EGU21-9461
https://doi.org/10.5194/egusphere-egu21-9461
EGU General Assembly 2021

Alpine stream characterization through the lens of hydrochemistry: a comparison study from two high-elevation catchments (Eastern Italian Alps)

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High-elevation catchments are rapidly changing as glaciers retreat and permafrost thawing intensifies. Consequently, alpine stream hydrochemistry is shifting but the interaction with complex hydrological and geological settings often confounds the effect of the climatic signal. To evaluate the effect of different glacier coverage and rock glacier presence, our study involves a multi-parameter approach of different tracers in two high-elevation catchments. Both catchments (Schnals and Martell; Eastern Italian Alps) share a comparable metamorphic geology but contrast in their glacier cover (4% and 22%, respectively) and abundance of active rock glaciers (numerous in the Schnals catchment).

Based on these different settings, we hypothesized that i) the glacier melt contribution at the daily and monthly scale in Martell is larger than in Schnals, ii) metamorphic catchments share similar hydrochemical patterns along the river network, and iii) rock glacier meltwaters affect more strongly the hydrochemistry of the main stream in Schnals than in Martell, given the higher abundance of active rock glaciers in the former catchment.

From June 2019 to October 2020, we carried out a monthly sampling of stream water along the main river, major tributaries, springs and a rock glacier. Snowmelt and ice melt (only at Martell) were occasionally sampled as well. Rain was collected on a monthly basis. Electrical conductivity of water samples was measured on-site while stable water isotopes and concentrations of major, minor, and trace elements were measured in the laboratory.

Our results indicate that the isotopic composition of streams and tributaries in Martell mainly originated from snowmelt and ice melt, with a minor contribution from groundwater. In contrast, the contribution of precipitation, shallow groundwater, and rock glaciers was larger in the Schnals catchment. The two catchments showed distinct hydrochemical patterns, based on their different elemental concentrations. Mostly during the glacier ablation period and autumn, alkali elements dominated Schnals hydrochemistry, whereas arsenic and strontium characterized the stream

hydrochemistry of Martell. Concentrations of metals and metalloids had a sharp increase during autumn, when thawing permafrost and the subglacial drainage was highest, thus affecting the hydrochemistry of the entire river network. As thawing permafrost increasingly influences the quality of freshwaters in deglaciating catchments, efforts must be dedicated to the long-term monitoring of alpine river networks, given the potential implications for human health and ecosystem quality.