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Integrated use of stable isotopes and electrical conductivity for the analysis of the water sources to runoff in a glacierized alpine catchment

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High elevation and glacierized catchments are complex hydrological systems where different and spatio-temporally variable water sources contribute to the hydrochemical signature of stream water. Understanding such a complexity is a first step toward a better conceptualization of catchment functioning that is critical for natural risk assessment and for effective water resources management.
In this work, we present stable water isotope and electrical conductivity (EC) data collected from different potential water sources over three years in the 62-km2 glacierized Saldur catchment (Eastern Italian Alps, 1600-3700 m a.s.l.). The study aims to experimentally identify end-members to stream runoff and describe their spatial and temporal dynamics, in order to obtain a first perception of the dominant runoff generation processes useful for future model-based runoff predictions.
In addition to continuous measurements of streamflow at two cross sections and of precipitation and temperature at two elevations, grab water samples from the Saldur stream at seven locations, from five tributaries and from four springs were collected roughly monthly during not rainy periods from April to October 2011, 2012 and 2013. Bulk precipitation was sampled at five locations along an altitudinal gradient and samples of snow, snowmelt (from lysimeters and melting snow patches) and glacier melt (from rivulets on the glacier surface and debris-covered ice) were taken occasionally during the summer. The isotopic composition of water samples was determined by laser spectroscopy and EC was measured in the field.

Streamflow showed a strong daily variability clearly dependent on air temperature, indicating the relevant influence of meltwater on runoff during the warmest months. The highest and isolated streamflow peaks were related to single intense rainfall events. Indeed, results from mixing analysis revealed that snowmelt and glacier melt were important end-members for stream runoff with a limited influence of rain water. Snowmelt and glacier melt had similar EC but a different isotopic composition that allowed distinguishing their different contribution to runoff over the season. On average, stream water EC in June, July and August was similar and was lower than in September and October. However, the stream isotopic composition increased gradually over the season, from very negative values in June, less negative and more variable values in July up to more positive and less variable values in October. This suggests that stream water was mainly dominated by snowmelt at the beginning of the melting season (roughly May-June), by a mixture of snowmelt and glacier melt during mid-summer (roughly July), and by glacier melt during the end of the summer (end of August-September). The same seasonal pattern observed in streamflow was also evident for the selected springs, with the highest EC and least negative isotopic values found during limited melting periods. Particularly, the application of a two-component mixing model showed that, overall, snowmelt contribution to groundwater recharge ranged between 59% and 74%.
These results underline the marked variability of hydrochemical composition of stream water and the complexity of hydrological processes in glacierized environments and confirm the usefulness of an integrated tracer approach to evaluate water sources dynamics in high-elevation catchments.

Keywords: isotopes, electrical conductivity, mixing model, snowmelt, glacier melt