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Spatio-temporal dynamics of runoff sources in Andean Páramo catchments: An event-based approach analysis

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Páramos (Andean alpine grasslands) have an undisputed hydrological importance for drinking water supply, irrigation and hydropower in the Andes. Despite their relevance, these ecosystems remain among the least studied and described in the world. To improve our understanding of water source dynamics, we assessed the spatio-temporal variation of source-contributions to runoff from three rainfall-runoff events (5-240 min resolution) within six nested headwater catchments (total catchment size 7.53 km2) in the Ecuadorian Andes. Multi-tracer data sets of solutes, water stable isotopes and electrical conductivity were sampled during 2013 and 2014 from streams and twelve potential water sources. This information was used as input to an End Member Mixing Analysis (EMMA). A four component EMMA was found to be the most suitable to describe the hydrological system. Rainfall, spring water and water from two different soils types, Histosols and Andosols, were then used as End Members. Diagnostic statistics were computed to assess the consistency of the controlling four End Members across the five tributaries and their contribution calculated for each stream.
Results indicate that the set of controlling End Members was able to explain largely (except for one tributary) the hydrological behavior and contribution of runoff sources in the studied catchment. Source dynamics across the nested system revealed that Histosol and Andosol sources are the main contributors to runoff during rainfall-runoff events. Histosols increase their contribution when the catchment size increases, whilst the contribution of spring water decreases. The majority of events exhibited anticlockwise hysteresis and depicted the composition of spring and Histosols sources prior to rainfall-runoff events, Histosols in the rising limb, Andosols during peaks and Andosols-rainfall in the recession period.
This multi-tracer based study enhances our understanding of the hydrological functioning of the páramo. Results provide detailed insight to spatially distributed hydrological processes which will likely help to better understand the impact of land use and climate change on future water resources of these water towers of the Andes.