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Physically-calibrated, 3D numerically modelled response of a temperate valley glacier to predicted climate change

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Changes to Tsanfleuron Glacier over the next 100 years are modelled with a 3D, first-order ice flow model that uses existing empirical data on ice geometry and surface mass balance, and empirically optimized data on basal sliding distribution and ice rheology. The model is driven by IPCC-based estimates of future climate change. The broad aims of the experiment are to determine (a) what is a likely scenario for the future retreat of the glacier; and (b) which of the model parameters are the most important. Ice rheology calibration is based on an optimization scheme that matches modelled internal strain rates to those measured at the glacier by repeat borehole inclinometry. A two-layer ice rheology is used, in which an enhancement factor is introduced to represent the relatively 'lower zone' basal ice layer. In this representation the rate factor has one value for the basal 10 m and a different value for the overlying ice. The best-fit flow law parameters are again determined on the basis of an empirical optimization scheme. The basal sliding field is calculated using a linear sliding law where the sliding coefficient is determined for each basal grid node using the sliding and basal shear stress results from the optimization scheme.

The model is driven with three likely IPCC climate change scenarios, each under three realistic physical parameter settings, resulting in nine separate model runs. Of these, seven result in the complete disappearance of the glacier in under 70 years, with its maximum longevity being 100 years. The single 'most likely' scenario outcome is the

completed disappearance of the glacier in $\sim$65 years. Sensitivity tests reveal the most important variables are, in order of importance, mass-balance gradient, ELA change, sliding coefficient, and ice deformation rate factor.