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Multiple approaches for quantifying fuels, combustion dynamics, and regional fire emissions in the Amazon and Cerrado

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Fires in the Amazon are of great concern because they threaten the integrity of the tropical forest biome, the carbon cycle, and air quality. Fire emissions depend on the burning behaviour of vegetation biomass, woody debris, and litter. However, the effects of fuels on the combustion process and on the composition of fire emissions are simplified in current fire emission inventories and models. Several new fire emission approaches have recently been developed to better quantify fire emissions by either making use the improved spatial resolution of modern satellite observations or by developing new modelling approaches.

Here we compare several current and novel approaches to quantify fuel consumption and fire emissions for the Amazon and Cerrado for the fire season in 2020. The approaches include the widely used GFAS, a top-down approach based on Sentinel-5p observations (KNMI.S5p), a bottom-up approach based on active fire observations from VIIRS (GFA.S4F), two bottom-up approaches based on MODIS burned area data (500-m version of GFED, REFIT.AC), a data-model fusion approach with dynamic emission factors that integrates several Earth observation products (TUD.S4F), and three dynamic global vegetation models in diagnostic mode with prescribed burned area. The different approaches to estimate fire emission show that forest and deforestation fires dominate the regional total fire emissions. However, large differences exist in

the very high emissions of individual fires that mainly contribute to the regional total fire emissions. We found a higher agreement in estimated CO and NOx emissions between approaches for savannah fires (normalised RMSE < 20%) than for forest and deforestation fires (nRMSE 30%). We estimate that only 10% of all fire events contribute between 85% and 97% of the regional total fire emissions. By using the TUD.S4F data-model fusion approach with dynamic emission factors, we show that most fire CO emissions originate from the burning of woody debris, which burns with low combustion efficiency and hence has higher emission factors for CO. Comparisons with regional field-based investigations show, however, large differences in estimates of surface fuel loads and fuel consumption. Our results demonstrate the advantage of exploring several complementary fire emission approaches to better understand the underlying processes and to account for regional to global fire emissions and their uncertainties.