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An automatic method for bamboo-dominated forests die-off detection based on remote sensing time series and bamboo life cycle characteristics

Ricardo Dalagnol, Fabien Hubert Wagner, Lênio Soares Galvão, and Luiz Eduardo Oliveira e Cruz de Aragão

National Institute for Space Research (INPE), Remote sensing division, São José dos Campos, São Paulo, Brazil (ricds@hotmail.com)

Bamboo-dominated forests (BDF) represent at least 1% of the total world's forests. In southwest Amazon, the BDF cover 16.15 million ha, 3% of the biome's area, over Brazil, Peru, and Bolivia. These BDF are dominated by *Guadua* spp. semi-scandent woody bamboos that have an average life cycle length of 28 years. They are semelparous, that is, they have a single reproductive event followed by death, which happens synchronized in time and space. The die-off events can contribute to carbon emissions due to biomass decomposition and increased fire occurrence probability. Besides that, bamboo causes physical damage to trees and compete for resources, promoting higher tree mortality rates when compared to areas without bamboo. Previous studies have shown that the near infrared (NIR) wavelength was important to detect die-off events, because live bamboo showed higher NIR than dead bamboo and forests without bamboo. Here, based on the hypothesis that NIR increases with bamboo growth and sharply decreases when the bamboo dies, we developed a method to automatically detect BDF die-off events in southwest Amazon based on satellite NIR time series and characteristics of the bamboo life cycle. We used an annual time series of the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor (NIR bands 2 and 5), atmospherically corrected by the Multi-Angle Implementation of Atmospheric Correction (MAIAC), centered in August, from 2000 to 2016, with 1 km of spatial resolution. To determine the die-off year, for each pixel, we iteratively assessed the point of maximum correlation between the time series of MODIS (MAIAC) NIR reflectance, and the expected NIR temporal pattern: a linearly increasing NIR reflectance vector from 1 to 28 years followed by an abrupt reflectance decrease at 29 years of bamboo age. We compared the detected die-off year with 345 geolocations of bamboo die-off from 2001-2016, visually interpreted in false-color composites of MODIS bands 1 (Red), 2 (NIR), and 6 (shortwave infrared). Our findings showed that the exact bamboo die-off year can be detected with accuracies above 77%. The accuracy is above 95% when considering a deviation up to two years. During 2001-2016 a total of 589 bamboo patches died-off. The patches mean size was 105 km^2 and the largest patch had 4100 km^2. The results from bands 2 and 5 were 90% similar. Our method is easy to implement and can be applied to map BDF die-off and distribution around the world in order to investigate bamboo dynamics and potential associations between die-off and fire, pest attacks and tree mortality.