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Spatio-temporal dynamics of water sources at multiple spatial scales in tropical head catchments

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The importance of the Andean Páramos as water resource generators and ecosystem service providers has led numerous researchers in the recent decade to focus their efforts on understanding rainfall partitioning and runoff dynamics, identifying flow sources and flow paths at various spatial and temporal scales.
In this research, we identified dominant water sources, assessed their hydrological connectivity and water ages and analysed their spatio-temporal dynamics throughout the year and during rainfall runoff events.
We therefore collected spatial-distributed, high-resolution hydro-metric and hydro-chemical information from 2012 to 2014 within a tropical headwater catchment (7.53 km2) in the Ecuadorian Andes. A multi-tracer and multi-method approach were applied: End Member Mixing Analysis (EMMA), hydrograph separation, and Inverse Transit Time Proxies (ITTPs) for the inter-annual conceptualization of catchment functioning and analysis of hysteresis patterns and sources interactions during storms to conceptualize chronology of hydrological processes in event resolution.
Our results showed that water from the riparian zone represented the dominant contributing source to streamflow year-round and connectivity with hillslopes was particularly important during the wet season. The relative age of stream water decreased during wetter periods, when the contributing area of the riparian zone expands. The contribution of source to runoff in the individual sub-catchments varied among (e.g. Andosols $\sim$ 40% in tributaries and 25% in outlet) and within storm events (e.g. Histosols 15% higher in small peak discharge event), indicating a time-variable composition of streamflows. During rainfall-runoff events, different sources interaction evidenced a slower connectivity with hillslopes in the lower in relation with the upper sub-catchments. The analysis of hysteresis patterns presented bi-directionality of hysteresis loops (counterclockwise rotation in the lower catchments and clockwise hysteresis loops in the upper catchments). The foregoing may be related to lower slopes, wider riparian areas and higher proportion of Histosols in the lower compared to the upper catchments.
The work enabled to closely study the interchanging importance of flow processes and water source dynamics from an inter-annual and event-based perspective.