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Exploring uncertainty in glacier mass balance modelling with Monte Carlo simulation

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In this study we wish to explore both the typical uncertainties, and their sources, in modelled glacier mass balance. By means of Monte Carlo simulations we calculated uncertainty in modelled cumulative mass balance over 400 days at one particular point on the tongue of Morteratsch Glacier, Switzerland, using a glacier energy balance model of intermediate complexity. Before uncertainty assessment, the model was tuned to observed mass balance for the investigated time period and its robustness was tested by comparing observed and modelled mass balance over 11 years, yielding very small deviations. Both systematic and random uncertainties are assigned to twelve input parameters and their respective values estimated from the literature or from available meteorological data sets. The calculated overall uncertainty in the model output is dominated by systematic errors and amounts to 0.7 m w.e. or approximately 10% of total melt over the investigated time span. In order to provide a first order estimate on variability in uncertainty depending on the quality of input data, we conducted a further experiment, calculating overall uncertainty for different levels of uncertainty in measured global radiation and air temperature. Our results show that the output of a well calibrated model is subject to considerable uncertainties, in particular when applied for extrapolation in time and space where systematic errors are likely to be an important issue.