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Natural and anthropogenic drivers of mid- to late-Holocene hydroclimate and vegetation changes in eastern Amazonia: Insights from lacustrine biomarkers

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The isotopic and structural composition of plant wax biomarkers preserved in sedimentary archives can reveal details about past shifts in hydroclimate and ecology. Yet, previous studies of mid- to late-Holocene climate and forest cover in Amazonia have rarely incorporated these analyses in their reconstructions, despite the critical role that Amazonia plays in global carbon and hydrologic cycling. In addition, humans have been present in lowland Amazonia since the early-Holocene, and have impacted forest composition and structure via plant domestication and crop cultivation, facilitated by controlled burnings. Here, we present biomarker records of hydroclimate and vegetation shifts over the past ~5,600 years from Lago Caranã (2.84 S, 55.04 W, 5 m asl), Pará, Brazil. We compare the $\delta^{13}C$ and δD of leaf waxes to detailed fossil pollen and charcoal data analyzed from the same sediment core to disentangle hydroclimate and vegetation changes. Amazonian freshwater resources depend on precipitation from the South American Summer Monsoon (SASM) and the Intertropical Convergence Zone (ITCZ), and the SASM strongly influences modern precipitation δD (δD_{precip}). However, unlike several proxy records located elsewhere in the SASM domain, we observe no orbital-scale trend in reconstructed δD_{precip}. Instead, we observe pronounced multi-decadal to centennial-scale δD_{precip} variability after ~2,000 yr BP, potentially reflecting periodic expansions and contractions in the seasonal range of the Atlantic ITCZ. This suggests regional heterogeneities and distinct responses to orbital and external forcings across the SASM domain. Local vegetation changes do not have a consistent relationship with the multi-decadal to centennial-scale precipitation variability evident from the δD_{precip} record. However, $\delta^{13}C$ and *n*-alkane average chain length (ACL), together with fossil pollen and charcoal data, may to some extent reflect changes in land use, for example via the impacts of indigenous agroforestry practices on opening of the rainforest canopy. Our results provide new insights into the mechanisms modulating hydroclimate and vegetation changes in eastern Amazonia, and demonstrate the utility of adopting a multi-proxy approach for disentangling human- and climate-driven ecological changes.