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Quantification of snowmelt processes in a high Alpine catchment from hydrographs, satellite images and stable water isotopes

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In Switzerland, water from Alpine catchments provides a large proportion of available water resources. However, large uncertainties regarding changes in glacier volume and snow accumulation can have significant impacts on hydrologic, biologic, physical and economic processes. Accurately quantifying, modeling, and predicting these water resources is therefore an on-going challenge. Given the well-known difficulty observing solid precipitation (snowfall), it can be assumed that most of the uncertainty in water balance estimates for snow-dominated environments is due to: 1) Poor measurement of winter precipitation, 2) Poor estimation of timing and amount of snow melt, and 3) Lack of knowledge about groundwater recharge processes. It is noteworthy that the timing and amount of snowmelt plays a crucial role even for annual water balance estimates since it might significantly influence melt runoff flow paths and thereby groundwater recharge.

Despite the relatively high number of automatic weather stations spread across Switzerland, high altitudes are strongly underrepresented and many valleys remain poorly observed. Furthermore, onsite snow accumulation and melt observations are crucially lacking at many places.
In this context, we propose a new framework to investigate what information about snow melting processes can be extracted directly from observed hydrographs, their shape and amplitude, coupled with snow cover information from high resolution satellite images. A key question to answer is hereby whether the additional use of natural discharge tracers, such as water stable isotopes, can further constrain our knowledge about snow processes at the catchment scale, or whether such relatively sophisticated data sets do not contain significantly more information than discharge observations alone.

Detailed hydrologic observations in the experimental Vallon de Nant catchment in the Vaud Alps of Switzerland, started in 2016 and now span two years and include high resolution water stable isotopes (δO18 and δD) and continuous monitoring of climatic and hydrologic parameters. The Vallon de Nant (14 km2, 1200 to 3051 m asl.) is a narrow valley that accumulates large amounts of snow during winter and subsequent spring and summer discharge is mainly supplied by snowmelt, with additional inputs from a small glacier and rainfall. Measurements and sampling in such an environment is challenging and has rarely been done at such a high temporal resolution for a full annual cycle.