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Estimating Landscape Fire Particulate Matter (PM) Emissions over Southern Africa using MSG-SEVIRI Fire Radiative Power (FRP) and MODIS Aerosol Optical Thickness Observations

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The approach to estimating landscape fire fuel consumption based on the remotely sensed fire radiative power (FRP) thermal energy release rate, as opposed to burned area, is now relatively widely used in studies of fire emissions, including operationally within the Copernicus Atmosphere Monitoring Service (CAMS). Nevertheless, there are still limitations to the approach, including uncertainties associated with using only the few daily overpasses typically provided by polar orbiting satellite systems, the conversion between FRP and smoke emissions, and the increased likelihood that the more frequent data from geostationary systems fails to detect the (probably highly numerous) smaller (i.e. low FRP) component of a regions fire regime. In this study, we address these limitations to directly estimate fire emissions of Particular Matter (PM; or smoke aerosols) by presenting an approach combining the "bottom-up" FRP observations available every 15 minutes across Africa from the Meteosat Spinning Enhanced Visible and Infrared Imager (SEVIRI) Fire Radiative Product (FRP) processed at the EUMETSAT LSA SAF, and the "top-down" aerosol optical thickness (AOT) measures of the fire plumes themselves as measured by the Moderate-resolution Imaging Spectro-radiometer (MODIS) sensors aboard the Terra (MOD04_L2) and Aqua (MYD04_L2) satellites. We determine PM emission coefficients that relate directly to FRP measures by combining these two datasets, and the use of the almost continuous geostationary FRP observations allows us to do this without recourse to (uncertain) data on wind speed at the (unknown) height of the matching plume. We also develop compensation factors to address the detection limitations of small/low intensity (low FRP) fires, and remove the need to estimate fuel consumption by going directly from FRP to PM emissions. We derive the smoke PM emissions coefficients per land cover class by comparing the total fire radiative energy (FRE) released from individual fires and the MODIS AOD seen in the corresponding plume. Analysis was performed for plumes extracted from 31 study sites covering 10,000km^2each, during 10 consecutive days, for the 2011 southern Africa fire season. Compensation factors associated with undetected low FRP fires was based on extraction and application of frequency density function shape parameters, characterized by analyzing 4 years (2009-2013) of MSG-SEVIRI FRP data in 0.5^o degree cells. Using the derived emission coefficients and compensation factors we estimate Total Particulate Matter (TPM) emissions for 2011 on a daily basis and 0.25^o spatial resolution across southern Africa. Preliminary results show agreement between our derived emission coefficients and those of past studies following similar methods but with MODIS FRP data, and our annual TPM estimate is in reasonable agreement with those of other emission inventories based on burned area approaches. The proposed approach shows strong potential to be applied to other regions, and also to other geostationary satellite FRP products. Once the smoke emissions coefficients have been derived via comparison to the AOD data, the method requires only the FRP data, which is available at very high temporal frequency from geostationary orbit. Therefore our approach can provide near real time smoke emissions estimates which are essential for operational activities such as NRT smoke dispersion modeling and air quality forecasting.