Enhancements in Deriving Smoke Emission Coefficients from Fire Radiative Power Measurements

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Abstract
Smoke emissions have long been quantified after the fact by simple multiplication of burned area, biomass density, fraction of above-ground biomass, and burn efficiency. A new algorithm has been suggested, as described in Ichoku & Kaufman (2005), for use in calculating smoke emissions directly from fire radiative power (FRP) measurements such that the latency and uncertainty associated with the previously listed variables are avoided. Application of this new, simple and more direct algorithm is automated, based only on a fire’s FRP measurement and a predetermined coefficient of smoke emission for a given fire. Attaining accurate coefficients of smoke emission is therefore critical to the success of this algorithm. In the aforementioned paper, an initial effort was made to derive coefficients of smoke emission for different large regions of interest using calculations of smoke emission rate from MODIS FRP and aerosol optical depth (AOD) measurements. Further work had resulted in a first draft of a 1° resolution map of these coefficients. This poster will present the work done to refine the algorithm toward the first production of global smoke emission coefficients. Main updates in the algorithm include: U inclusion of wind vectors to help refine several parameters, 2 defining new methods for calculating the fire-emitted AOD fractions, and 3 calculating smoke emission rates on a per pixel basis and aggregating to grid cells instead of using so far on in the process. In addition to a presentation of the methodology used to derive this product, maps depicting preliminary results as well as an outline of the future application of such a product into specific research opportunities will be shown.

Methodology
The basic premise of the two algorithms used in this research is that smoke emission from a fire can be determined directly from its FRP and a coefficient of emission, C, which can be determined from a linear relationship between FRP and the rate of smoke emission, Rsa. Rsa is calculated as the total smoke emitted divided by the total time, T, it takes the smoke to clear the designated area. Ms, is estimated from surrounding AOD data values from the MODIS 10km MOD04_L2 product, and T is estimated using a pixel geometry and 850mbar wind speed data from MERRA’s 1.25×1.25° resolution "inst3_3d_asm_Cp" product. Ichoku & Ellison algorithm expands on it’s predecessor by using wind direction as well as magnitude to better estimate smoke emission rates. Wind magnitudes are also used in conjunction with relative fire locations within an aerosol pixel to improve values of T, Ms, and preventing parameters are also calculated on a per pixel basis and therefore theoretically eliminate the uncertainty in estimating these parameters on a much larger scale.

MISR Plume Inventory Case Studies

Global Emission Coefficient Maps

Figure 4: C is calculated from regression plots, where FRP is the independent variable and Rsa is the dependent variable, forced through the origin using linear regression forced through the origin is used to calculate C using all available data between 2003 - 2010 at 1° resolution.

Figure 5: Coefficient of emission (C) maps as shown in Figure 4 are used along with SEVIRI hourly, 1° gridded MODIS corrected FRP data over northern sub-Saharan Africa to derive monthly smoke emissions.

Conclusion
Good progress has been made to obtain sufficient amounts of data to make initial estimations of emission coefficients, using both the Ichoku & Kaufman (2005) algorithm and the Ichoku & Ellison algorithm, which has also been used to easily and quickly derive emissions of total particulate matter over northern sub-Saharan Africa. The initial product will be made available soon, with subsequent versions following to gain better correlation between FRP and Rsa by identifying and filtering out bad data.

References