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Water origin and flow pathways investigated by tracers in a small Dolomitic catchment

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Understanding runoff generation and water origin in mountain headwater catchments is often hampered by the superimposition of topographic, geomorphologic and hydrogeologic factors. Particularly, the complexity of catchments in Dolomitic regions is enhanced by karst processes that create preferential flow paths and make even more challenging to follow the water from its sources to the outlet. Environmental tracers, such as stable isotopes of water (18O and 2H) and electrical conductivity (EC), can help to unravel such a complexity. In this work, isotopic and EC measurements were used to i) identify the main end-members that contribute to streamflow, ii) quantify the role of snowmelt in spring water and surface runoff, and iii) assess the hydrological connection between runoff from springs and ephemeral water courses in rocky channels in the upper part, and surface and subsurface runoff in the lower part of a small Dolomitic catchment.

The experimental activities were carried out in the 1.9 km2 Vauz Creek catchment, Dolomites, Central-Eastern Italian Alps. The elevation range is 1835-3152 m a.s.l.. Dolomite rocks prevail in the upper part of the catchment (above 2200 m a.s.l.), which is mostly non-vegetated. The lower sector, where mudstone, sandstone and marls outcrop, is covered by Alpine grassland and sparse trees. We took water samples for isotopic analyses roughly monthly from 2010 to 2014 in the lower part and from June to October 2011-2013 in the upper part of the catchment. We sampled precipitation (by rainfall collectors), snow (by snow corers), snowmelt (by snow lysimeters or by dripping snow patches), soil water (by suction cups) and, manually, stream water, spring water and groundwater in piezometric wells at different locations. Isotopic analyses were conducted by laser spectroscopy. EC was measured in the field with a portable meter.

Results show a high variability in the tracer signature among the different sampled waters, reflecting the complex hydrogeological interactions in the catchment. End-member mixing analysis reveals that rainfall, snowmelt, shallow riparian groundwater and near-surface soil water are the main contributors to stream and channel runoff and to spring recharge. Particularly, snowmelts contributes on average for 51% (±26%) and 69% (±14%) to spring water and stream water, respectively, in the upper part of the catchment, and for 54% (±7%) and 51% (±3%) to spring water and stream water, respectively, in the lower part. We observe a decoupling in the isotopic and EC signal within the catchment. Springs and surface runoff in the upper part reflect a more direct influence of rainfall and snowmelt than springs and surface runoff in the lower part. High tracer variability, relatively low conductivity, no evaporation signal and consistency of isotopic regression lines with those of rainfall and snowmelt indicate that water infiltrating in the karst rock in the upper part of the catchment after the rainfall or snowmelt input drains rapidly at the base of the vertical Dolomitic walls, feeding intermittent runoff in rock channels. Conversely, relatively stable isotopic composition and EC in streams and springs in the lower part, and evaporation signal suggest slower subsurface flow and longer residence time.