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Analysis of catchment response to rainfall and snowmelt by means of isotopic, geochemical and hydrometric data

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In high-elevation environments, the analysis of both snowmelt-runoff and rainfall-runoff events is critical to understand the catchment hydrological behaviour. In this study we analyze the hydrological response of a small alpine watershed (Bridge Creek Catchment, 0.14 km^2, Italian Dolomites) by means of isotopic, geochemical and hydrometric data for two snowmelt-runoff events and six rainfall-runoff events occurred in April (warm, sunny days with high radiation energy) and mid-late summer 2010, respectively. The catchment is equipped with one rain gauge, one streamgauge, 27 piezometric wells provided with capacitance rods for shallow groundwater monitoring, and 15 soil moisture probes (not available in the snowmelt period) installed at different depths in the riparian, mid-slope and upslope zone. Grab water samples were manually collected at variable temporal resolution (ranging from 15 minutes during the hydrograph concentration limb to several hours during the recession limb) from the stream weir, five piezometric wells and two snow lysimeters. The delta value of deuterium and 18-oxygen was determined by means of a laser absorption spectroscope. Electrical conductivity of all water samples was measured in the field by a portable conductivity meter.
The application of the two-component hydrograph separation method for the isotopic tracers shows that the pre-event water is the dominant contributor to total runoff during both snowmelt and rainfall events.
During the hydrograph rising limb of the snowmelt-runoff events, the streamflow reflects the isotopic composition and the electrical conductivity of snow-derived water ("new water"). The peak discharge corresponds to the lowest value of electrical conductivity (highest solutes dilution) and to the most depleted value of isotopic content (due to the isotopically light melted snow) sampled in the stream, revealing the maximum fraction of event water to total runoff (up to 40%). During the hydrograph recession limb, the streamflow turns back to the pre-event isotopic and electrical conductivity conditions, reflecting the highest contribution of "old water".
The sequential sampling of precipitation during each summer rainstorm reveals the marked temporal variability of the rainfall isotopic composition (whereas the electrical conductivity maintains very low values for the entire event). The streamflow reflects the isotopic signal of the rainfall mainly at the beginning of the event. This process was related to the surface flow generated on the wet riparian areas. Groundwater mostly contributes to the total flow later in the event. A positive correlation is found between the catchment antecedent moisture conditions and the fraction of "old water": in dry conditions, the contribution of pre-event water is markedly lower than during wet events. This observation is consistent with previous studies carried out in the catchment that highlighted the role of the wet riparian zone as the most important area for runoff production in dry periods, whereas in wet conditions the pre-event water stored in the hillslopes likely becomes the most significant component of the total catchment runoff.

Key words: water isotopes, electrical conductivity, catchment response, snowmelt, rainfall, old water, riparian zone.