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Impact of a retreating glacier on a karst aquifer system, Tsanfleuron - Swiss Alps

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The study area is a partly glacierised karst system in the Swiss Alps ranging in altitude between 1500 and 3000 m. Above 2700 m the aquifer is directly overlain by the Tsanfleuron glacier 5.4 km2 large. A karst spring at 1500 m, which is also used for drinking water supply, is the main drainage point of the aquifer. The glacier is rapidly retreating and has lost 47 % of its surface between 1850 (end of Little Ice Age) and 1973. The glacier retreated 75 m between 2001 and 2003, and is expected to lose another 50 % of its surface in the next 15 years. Mainly during dry summer periods, the glacier is the main source of aquifer recharge. Diffuse infiltration of rain and snowmelt water into the karstified limestone (autogenic recharge) and sinking stream from adjacent non-karst areas (allogenic recharge) also contribute to the water balance.

Three types of groundwater recharge from the glacier were identified: diffuse infiltration of meltwater below the ice (inaccessible), infiltration of the main glacier stream into a swallow hole, and infiltration of numerous small meltwater streams near the glacier front. The connections between all relevant recharge points and the spring were proven by several multi-tracer tests.

In order to better quantify the contribution and temporal variability of the different recharge types and to set up an approximate water balance, a detailed hydrogeological map was prepared, and a comprehensive monitoring program was established. Discharge, water temperature, electrical conductivity, pH, turbidity and the chemical water composition were measured at the main karst spring; several sinking streams were also monitored. During dry periods, all parameters show regular diurnal variations. The time lag between the variations of the meltwater infiltration and the spring

discharge is only 5 to 7 hours (pressure pulse), while the transfer of tracers and suspended particles typically takes 7 to 12 hours. A hydrograph separation, based on simplified mixing calculations, made it possible to resolve the variable contributions of the different water types to spring discharge. Finally, the consequences of glacier retreat on the aquifer system are discussed. A complete disappearance of the glacier would completely alter the hydrological regime but would probably not lead to a general drinking water shortage.