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Exploring uncertainty in glacier mass balance modelling with Monte Carlo simulation

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Glacier mass balance models range widely in complexity from simple temperature index parameterisations to complex physically-based energy and mass balance models. Most models are both tuned and validated using limited data collected at a specific site, with varying degrees of parameterisation impacting on the applicabilty of models in new regions.

In this study we wish to explore both the typical uncertainties, and their sources, in model results from three approaches to glacier mass balance modelling of differing levels of complexity: (1) a temperature-index model; (2) a simple mass balance model, representing enhanced temperature index models or very simple energy balance models and (3) an energy balance model of intermediate complexity.

Our approach to representing uncertainty is firstly to characterise the uncertainty in input meteorological parameters at a point, before assessing the spatially autocorrelated uncertainty resulting from the interpolation of point measurements over a glacier surface. Having characterised the uncertainty in model inputs, we then apply Monte-Carlo simulations to explore the uncertainty and sensitivity of differing approaches to the modelled uncertainty in input parameters.

Initial analysis suggests that simpler approaches (1 & 2) are very sensitive to errors in temperature interpolation (i.e. through the lapse rate) while uncertainty for the more complex model (3) is controlled by the combination of a larger set of variables, with individual parameters having a correspondingly lower influence.