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Understanding key drivers controlling daily stable isotope variations in precipitation of Costa Rica, Central America

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Costa Rica is located on the Central American Isthmus, which receives direct moisture inputs from the Caribbean Sea and the Pacific Ocean. The relatively narrow, but high relief Central American land bridge is characterized by unique mountainous and lowland microclimates. However, only limited knowledge exists about the impact of relief and regional atmospheric circulation patterns on precipitation origin, transport, and isotopic composition in this tropical region. Therefore, the main scope of this study is to identify the key drivers controlling variations in meteoric waters of Costa Rica using stable isotopes based on daily sample collection for the year 2013. The monitoring sites comprise three strategic locations across Costa Rica: Heredia (Central Valley), Turrialba (Caribbean slope), and Caño Seco (South Pacific slope). Sporadic dry season rain is mostly related to isolated enriched events ranging from -5.8‰ d18O up to -0.9‰ d18O. By mid-May, the Intertropical Convergence Zone reaches Costa Rica resulting in a notable depletion in isotope ratios (up to $^{-1}8.5$‰ d18O). HYSPLIT back air mass trajectories indicate the strong influence on the origin and transport of precipitation of two main moisture transport mechanisms, the Caribbean Low Level Jet and the Colombian Low Level Jet as well as localized convection events. Multiple linear regression models constructed based on Random Forests of surface meteorological information and atmospheric sounding profiles suggest that Lifted Condensation Level and surface relative humidity are the main factors controlling isotopic variations. These findings diverge from the recognized 'amount effect' in monthly composite samples across the tropics. Understanding of stable isotope dynamics in tropical precipitation can be used to enhance catchment and groundwater modeling efforts in ungauged basins where scarcity of long-term monitoring data drastically limit current and future water resources management.