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The role of snowmelt and glacier melt on runoff in a glacierized catchment: a multi-tracer experiment

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The release of water as snowmelt and ice melt in high elevation catchments has significant social and economic impacts for population living in mountain areas. This is even more critical under the current conditions of glacier retreat as a consequence of global warming. Therefore, it is important to understand the role of ice and snow meltwater on runoff dynamics and groundwater recharge in glacierized environments. This task can be effectively accomplished by integrating isotopic and other tracers that are widely recognized as useful tools for the identification of the main water sources contributing to streamflow.
In this work, we collected water samples from different sources in the Saldur catchment (Eastern Italian Alps). The catchment (area: 62 km^2, elevation range: 1600-3700 m a.s.l.) hosts a small glacier (2.8 km^2) in its upper portion. Samples of rainfall, snow, snowmelt, glacier melt, stream water (main stream and tributaries) and spring water have been manually collected between April-October 2011 and April-November 2012 approximately on a monthly basis. Furthermore, 24-hour samplings with hourly collection frequency were performed at two cross sections during five melt-runoff events. The composition in stable water isotopes was determined by laser spectroscopy and mass spectrometry. Electrical conductivity (EC) and water temperature were measured in the field. Additionally, deuterium excess (DE) was computed for all samples based on the relationship between deuterium and 18-oxygen. The isotopic composition of rainfall and snow shows marked altitudinal and seasonal variations. A strong positive correlation is also evident in the relationship between DE of spring waters and elevation. Rainfall and snow samples fall perfectly on the Global Meteoric Water Line, revealing a predominant Atlantic origin of air masses producing precipitation in the study area. EC and water temperature linearly increase with the distance from the glacier snout, suggesting a decreasing influence of snow and glacier melt water (cold and little conductive) and an increasing contribution of non-glacierized areas moving downstream. Stream water shows a strong daily variability in isotopic composition and EC correlated well with discharge and air temperature, suggesting the relevant contribution of meltwater on runoff. Moreover, a seasonal trend is also observable in stream water and groundwater, with the most isotopically enriched and highest EC values found at low flow conditions (no melting periods), in early spring and late autumn. In agreement with these observations, end-member mixing analysis shows that summer precipitation plays a minor role on runoff temporal variability compared to glacier melt and snowmelt. Two- and three-component hydrograph separation for the summer melt-runoff events confirms the significant contribution of melting-event water (up to 73% for the upper station) and the importance of snowmelt and glacier melt (up to 37% and 28%, respectively) as water sources for streamflow at the daily scale in the study catchment.
These results underline the critical role played by meltwater stored in glaciers and snow on water availability in mountain regions. Moreover, this works reveals the usefulness of a multi-tracer approach for the analysis of the main contributors to streamflow in glacierized catchments.

Keywords: water stable isotopes, deuterium excess, electrical conductivity, snowmelt, glacier melt.