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Gauging the contributing catchment area from streamflow.

The hydrologic response of a catchment results from the interplay of the spatial distribution of contributing areas and the characteristics of the possible flow paths to the outlet. While the flow paths can often be described based on geomorphological catchment characteristics, the description of the temporal dynamics of source area activation is generally hampered by the difficulty to observe spatial precipitation inputs, especially in complex terrain. These temporal dynamics might, however, be extracted from the spatially integrated hydrologic response, i.e. from observed discharge.

We propose a new step in this direction for snow-dominated catchments with a pronounced winter low flow, for which we have developed an analytical characterization of the streamflow probability distribution functions. We extended the analytical model of Botter et al. (2007) by incorporating the temporary disconnection of high elevation areas that experience freezing conditions over the entire winter season, and the delaying effect on streamflows produced by the temporary accumulation of snow at lower elevations. The developed analytical model has four parameters than can be directly estimated from observed precipitation, temperature and discharge, and one parameter obtained from solving an inverse-problem, which reflects the size of the hydrologically responsive area during winter.

The proposed analytic model thus represents a means to extract information about the streamflow contributing area directly from observed discharge. We tested the developed approach with contrasting hydrologic data from 14 catchments located in the Swiss and the Italian Alps. The proposed analytic model reproduces the observed streamflow pdfs very well and, in addition, the contributing area parameter shows a remarkable regional relationship with catchment attributes.

Accordingly, our approach marks not only a progress for the statistical characterization (from first principles) of winter streamflow variability for mountainous environments, but also opens new perspectives for the inference of hydrologic dynamics from observed discharge in snow-dominated catchments.