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Hydroclimatic controls on non-stationary stream water ages in humid tropical catchments

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Streams in humid tropical countries provide a wide range of ecosystem services, yet a good understanding of their hydrological functioning is severely limited by lack of data. The transit time of water is a fundamental characteristic of catchment functioning and can often be related to water quality dynamics, thus providing potentially important information for water managers in these environments. In this study, we applied the widely used lumped convolution integral model in a moving window approach to acknowledge the time-variance of transit time distributions (TTD) and resulting moments such as the mean transit time (MTT). We show that for a two-year (2012-2014) rainfall-runoff stable isotope record from almost daily sampling in a humid tropical 30 km2 catchment in southern Costa Rica, the MTTs are generally short (< one year), but exhibit distinct inter and intra-annual patterns. The drier year (2012-13), which was under the influence of El-Niño causing less precipitation, exhibited MTTs up to one year. In contrast, the wetter year (2013-14) resulted in MTT estimates <100 days. Similar patterns were found at an intra-annual scale: the dry season MTTs were on average 185 days and only 15 days during the wet season. This can be explained by high rainfall volumes (> 3m/year) and events occurring throughout the year, the seasonality of rainfall and distinct moisture origin (Pacific, Atlantic and land surface), the likely dominance of quick near-surface flow paths and relatively low subsurface storage of the underlying volcanic and sedimentary rocks. The moisture origin of rainfall was found to be the most dominant driver of time-variable TTDs as indicated by the changing average wind directions following the transition from the dry into the wet season. This isotope study revealed a highly dynamic system that is likely to be sensitive to environmental change.