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What can mountain glaciers tell us about climate change? Quantifying past and future discharge variations in the Southern Alps and Himalaya (Penck Lecture)

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Glaciers in the tropical and middle latitudes respond rapidly to climate change. Variations in glacier area and ice flux recorded by Quaternary sediments are useful palaeoclimate indicators. We can constrain the timing and extent of past glacier fluctuations using geochronological techniques such as terrestrial cosmogenic nuclide and optically stimulated luminescence dating. Combining these results with numerical modelling allows us to use the geomorphological record of individual glaciers to discover the mechanisms of the global climate system. For example, the recession of the Rakaia Glacier in the Southern Alps of New Zealand from the Last Glacial Maximum occurred during Heinrich Event I in the North Atlantic, suggesting asynchrony in the timing of glaciation between the hemispheres. The proglacial sedimentary record in this catchment indicates a period of unstable climate with at least two glacial maxima over 10,000 years.

The response of mountain glaciers to climate change is modified by catchment and glacier characteristics and does not necessarily follow temperature in a straightforward manner. Mountain glaciers are often covered with rock debris that can either reduce or increase ablation depending on debris thickness, and model applications require capturing the interaction of rock debris with flowing ice in high relief terrain. Uncertainties in these glacier model applications are mainly due the representation of mass balance processes, and field data for validation are often scarce. Despite these challenges, by quantifying the sensitivities of mountain glaciers to climate change on a range of timescales we are able to make predictions about the future for ranges such as the Himalaya. This lecture will explore what glaciers can tell us about the mechanisms of Quaternary climate change and the implications for catchment geomorphology and hydrology at timescales ranging from glacial (tens of thousands of years) to anthropogenic (tens of years).