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A methodological comparison of catchment storages in mountainous catchments

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One of the most important functions of catchments is the temporary storage of water, which directly influences runoff dynamics, rainfall-runoff transformation, partitioning of evaporation and runoff fluxes, and accessibility of water to plants. Generally, a large catchment storage is considered beneficial and in particular increases the transit times and hence the buffer functioning related to water quality. Many different methods have been developed to assess catchment storage, however, there are hardly any direct comparisons of several of these methods. One challenge is the definition of water storage, while some methods allow estimation of the entire water storage in a catchment, other methods quantify only the dynamic storage. In addition, most studies focused more on lowland catchments with rain-dominated runoff regimes and observed groundwater fluctuations. Furthermore, these studies often focus on one or two catchments, but do not consider the influence of different climates on the relevance of water storage in the catchment.

We applied a range of different methods to assess catchment storage characteristics in 18 catchments in the Swiss Alps, ranging from 500 to 2000m of mean elevation and hence from rainfall- to snowmelt dominated runoff regimes. The first method use only discharge information during recession periods and with varying approaches to extract discharge and storage changes between high flow and low flow, the dynamic catchment storage can be derived. In the next methods the conceptual hydrological model HBV is calibrated to the runoff dynamics and the dynamic and total catchment storages of the different compartments are being evaluated. The last methods are based on stable water isotope data analysis. We use the model TRANSEP to derive the dynamic storage as well as the total water storage of the catchment based on the transit times using several years of fortnightly isotope data in streamflow.

The results show that the derived catchment storage characteristics are strongly dependent on the chosen method. However, the overall ranking of the catchments among the methods is quite similar, despite the derived catchment storage of one catchment may differ by one to two orders of magnitude. Surprisingly, the high elevation catchments generally show a much larger storage than most of the low elevation catchments. To investigate this surprising result further, we analyzed the effect of climate on the derived catchment storage in more detail, since an additional snow storage with the resulting melt period in spring may produce an large dynamic storage due to the concentrated input of water. We both used subsamples of discharge to divide the storage in snow or rain triggered storage and changed the climate input either to a rainfall or snowmelt dominated climate and compared the storage among the catchments based on a similar climate signal. We finally develop a framework for assessing and comparing catchment storages among catchments in different climates, geologies and with different physiographic characteristics. These analyses also provided more insights into the larger storage in mountainous catchments and its importance to catchments functions.