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Quantifying the role of aspect on probability distributions of snow-dominated streamflow

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We recently proposed a novel analytical characterization of streamflow probability distribution functions (pdfs) in catchments characterized by pronounced, snow-dominated winter low flow. The key concept of the stochastic framework to link precipitation and streamflow dynamics is the temporary disconnection of catchment areas that experience freezing conditions, where these "non-responsive" areas are identified based on their elevation.

The close relationship between solar radiation and the rate of snowmelt makes the exposure, however, a major factor in the characterization of discharge in snow-dominated catchments. We therefore propose to develop an updated analytical characterization of the winter streamflow pdfs considering the impact of aspect on snowmelt and, indirectly, on identifying the catchment areas with a permanent seasonal snow cover.

As a firs step, the present work analyzes the role of aspect and slope on the extension of the non-responsive area through a series of virtual experiments including plane rotations of the reference digital terrain model (DTM). The case study is the Dischma catchment located in the South-East of Switzerland near Davos, with a size of 43.3 km^2 and a mean elevation of 2370 m asl. The choice of this catchment is based on its morphology, simple and unidirectional, with two specular slopes separated by the main draining channel which extends along the main direction SE - NW. A spatially-explicit hydrologic response model was developed and calibrated to reproduce observed streamflow for the period 1989 - 1997.

This model accounts for the effect of aspect and slope on snowmelt through a distributed temperature-index snowmelt model including potential direct solar radiation. The simulation with this model for the calibration period represents the reference simulation against which to compare the streamflow obtained with rotated versions of the DTM. The analysis of the reference and the virtual streamflow time series is then used to characterize the extension of the non-responsive area as a function of elevation and aspect.

The overall framework under development allows to link the probabilistic structure of the low flow component of snow-dominated discharge with simple macroscopic parameters, with implications for water management and ecological functions in ungauged basins.