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Glacier surface melt modelling: inter-comparison of two energy-balance and two temperature-index approaches and their sensitivity to the input data quality

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Modelling distributed glacier mass balance requires input data to be extrapolated from a few measurement points. In this study, two different energy-balance (EB) and two enhanced temperature-index (TI) approaches were compared with respect to their robustness to quality variations in the input data. Meteorological data collected on Haut Glacier d'Arolla, Switzerland, during the 2001 ablation season and from other stations in the area were used. Applying different extrapolation schemes to these data, we obtain a set of input data to run the four modelling approaches at the point-scale. The first EB approach computes surface melt, assuming that the glacier surface is at 0 degree throughout the ablation season, whereas the second one includes computation of the heat exchange in the snowpack. In the first TI type of approach, the shortwave radiation flux is included in the melt computation, although the model requires only temperature and precipitation as measured inputs. It separates temperature-dependent and temperature-independent components in the equation of melt and uses a threshold temperature for melt onset. The second type of TI approach is closer to an EB one in that, besides separation of temperature-dependent and temperature-independent terms, it uses the total surface heat flux to determine whether melt onsets, and is therefore less empirical. The model results are compared among each other and validated with ablation stake readings and measurements of an ultrasonic gauge. First, we study which model is most robust to variations in the input data, and second, which are the magnitudes of the differences between the four modelling approaches and the individual runs.