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Fire patterns in the Amazonian biome

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This paper aims to provide an overview of our recent findings on the interplay between climate and land use dynamics in defining fire patterns in Amazonia. Understanding these relationships is currently a fundamental concern for assessing the vulnerability of Amazonia to climate change and its potential for mitigating current increases in atmospheric greenhouse gases. Reducing carbon emissions from tropical deforestation and forest degradation (REDD), for instance, could contribute to a cumulative emission reduction of 13-50 billion tons of carbon (GtC) by 2100. In Amazonia, though, forest fires can release similar quantities of carbon to the atmosphere (~0.2 GtC yr-1) as deforestation alone. Therefore, to achieve carbon savings through REDD mechanism there is an urgent need of understanding and subsequently restraining related Amazonian fire drivers. In this study, we analyze satellite-derived monthly and annual time-series of fires, rainfall and deforestation in Amazonia to: (1) quantify the seasonal patterns and relationships between these variables; (2) quantify fire and rainfall anomalies to evaluate the impact of recent drought on fire patterns; (3) quantify recent trends in fire and deforestation to understand how land use affects fire patterns in Amazonia. Our results demonstrate a marked seasonality of fires. The majority of fires occurs along the Arc of Deforestation, the expanding agricultural frontier in southern and eastern Amazonia, indicating humans are the major ignition sources determining fire seasonality, spatial distribution and long-term patterns. There is a marked seasonality of fires, which is highly correlated ($p<0.05$) with monthly rainfall and deforestation rates. Deforestation and fires reach their highest values three and six months, respectively, after the peak of the rainy season. This result clearly describes the impact of major human activities on fire incidence, which is generally characterized by the slash-and-burn of Amazonian vegetation for implementation of pastures and agricultural fields. The cumulative number of hot pixels is exponentially related to the monthly rainfall, which ultimately defines where and when fire can potentially strike. During the 2005 Amazonian drought, the number of hot pixels increased 33% in relation to mean 1998-2005. However, even with a large fraction of the basin experiencing considerable water deficits, fires have only affect areas with extensive human activity. Our spatially explicit trend analysis on deforestation and fire data revealed that more than half of the area experiencing increased fire occurrence have reduced deforestation rates. This reverse pattern is likely to be associated with the slash-and-burn of secondary forests and the increase of fragmentation and forest edges, favouring the leakage of fires from deforested lands into forests. Finally, our analysis points towards a reduction of fire incidence due to land use intensification in this region. In this study, we demonstrated that anthropogenic forcing, such as deforestation rates, is decisive in determining the seasonality and annual patterns of fire occurrence. Moreover, droughts can significantly increase the number of fires in the region exacerbating human impacts in Amazonia. Due to ongoing deforestation and the predicted intensification of climate change induced droughts, it is anticipated that a large area of forest edge will be under increased risk of fires and carbon savings from REDD may be partially offset by increased emissions following fire events. Improved fire-free land management practices may provide a sustainable solution for reducing emissions from the world's largest rainforest.

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