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Origin of surface and subsurface waters in a periglacial catchment analysed by means of environmental tracers

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The hydrological response of high elevation catchments is strongly influenced by snowmelt processes. Moreover, in alpine periglacial environments, the presence of permafrost (generally discontinuous and frequently associated to landforms such as rock glaciers) makes even more difficult to identify the origin of surface and subsurface waters and the main contributors to stream runoff. Based on the use of isotopic (deuterium and 18-oxygen), electrical conductivity and water temperature data, this study aims to: i) identify which environmental tracer(s) could be used as indicator(s) of the possible influence of permafrost on groundwater and stream water; ii) investigate the role of snowmelt and rainfall on the seasonal runoff response in a periglacial catchment.

Field surveys were carried out during summer and early autumn of 2010 and 2011 in the Upper Val de La Mare basin (36 km2, Ortles-Cevedale massif, Eastern Italian Alps). In 2010, 54 springs were manually sampled during seven field campaigns in the entire area in order to capture the spatial variability of the tracer composition of groundwater. In 2011, the analyses focused more on the temporal variability of groundwater by sampling two springs (one of these flowing from a rock glacier) and a small stream during six field campaigns conducted in a 0.8 km2 subcatchment. Precipitation, air temperature and stream water stage were recorded continuously. Bulk precipitation was collected for isotopic analyses. The isotopic content of liquid samples was determined by laser absorption spectroscopy. Water temperature and electrical conductivity were measured in the field by a portable conductivity meter.

Results show that water temperature of springs emerging at the front of rock glaciers is statistically lower than water temperature of other springs, revealing the influence of permafrost on temperature, and possibly, origin of groundwater in these areas. This also suggests that water temperature can be used as an effective indicator of permafrost-related springs. On the contrary, electrical conductivity and the isotopic composition of spring water do not yield significant information about the origin from different water sources, likely due to the effect of other interacting processes (lithology for electrical conductivity, evaporation and mixing with other waters for the isotopic content). In the small subcatchment, the isotopic signal of stream water and of the rock glacier-fed spring is very similar whereas the spring which is not related to permafrost landforms is characterized by a different tracer signature. This suggests the development of preferential flowpaths and indicates the possible role of permafrost on the stream runoff response.
At the seasonal scale (from June to October), the stream discharge in the subcatchment tends to decrease. At the same time, stream water and groundwater become more conductive and enriched in heavy isotopes, reflecting the decreasing contribution of snowmelt. Once the snowmelt contribution drops, the runoff response appears to be mainly dependent on (even small) rainfall events that lead to a decrease of electrical conductivity and to a marked isotopic enrichment of stream water.

Keywords: tracers, rock glacier, permafrost, spring, snowmelt.