Geophysical Research Abstracts
Vol. 20, EGU2018-8555, 2018
EGU General Assembly 2018

Impact of drought periods on fire-vegetation interactions in the Amazon basin

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The tropical forest in the Amazon basin is a large sink for atmospheric CO_2 and the largest store of terrestrial biodiversity. However, a warmer and drier climate, connected to an increase of atmospheric CO_2 concentration, along with land-use change are threatening the forest's future and might shift the positon of the savanna-forest biome boundary towards savanna. Savanna areas, as the central Brazilian Cerrado, have a lower biomass moisture content and hence, are vulnerable to increasing fire regimes.

Especially in periods of drought, more frequent and intense fires cause, in addition to higher carbon and aerosol emissions, also several vegetation-fire feedbacks that modify evapotranspiration and surface albedo. These effects could accelerate forest fragmentation and put the functioning of the Amazon rainforest at risk. The aim of this study was to evaluate fire emissions and their feedback processes on the vegetation in the Amazon and Cerrado region.

We used the SPITFIRE fire model (Thonicke et al., 2010), which is fully coupled with the LPJmL Dynamic Global Vegetation Model 4.0 (Schaphoff et al., GMD 2018). The process based LPJmL-SPITFIRE-model considers the influence of fuel characteristics and enables, through its coupling, the investigation of several feedback processes involving fire and vegetation. As model input data we applied GLDAS climate data (NASA/GSFC/HSL, 2015) from the years 1948 to 2017 at a daily temporal resolution. Such long time coverage and high frequency sampling allows the investigation of intra- and interannual variability of fire occurrence in the Amazon basin and Cerrado region.

SPITFIRE calculates fire emissions as a function of burned biomass, depending on emission factors, which vary for different plant functional types (PFTs). The amount of burned biomass is determined by different factors including wind-speed, ignition rate and the tree-grass cover, which is taken from the coupled LPJmL. While the fire ignition rate depends on the fuel moisture, the composition of the fire emissions neglects this dependency. To additionally account for feedback processes involving the fuel moisture, a function to modify the emission factors for different combustions efficiencies was implemented in the code. Using the GLDAS input data, we identified drought periods, and compared fire occurrence and emissions in these periods with standard conditions. The modeled results were validated by comparing them with GFED4 burnt area and fire emissions (Giglio et al., 2013) for the years 1997 - 2016.

We find that especially in the drought periods during El Niño events, deforestation leads to larger fires and enhanced emissions. These results underscore the risk of a global change to a permanently warmer and drier climate for the Amazon basin and Cerrado region and calls for enhanced regional policies for forest conservation paired with global efforts to mitigate climate change.