Hydrological Processes • Volume 36, Issue 10 • October 2022 • Article number e14725

Document type
Conference Paper

Source type
Journal

ISSN
08856087

DOI
10.1002/hyp.14725

Delineation of water flow paths in a tropical Andean headwater catchment with deep soils and permeable bedrock

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Abstract

Traditional hydrometric data combined with environmental tracers such as water stable isotopes contributes to improve the understanding of catchment hydrology. Nevertheless, the application of isotopic tracers in headwater catchments of the tropical Andes with deep soils and permeable parent material influenced by recent volcanism remains limited. In this study, the stable isotopic composition

of precipitation, soil water, wetlands, and streamflow was studied to provide insights into the hydrology of a small tropical Andean catchment with deep and permeable volcanic soils, ash layers, and fractured bedrock resulting from Holocene volcanic activity. Although local precipitation forms under isotopic equilibrium conditions, the stable isotopic composition of precipitation is influenced by atmospheric moisture recycling processes. The spatial and temporal variability of isotopic signals and the analysis of inverse transit time proxies (ITTPs) of surface (streamflow) and subsurface (soil and wetlands) waters indicate that vertical flow paths through the deep volcanic ash soils are dominant across the catchment. The strongly damped isotopic composition of these waters points to high soil and wetlands water storage, increasing the transit time or age of stream water in the hydrological system. These findings indicate that water mobilizing through subsurface flow paths–that is, volcanic soils, ash layers, and cracks in the fractured bedrock resulting from Holocene volcanism–is the main contributor to streamflow generation. Comparison with previously published work from Andean catchments and other volcanic areas shows the diversity of hydrological conditions that can be found as a result of pedological and lithological differences shaped by volcanic activity. Therefore, site-specific strategies may be needed to improve water resources management.

Author keywords

Andes; Antisana; Ecuador; flow path; runoff generation; stables isotopes; tropical mountains

Indexed keywords

SciVal Topics

Metrics

Funding details

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