An Overview of the New FEER Smoke Emissions Product and its Applications Towards Northern Sub-Saharan Africa

Abstract

A new smoke emissions inventory is being derived by NASA's Fire Energetics and Emissions Research (FEER, http://feer.gsfc.nasa.gov) group in conjunction with the NASA-funded interdisciplinary research project on the interactions and feedbacks between biomass burning and water cycle dynamics across the Northern Sub-Saharan African (NSSA) region. The vast amount of anthropogenic biomass burning conducted in NSSA during the dry months contributes significant amounts of aerosols and particulate emissions to the local climate system. The emissions product presented here is a result of the efforts made to utilize quantitative satellite measurements of important fire and smoke variables to generate an accurate emissions product that can be used to quantify the relationship between biomass burning and regional climate impacts. This new product is based on a unique top-down approach whereby satellite-derived fire radiative power and aerosol optical depth (AOD) from the two active Moderate Resolution Imaging Spectroradiometer (MODIS) instruments. The algorithm produces a 3×1 global grid of coefficients of emission, Ce, that directly relate FRP to emissions, or equivalently, fire radiative energy (FRE, the temporally integrated FRP curve) to emissions. Thus, emissions can be easily and quickly obtained in a given region by multiplying the Ce grid with FRP measurements acquired within that region. The Ce product offers the user flexibility in using any desired FRP data source, and the lag time in generating emissions is only constrained by that of obtaining FRP. The accuracy of this emissions product and its comparisons to other established emissions databases are presented here, as is a discussion of the limitations that this product will make toward accounting for climate variables in the NSSA region.

Coefficient of Emission Product

Figure 1. The coefficients of emission (Ce) represent the trend between the amount of emitted species from fires per their respective radiative energy output, and are in kg/MJ. These Ce values can be multiplied against fire radiative power (FRP) to get emission rates, or against the corresponding energy, FRE (temporally integrated FRP), to get emissions.

Figure 2. In generating the Ce product in Figure 1, several levels of quality control were applied to the data and these were combined into one product with maximum coverage. Thus, the resulting variation in confidence of Ce is depicted via this quality assurance (QA) product, where four is the highest confidence.

Figure 3. The Ce values shown in Figure 1 are calculated from linear curve fits forced through the origin. The corresponding R² values as described in Eisenhauer 2003 are shown here. The QA values in Figure 2 roughly follow these R² values.

Northern Africa Emissions Comparisons

Figure 4 shows comparisons between FEER emissions and GFAS and FRE emissions over Northern Africa in 2010. Due to the unavailability of a standard FRE product, and because FRE can vary greatly depending on the method used to derive it, and in order to base the comparison on the differences between the coefficients and methodologies that convert FRE to emissions, the FRE data from the GFAS product for 2010 in (a) was then used to create the FEER emissions shown in (a). Two major differences are apparent: 1) the total amount of emitted PM increases twofold, which helps to close the gap between bottom-up and top-down approaches in estimating fire emissions; and 2) the emissions across the whole Sahel region is much more constrained than at a latter observation has yet been validated as being realistic, and it is recognized that the Ce product shown in Figure 1 seems to be sensitive to contamination from pollution. However, the fact that the FEER coefficient of emission product has much greater spatial resolution and is a much more direct, top-down approach, the FEER emissions product offers great potential in taking the next step in accurate fire emissions estimations.

Figure 5. MODIS detected fires from Nov 2009 through Feb 2010 are shown here with darker colors representing the more powerful fires.

References


Coefﬁcient of determination is derived Coefﬁcients of emission from FRP and AOD measurements during 2003-2009.