



## Response time of glacial erosion

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There has been great progress in the understanding of the evolution of Quaternary climate. At the same time, there have been improvements in the understanding of glacial erosion processes, with better parameter constraints. Despite this, there remains much debate about whether or not the observed cooling over the Quaternary has driven an increase in glacial erosion. All agree that the erosional response to climate change must be transient, therefore the timescale of the climatic change and the response time of glacial erosion must be accounted for. Here we develop an analytical solution to the equations governing glacial erosion in a steadily uplifting landscape with variable climatic forcing, from which we derived expressions for two fundamental response timescales. The first time scale describes the response of the glacier and the second one the glacial erosion response. We also used a numerical model to validate the approximations made to derive the analytical solutions. The solutions show that short period forcing is dampened by the ice response time, and long period forcing is dampened by erosional response of glaciers. We expect to see the strongest response of glacial erosion to periodic climatic forcing corresponding to Plio-Pleistocene climatic cycles. We use this to predict the response of glacial systems to the observed climatic forcing of the Quaternary, including, but not limited to, the Milankovich periods and the long-term secular cooling trend. Using the solution, we predict erosion histories and estimate under what conditions the erosional response of glaciers to long-term climatic change could potentially be observed.