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Global and hemispheric temperature reconstruction from glacier length fluctuations

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Temperature reconstructions for recent centuries provide a historical context for the warming over the twentieth century. They are the essential basis of estimations of the natural variability in temperature before and during the onset of anthropogenic perturbation. For the period before meteorological measurements started, as well as for remote regions from which meteorological series are short or absent, documented glacier fluctuations can provide valuable information on climate change. We use glacier length fluctuations to reconstruct annual averaged surface temperatures of the past 400 years on European, hemispherical and global scales.

We have collected a set of 281 glacier length records starting before 1945. The majority of the available records is located at the mid-latitudes of the Northern Hemisphere, but we have also records in the tropics, the Arctic and at the mid-latitudes of the Southern Hemisphere. Temperatures are derived from glacier length changes using a linear response equation that has two parameters: the response time and the climate sensitivity of a glacier. The values of these parameters are estimated for each glacier by means of a simple model, that is calibrated on numerical model results.

Our reconstruction is a temperature proxy with decadal resolution that is completely independent of other temperature records. The global and hemispherical temperatures reconstructed from glacier length fluctuations are in good agreement with the instrumental record of the last century. This agreement validates our method. Furthermore our results agree with existing multi-proxy reconstructions of temperature in the pre-instrumental period. The temperature record obtained from glacier fluctuations provides an independent confirmation of the warming of the twentieth century, giving a global cumulative warming of 0.93 ± 0.46 K over the period 1830 - 2000 and a cumulative warming of 0.91 ± 0.79 K over the period 1600 - 2000.