Sediment Quantification and Ground Water Storage in an Alpine Permafrost Catchment

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Changing permafrost may have significant consequences on the hydrological regime of an alpine catchment. For an area abundant in unconsolidated sediments model parameters such as the spatial distribution of the effective storage volume, the permafrost distribution and the hydraulic conductivity are essential. In this work the first steps such as the quantification of the effective storage volume, the detection of permafrost, and the estimation of ground water storage are presented.

The study area (Krummgampen Valley, Ötztal Alps, Austria) is located at altitudes between 2400 and 3300 m.a.s.l and covers an area of 5.5 km². The mean annual precipitation is ~1500 mm and the mean annual air temperature at a nearby meteorological station (2500 m.a.s.l) is ~ -0.7 °C. Active rock glaciers, fissure ice in bedrock and patterned ground indicate the presence of extensive alpine permafrost. Predominant subsurface classes are talus slopes (17%), pre-LIA lodgement and meltout till (18%), LIA lodgement and meltout till (27%), rock glacier (5%), and bedrock (33%). Geophysical methods (seismic refraction, georadar) along numerous profiles are applied to estimate the sediment volume. Statistic correlations between the subsurface class's thickness and their geomorphometric surface characteristics were used to extrapolate for the entire valley. The permafrost distribution was assessed by seismic methods and evaluated by continuously recorded BTS-temperatures. Discharge data is available for 2008 and 2009 for the main catchment and for 2009 for three sub-catchments. Base flow recession analysis was applied to separate the ground water flow from surface and subsurface runoff.

Permafrost with active layer depths of up to ~ 3 m was detected above 2500 m.a.s.l (north facing). Estimated mean sediment thicknesses (disregarding the impermeable permafrost) are 8 m (talus slopes), 6 m (pre-LIA till), 5 m (LIA till), and 20 m (rock glacier). The flow data recorded by the hydrograph at the main outlet is characterized by processes such as snow melt, ground water flow, subsurface and surface run off with peak flows of up to 2000 l/s. The hydrologic data from 2009 show a recharge of ground water lasting from late April to early August. According to recession analysis the ground water system has a response time larger than 30 days. The ground water storage computed from recession analysis and the effective water storage estimated from the sediment volume by geophysical investigations show similar values. Finally we discuss how permafrost degradation could affect the hydrological regime.