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How much information do today‘s glaciers carry about their past?

Julia Eis (1), Fabien Maussion (2), Ben Marzeion (1,3)

(1) Institute of Geography, University of Bremen, Bremen, Germany (jeis@uni-bremen.de), (2) Department of Atmospheric and Cryospheric Sciences, Universität Innsbruck, Innsbruck, Austria (fabien.maussion@uibk.ac.at), (3) MARUM - Center for Marine Environmental Sciences, University of Bremen, Bremen,Germany (ben.marzeion@uni-bremen.de)

Reconstructing past glacier change is of interest for different applications, e.g. for quantifying their contribution to sea-level change. One approach is to use a glacier model, forced by reconstructions of climate, to estimate past glacier states. However, glaciers respond to climate variability and change with time lags between a few years and many centuries, and the backwards reconstruction is impeded by the non-linear interaction between glacier geometry and mass balance.

Here we present an approach based on applying the Open Global Glacier Model (OGGM, https://oggm.org/). First, we generate a large set of physically plausible glacier candidates for a given year in the past. We then evaluate each of them, by performing a forward model run towards the date of the observed glacier outline, and by comparing the result of the forward run to the observed outline. In most cases, the resulting reconstruction is non-unique, as multiple initial states converge towards the observed state in the year of observation. The range of possible past glacier states depends on characteristics like area, ice thickness distribution, and slope, but also on the year of initialization.

Our method thus not only allows to reconstruct glaciers, but also provides quantitative information on how well past glacier states are constrained through the combination of present-day outlines with past climate conditions. E.g., for most tested glaciers (all of them in the Alps), the state is only weakly constrained in 1850, but well constrained in 1930.