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The impact of temperature distributions and snowmelt rates on runoff production; a case study in the Swiss Alps

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Hydrologic prediction in Alpine areas crucially depends on the simulation of snow melt processes. For most operational models, a detailed energy-balance for melt computation is not feasible and the complex melt processes are simulated with a simplified degree-day factor (DDF) method approach, often including some melt factor correction to account for slope and aspect. Although, the DDF method is known to work sufficiently well for many applications, the question remains open whether a more or less heuristic approach accounting for radiation effects in a degree-day method necessarily yields an improved description of the natural variability of melt processes or if it simply compensates for the unknown spatial distribution of temperature.

To test this question, this work analyzes temperature distributions and snowmelt rates in a Swiss alpine catchment to determine their impacts on runoff. Using high resolution Sensorscope station data (sensorscope.epfl.ch) from two transects located between 1780 and 2430 m.a.s.l, three case studies were compared. The first study uses all the field station data available. The second and third studies consider the southwest and southeast facing transect stations separately to demonstrate the effect of lapse and melt rates described by different aspects. Melt rates were described by a rescaled degree-day factor (DDF) method and an extended Hock method; the former method is based on temperature data which has been rescaled to correspond with measured radiation data. The latter method is based on melt rates determined by distributed temperature, aspect, elevation and slope data with a correction factor incorporating the potential and measured radiation. Application of the calculated melt and temperature fields in a distributed hydrological model is proven here to be critical in determining the performances of each melt method.