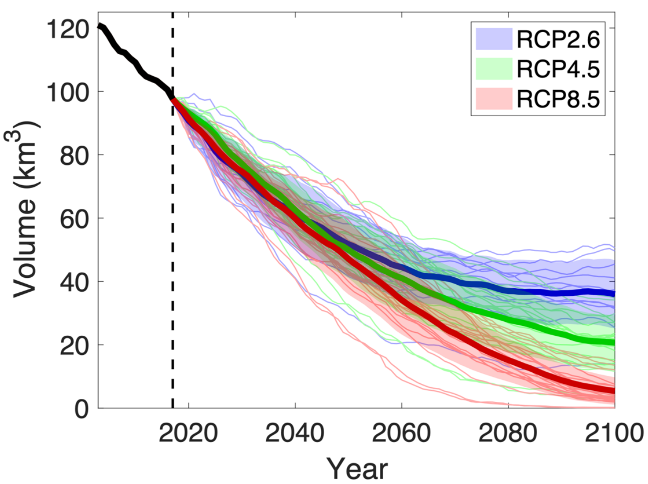

Figure 1. Evolution of total glacier volume in the European Alps between 2003 and 2100. Thin lines represent the evolution of the glacier evolution for a given future climate simulation from the EURO-CORDEX ensemble (51 are considered in total). The thick line is the mean from all simulations for a given RCP (representative concentration pathway), and the shaded area corresponds to the spread around this value. The dotted vertical line represents the year 2017. Figure modified from Zekollari et al. (2019).

References

Zekollari, H., Huss, M., & Farinotti, D. (2019). Modelling the future evolution of glaciers in the European Alps under the EURO-CORDEX RCM ensemble. *The Cryosphere*, *13*, 1125–1146. https://doi.org/10.5194/tc-13-1125-2019