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Using LiDAR waveform metrics to describe and identify successional stages of tropical dry forests

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Secondary forests are becoming increasingly dominant in tropical regions, but little work has been dedicated to identifying tools for accurately classifying forests in different levels of ecological succession. This paper explores the potential of full-waveform LiDAR metrics in the identification and classification of tropical dry forests (TDFs) at three different levels of ecological succession: early, intermediate, and late.
Based on the effective LiDAR waveform and the cumulative return energy curve from the Laser Vegetation Imaging Sensor (LVIS), we derived a total of 21 LiDAR metrics which can be classified into point-, line-, area-, or shape-based groups. We further evaluated their ability in differentiating TDF succession using multiple comparison analysis (Duncan method and Tanhane's T2 method) and ISODATA clustering.
Our results showed that the response of LiDAR energy could well reflect the variation in TDF vertical structure. The effective LiDAR waveform of the early successional stage was characterized by one narrow peak; the late successional stage was characterized by multiple major and minor peaks; and the intermediate stage showed transitional characteristics. The normalized cumulative curves tended to be linear with the development of succession.
Our multiple comparison analysis suggested that shape- and area-based metrics were generally better than point- and line-based ones in the differentiation of successional stages. Meanwhile the late successional stage can be identified by metrics from any of the four metric groups, the early and intermediate successional stages can be better identified using shape- or area-based metrics. Our ISODATA classification results further confirmed the advantages of area-based metrics since they presented the highest accuracies in nearly all accuracy measurements and for all successional stages.
Our study suggests the encouraging potential of LiDAR waveform metrics in the quantification of tropical forests structure as a function of different levels of ecological succession.