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Estimating groundwater recharge from summer and winter precipitation in Switzerland – a combination of hydrological recession analysis and stable water isotopes

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From a water storage perspective, snowfall-dominated catchments are particularly challenging since incoming precipitation is stored over long time periods on ground before entering the subsurface. In a warming climate, more precipitation is expected to fall as liquid rain versus solid snow. Given that snow is often more efficient at recharging groundwater than rain, especially in temperate regions, a change in the amount of snowfall can translate to changes in the seasonality of groundwater recharge, which in turn can lead to significant impacts on water resources availability. In this work, we propose to quantify the role of snow for groundwater recharge based on a discharge recession analysis and stable water isotopes. In fact, as stable isotopes of water show significant seasonality in precipitation, they can be used to estimate the proportion of groundwater recharge from rain versus snow on seasonal to annual basis. Combining these relative snow recharge estimates with an estimate of actual groundwater recharge amounts obtained from discharge recession analysis, can lead to long term groundwater recharge estimates. We use isotopic data collected at 50 groundwater monitoring stations spread across Switzerland along with precipitation isotopic data collected at 19 gauging stations to estimate the seasonality in groundwater recharge across Switzerland. We then combine these estimates with recharge amount estimates obtained for all unperturbed Swiss rivers with long term discharge monitoring to estimate the amount of groundwater recharge from snow across Switzerland. This regional analysis sheds a new light on the information that can be extracted from existing datasets on the role of water storage in snow and groundwater for the water resources of an Alpine country. Given the wide range of hydro-climatic regimes present in the study region, the obtained results also allow insights into potential climate change effects.