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Regional modelling of Svalbard glacier mass balance

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Spatially distributed mass balance models are valuable tools for exploring the detailed spatial and temporal responses of mountain glaciers to climate forcing. The last two decades have seen their application become increasingly widespread, partly due to the increased availability of computational resources, and partly because scientists have a natural tendency to adopt realistic descriptions of real-world processes. However, up to now, spatially distributed models have mainly been applied to individual "benchmark" glaciers that are easily accessible and have a wealth of observational data available. Meanwhile, the full potential for large-area distributed applications has remained notably under-exploited. As a result, very little is currently known about the intricacies of glacier-climate interactions over entire mountain ranges. This work aims to address this gap in the literature by developing, calibrating and validating a high resolution (200 m) spatially distributed surface mass balance model for Northwest Spitsbergen, Svalbard. In order to achieve this aim, two key advances have been required. First, the application of mass balance models to large regions has previously been inhibited by the inadequate spatial coverage of in situ meteorological observations. In order to overcome this problem, the spatially distributed surface mass balance model will be forced using the European Center for Medium Range Weather Forecasts ERA-40 reanalysis (1958–2002). The ERA-40 data are validated against in situ meteorological records from Northwest Spitsbergen and corrected for systematic bias using a quantile-mapping technique. Second, while considerable progress has been made in the development of increasingly sophisticated glacier mass balance models, very little attention has been given to their predictive uncertainty. The present study will address this limitation through the novel application of a calibration technique previously not employed in glacial modelling – multi-objective optimisation – designed to identify multiple optimal parameter sets that fit different characteristics of the real-world observations, thereby enabling an assessment of the uncertainty associated with predictions. The modelling approach is validated against geodetic mass balance measurements. Overall, the modelled and observed mass balances agree surprisingly well, indicating that high-resolution regional modelling in mountain regions can provide a valuable tool for investigating glacier-climate interactions.