Forest Canopy Gap Dynamics Vary Across a Climatic Gradient in the Brazilian Amazon

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The limited knowledge on tropical tree mortality - or gap dynamics - constrains our ability to accurately model earth system processes and predict future states of ecosystems under environmental and climate change scenarios. While site-based studies have analyzed local drivers of canopy gap dynamics in neotropical forests, regional-scale climate drivers remain to be explained. Here, to describe the variability of canopy gaps and explore its relationship with climate drivers, we used 20 transects of 15 x 0.6 km (180 km²) airborne LiDAR data acquired in 2016 across a precipitation gradient in the Brazilian Amazon. Gaps were delineated considering areas with less than 10 m height, and within the sizes of 1 m² and 0.5 ha. The gap size-frequency distribution was quantified by fitting a discrete power-law probability (Zeta distribution) to the data - described by the λ parameter (low λ indicate a higher frequency of large gaps, and vice-versa). To describe the climatic gradient, we used a time series (1998-2017) of the TRMM-3B43V7 and computed for each site the mean monthly rainfall (R) and two descriptors of seasonality: Feng index (S, varies from 0 to 0.2) and the dry season length (DSL, number of months with rainfall below 100 mm). A narrow range of λ was observed varying from 1.42 to 1.63 (mean gap sizes of 37 and 7 m², respectively). Our highest λ occurred at the north-west, an area with high R (284 mm) and almost no seasonality (S and DSL = ~0). By contrast, the lowest λ occurred at the south-east, an area with lower R (170 mm) and high seasonality (S = 0.12, DSL = 7 mo). The variability of λ was largely explained by seasonality by DSL (R^2 = 0.56) and S (R^2 = 0.48) with negative relationships, and also by R (R^2 = 0.55) with a positive relationship. While these relationships are not necessarily causal, rainfall mean and seasonality seem to play important roles for regional-scale gap dynamics. They are likely linked to forest structure variability and turnover. Regions with lower seasonality offer abundant resources and should be more prone to high growth, faster turnover and occurrence of smaller individuals (small gaps), while regions with higher seasonality might favor slow growth, slower turnover and occurrence of fewer but larger trees (large gaps). Future investigations should consider topographic and soil effects over canopy gap dynamics.

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