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# Thermal characteristics of springs fed by mountain permafrost in Val di Sole (Eastern Italian Alps)

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In alpine areas, spring-water temperature is affected by the presence of permafrost and by changes in the periglacial domain caused by the current atmospheric warming. Our interest in spring-water temperature is related to the possibility of investigating the spatial distribution of alpine permafrost and its changes. In particular, spring-water temperature might be helpful as indicator of permafrost occurrence in areas where it is discontinuous or sporadic, and in general where its distribution is poorly known.

The spring-water temperature in late summer is a useful evidence of permafrost, and various authors employed such method as auxiliary permafrost evidence, or as a stand-alone method that can be used for mapping permafrost distribution at the catchment scale. However, little is known on the spatial and temporal variability of water temperature at springs with different permafrost contribution and characteristics.

Here we present an analysis of the spatial and temporal variability of spring-water temperature in a 795 km$^2$ catchment located in the Eastern Italian Alps, aimed at investigating the spatial distribution of permafrost and its effect on spring-water temperature. From 2018 to 2021, we measured the late-summer spring-water temperature at 220 springs, 133 of which are located downslope of rock glaciers, 81 downslope of other deposits, and 8 in bedrock. In addition, we installed dataloggers for continuous temperature measurements at 31 springs.

Results show that the cold springs are mainly associated with intact rock glaciers but also with rock glaciers classified as relict, especially if they have blocky and sparsely vegetated surface. Accordingly, the latter should be reclassified as pseudo-relict, i.e. they appear to be visually relict but host patchy permafrost, as confirmed by geophysics carried out at selected case studies. These results have important implications for the study and modelling of the hydrological, hydrochemical and ecological response of periglacial environments under ongoing climate change.