AGU Fall Meeting 2012
GC33A-1011

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

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http://feer.gsfc.nasa.gov/

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 gaseous and particulate emissions to the local climate system. The emissions product presented here is a result of the efforts made to utilize quantitative satellite measures 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 radiant energy and emission rates are related from independent yet coincident remotely sensed retrievals of fire radiative power (FRP) and aerosol optical depth (AOD) from the two active Moderate Resolution Imaging Spectroradiometer (MODIS) instruments. The algorithm produces a 1×1° global grid of coefficients of emission, Ce, that directly relate FRP to emission rates, 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 contribution that this product will make toward accounting for climate variabilities in the NSSA region.

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Coefficient of Emission Product

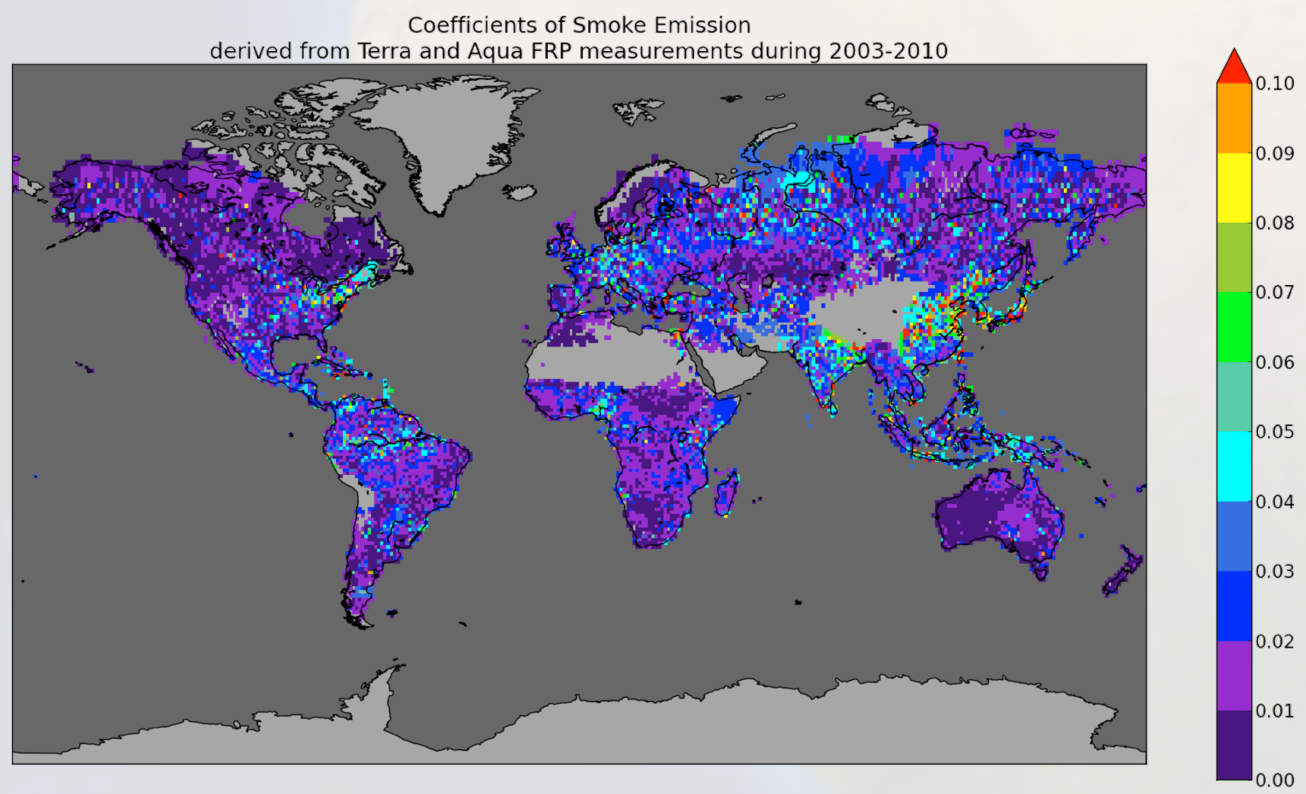


Figure 1. The coefficients of emission (C_e) represent the trend between the amount of emitted species from fires per their radiative energy output, and is given in kg/MJ. These C_e values can be multiplied against fire radiative power (FRP) to get emission rates, or against the corresponding energy,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

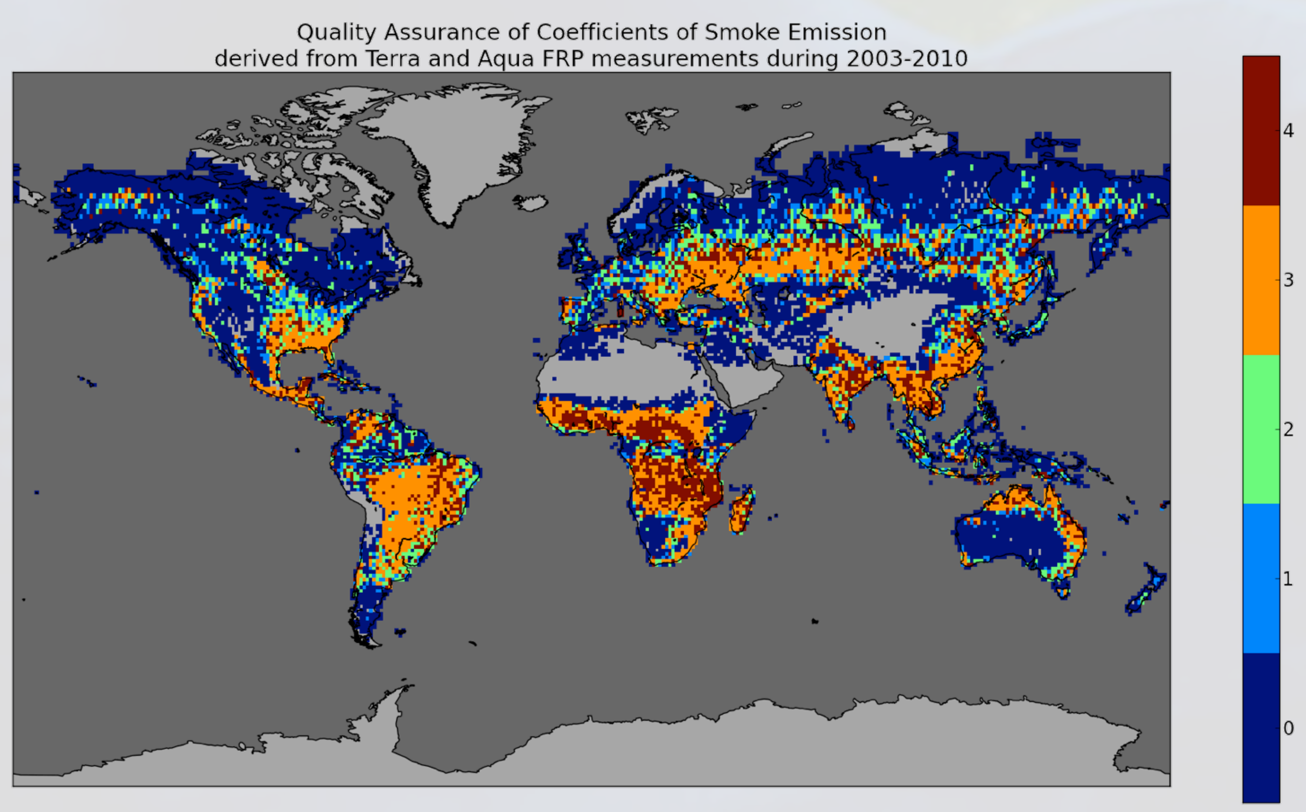


Figure 2. In generating the C_e product in Figure 1, several levels of quality control were applied to the data and these were combined into one product with maximum coverage. Thus, the resulting variation in confidence of C_e is depicted via this quality assurance (QA) product, where four is the highest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

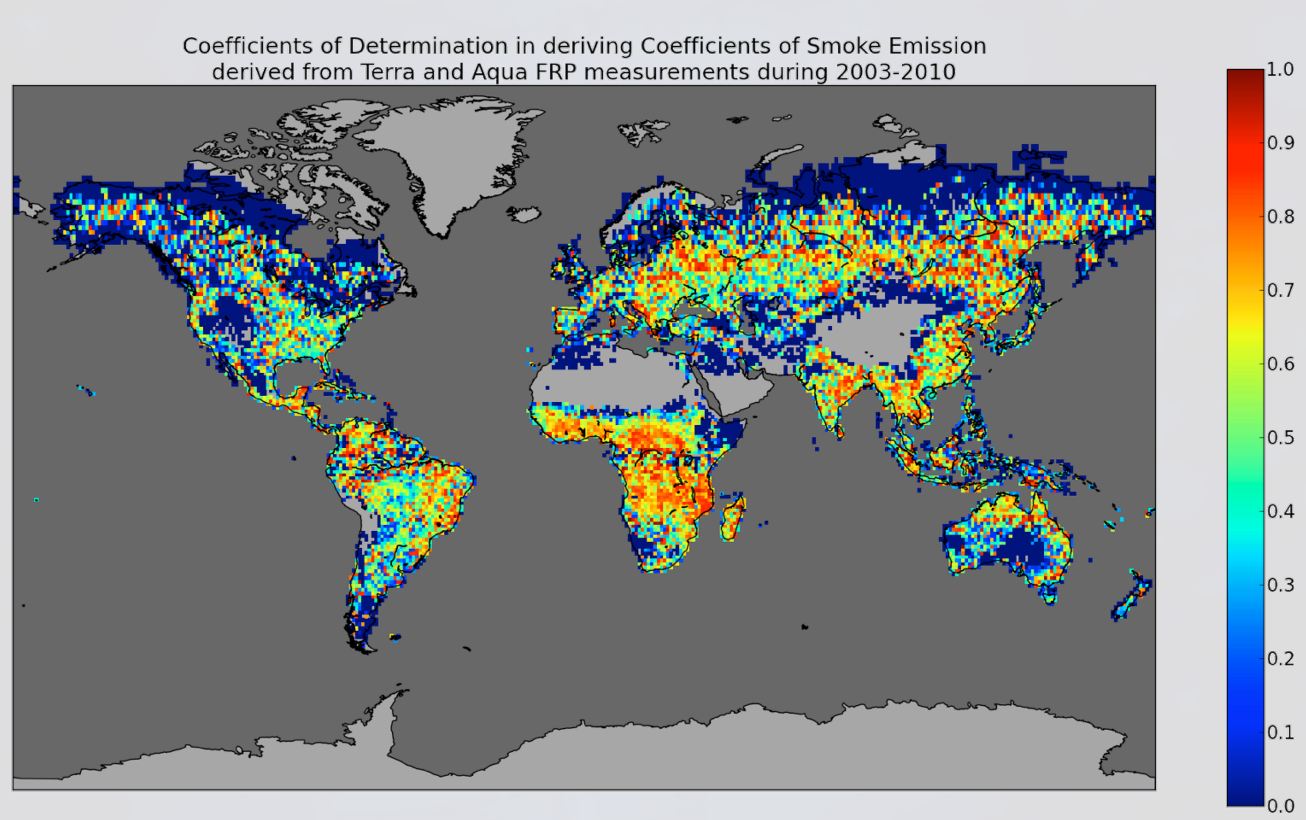


Figure 3. The C_e values shown in Figure 1 are calculated from linear curve fits forced through the origin. The corresponding R^2 values as described in *Eisenhauer 2003* are shown here. The QA values in Figure 2 roughly follow these R^2 values.

Northern Africa Emissions Comparisons

Figure 4 shows comparisons between FEER emissions and GFAS and GFED 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 difference between the coefficients and methodologies that convert FRE to emissions, the FRE data from the GFAS product for 2010 in (b) was therefore used to generate 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 continuous. This latter observation has yet to be validated as being realistic, and it is recognized that the C_e 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 4.

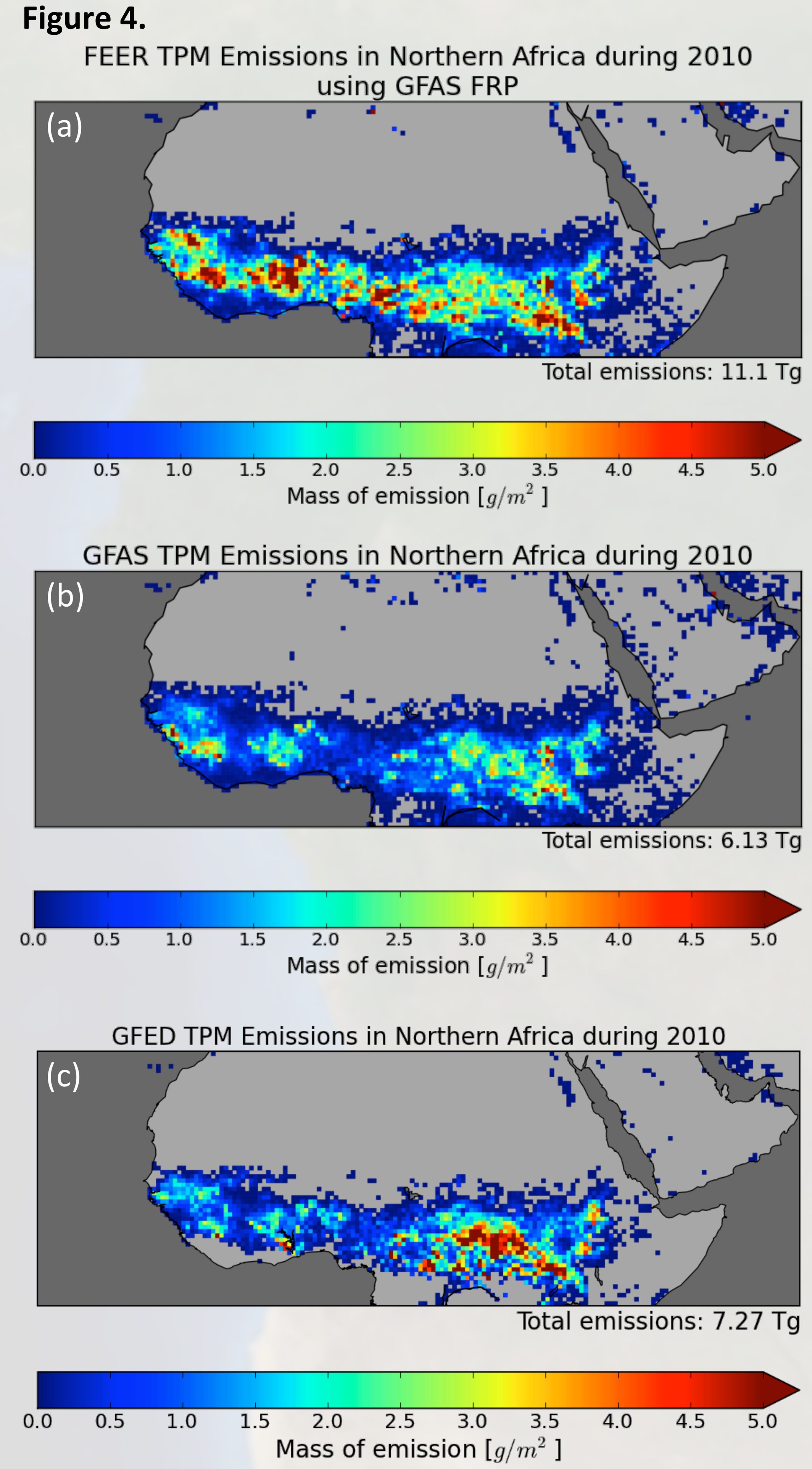
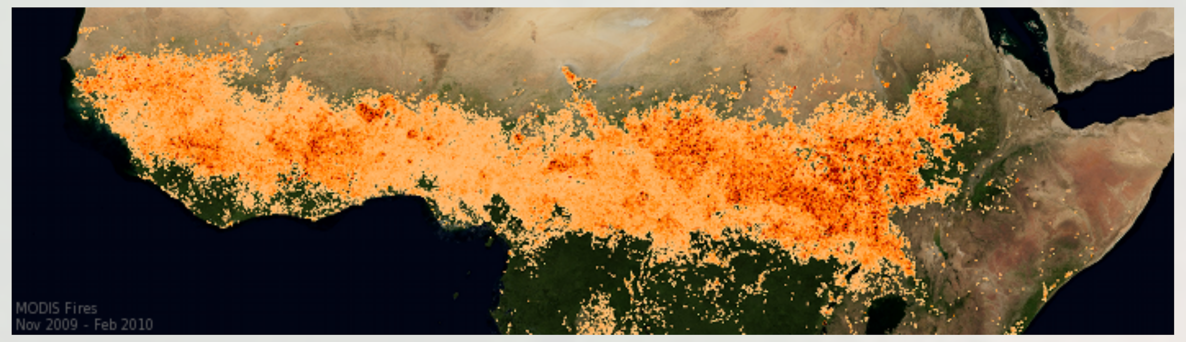


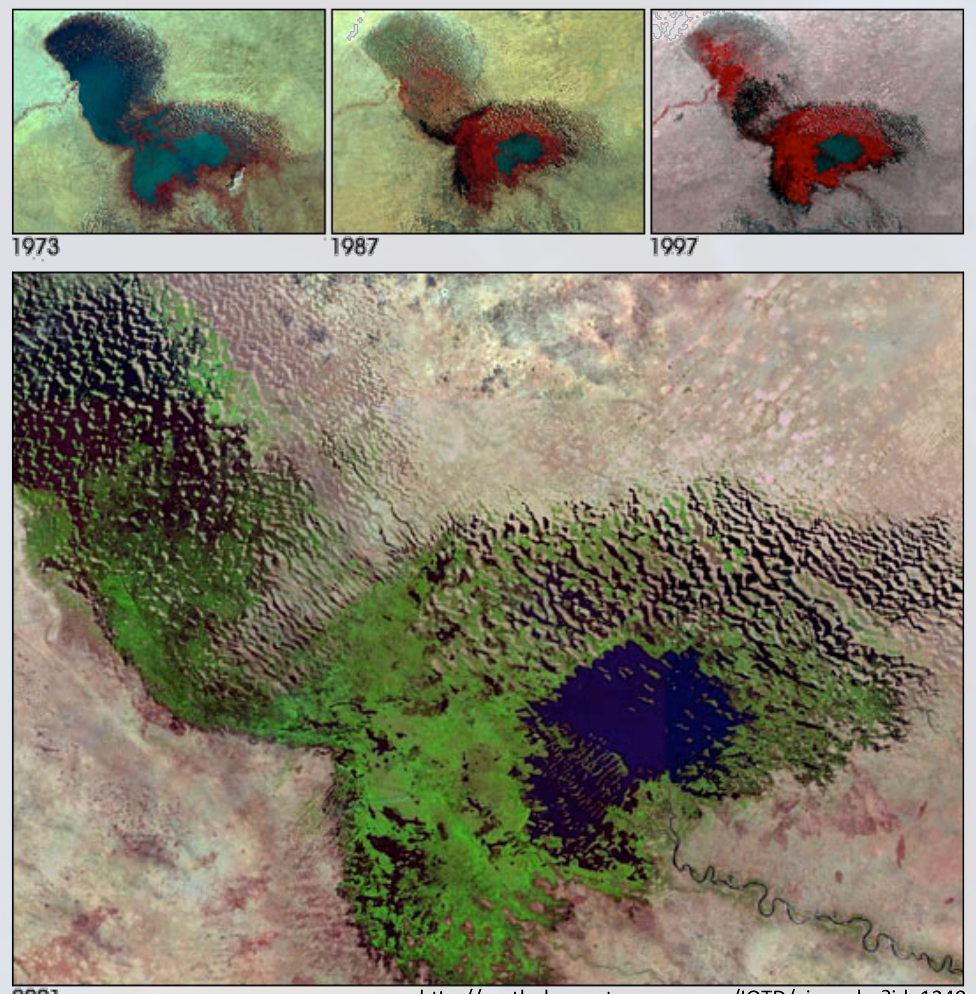
Figure 5. MODIS detected fires from Nov 2009 through Feb 2010 are shown here with darker colors representing the more powerful fires.



Implications and Applications for Northern Sub-Saharan Africa

The Northern Sub-Saharan Africa (NSSA) region is undergoing an elongated drought, the effects of which are theorized to be in part caused by the persistency of the immense amount of biomass burning in this region. The NASA-led multidisciplinary, multiagency effort currently in its third year of funding to examine this theory looks to integrate research in albedo, groundwater storage and runoff (specifically around Lake Chad), soil moisture, precipitation, atmospheric heating rates, and overall climatology along with biomass burning emissions into climate models in order to understand the interactions and feedbacks that biomass burning is having on the region and long-term climate trends. Therefore, it is imperative that an accurate representation of biomass burning emissions is fed into this analysis. The FEER emissions product is soon to be incorporated into these models.

Figure 6. The Lake Chad surface water level has been steadily decreasing over the past half-century, and is being investigated to understand how biomass burning has affected this trend.



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