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Fuel consumption and fire emissions estimates using Fire Radiative Power, burned area and statistical modelling on the fire event scale

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Fire Radiative Power (FRP) retrieved by infrared sensors, such as flown on several polar orbiting and geostationary satellites, has been shown to be proportional to fuel consumption rates in vegetation fires, and hence the total radiative energy released by a fire (Fire Radiative Energy, FRE) is proportional to the total amount of biomass burned. However, due to the sparse temporal coverage of polar orbiting and the coarse spatial resolution of geostationary sensors, it is difficult to estimate fuel consumption for single fire events. Here we explore an approach for estimating FRE through temporal integration of MODIS FRP retrievals over MODIS-derived burned areas. Temporal integration is aided by statistical modelling to estimate missing observations using a generalized additive model (GAM) and taking advantage of additional information such as land cover and a global dataset of the Canadian Fire Weather Index (FWI), as well as diurnal and annual FRP fluctuation patterns. Based on results from study areas located in savannah regions of Southern and Eastern Africa and Brazil, we compare this method to estimates based on simple temporal integration of FRP retrievals over the fire lifetime, and estimate the potential variability of FRP integration results across a range of fire sizes. We compare FRE-based fuel consumption against a database of field experiments in similar landscapes. Results show that for larger fires, this method yields realistic estimates and is more robust when only a small number of observations is available than the simple temporal integration. Finally, we offer an outlook on the integration of data from other satellites, specifically FireBird, S-NPP VIIRS and Sentinel-3, as well as on using higher resolution burned area data sets derived from Landsat and similar sensors.