NC STATE UNIVERSITY

Central American Biomass Burning Aerosols and Their Impact on Southeastern United States Tornado Events

S36

Michael Mugrage and Nicholas Meskhidze
North Carolina State University, Raleigh, NC

I. Introduction

The southeastern United States is no stranger to tornado outbreaks, but the ability to accurately predict them in regards to numbers and severity still has room for improvement. Circumstantial evidence exists for tornadoes in this region to be episodically accompanied by smoke from biomass burning in central America. The proposed hypothesis is that adding smoke to an environment already conducive to severe thunderstorm development can increase the likelihood of tornado occurrence.

Previous studies have shown these aerosols have an impact on the surface based Lifted Condensation Level (sbLCL) and the 0-6km Bulk Shear, both of which are components of the Significant Tornado Parameter (STP) (Saide et. al 2015). How does Aerosol Optical Depth (AOD), a measure of aerosols abundance within a column of air, impact the magnitude and severity of tornado outbreaks in the southeast? Dissecting the STP into it's components of surface based Convective Available Potential Energy (sbCAPE), sbLCL, 0-6km Bulk Shear, and 0-1km Storm Relative Helicity (SRH) and analyzing those with respect to the AOD could help in understanding the relationship between biomass burning aerosols and tornado outbreaks. Prior studies have focused on a single "super" outbreak. Here we focus on a multitude of outbreaks with the goal to capture a relationship between biomass burning aerosols and tornado outbreaks.

II. Data/Methods

- Collected AOD's using Giovanni NASA database over specific regions using Combined Dark Target and Deep Blue AOD at 0.55 micron for land and ocean (MODIS-Terra Daily 1° resolution) (Fig. 1 and Fig. 2)
- Southern latitudinal boundary for the regions was held at 27°S, while the northern latitudinal boundary was varied for each outbreak
- 20 outbreaks were analyzed with 24 different local National Weather Service soundings used via the Storm Prediction Center mesoanalysis archive and University of Wyoming and collected Storm Reports to confirm the outbreak occurrence over the time period from 2008 through 2016 (Fig. 3 and Fig. 4)
- Sounding data analyzed for the STP include sbLCL, sbCAPE, SRH 0-1km, surface to 6km bulk shear
- STP was calculated using the above parameters; the AOD is plotted against sbLCL (Fig. 5), 0-6km shear (Fig. 6), and overall STP (Fig. 7)
- Linear regression analysis was used with calculated trend line and correlation coefficient

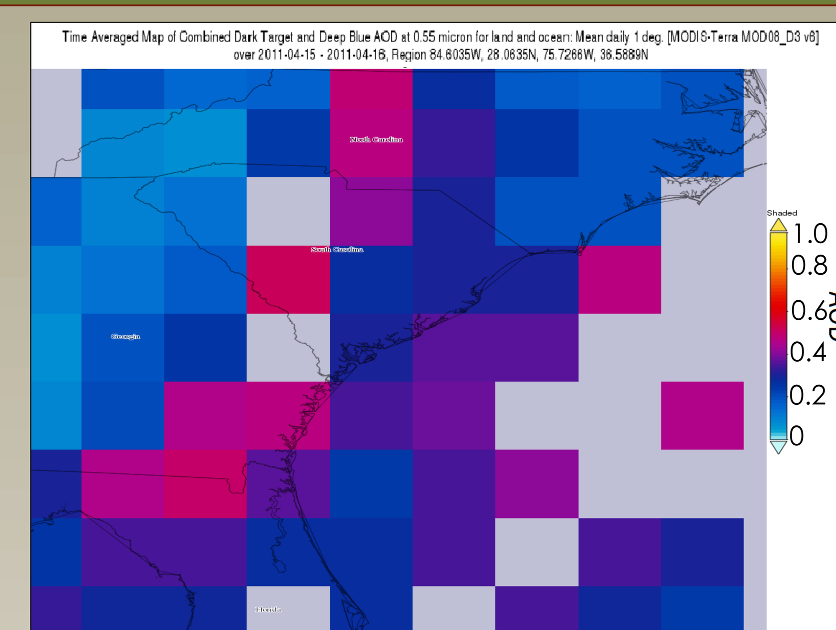

Figure 1: AOD daily average across the southeast on April 16th, 2011

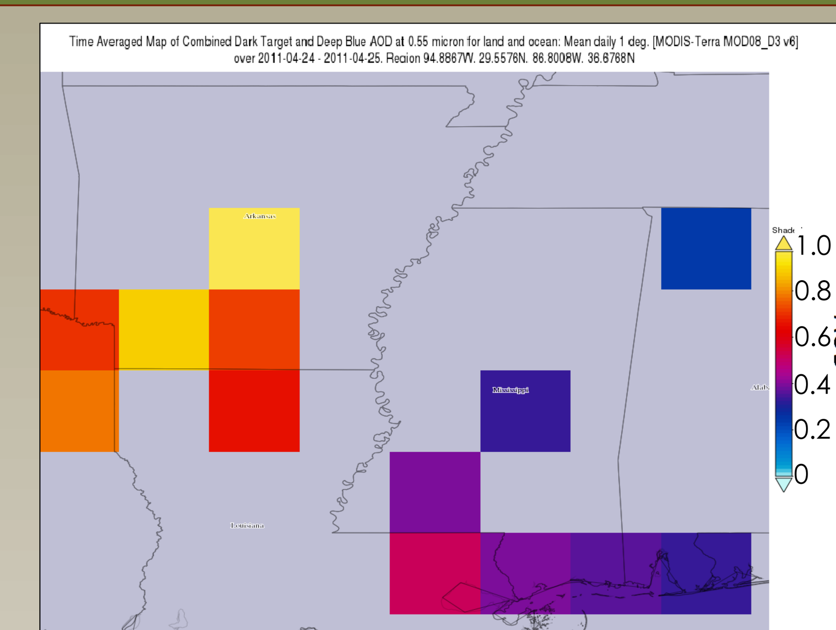

Figure 2: AOD daily average across the south on April 25th, 2011

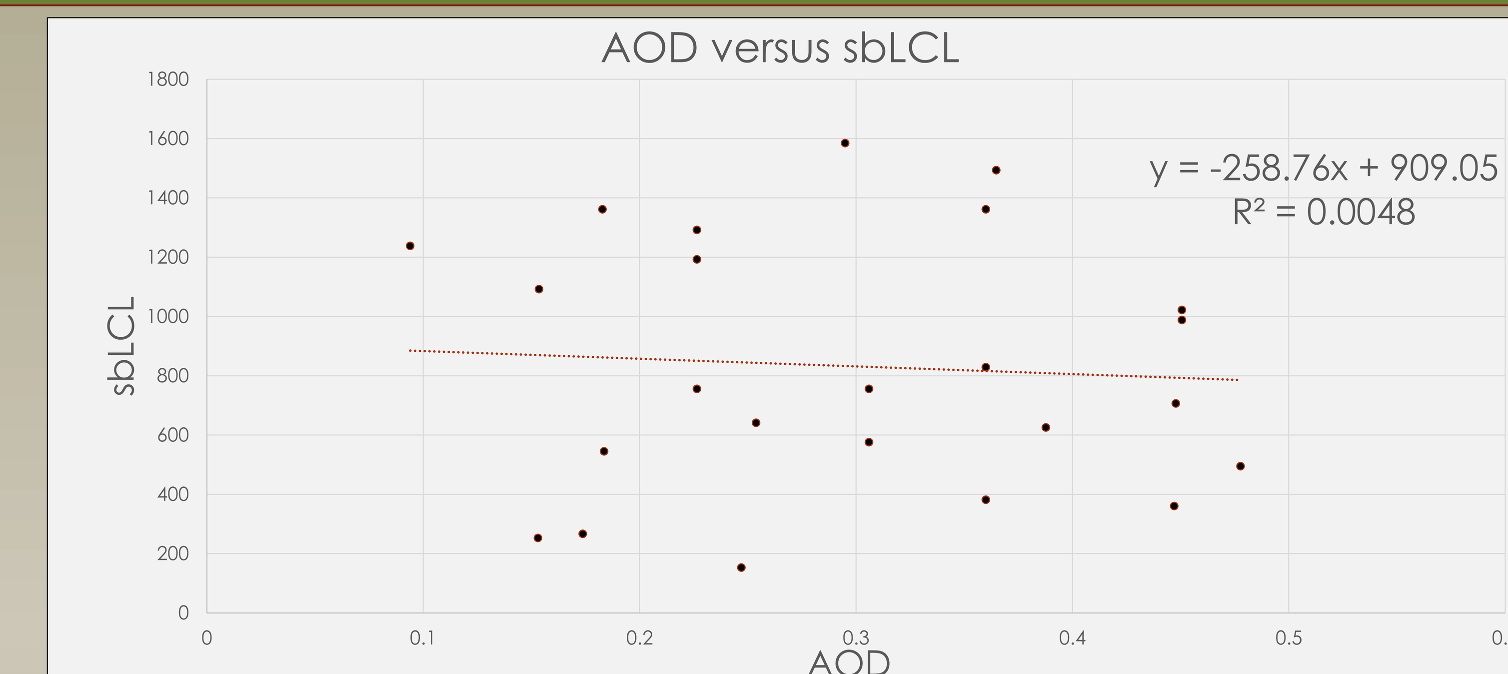

Figure 5: AOD plotted against sbLCL with linear regression equation and correlation coefficient

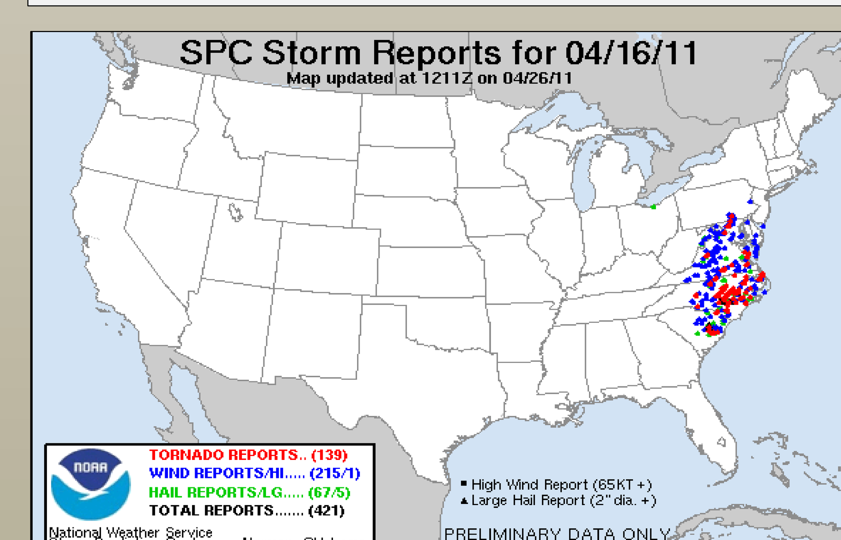

Figure 3: Storm reports demonstrating the extent of the April 16th, 2011 outbreak

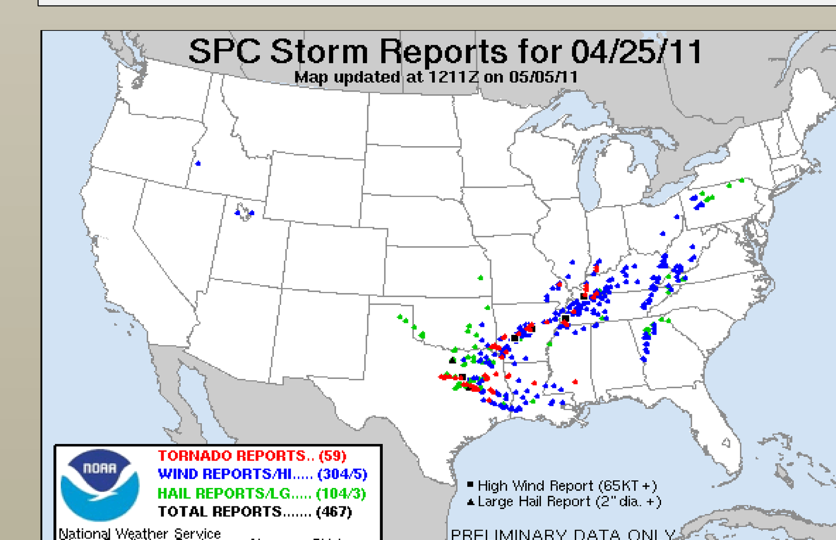

Figure 4: Storm reports demonstrating the extent of the April 25th, 2011 outbreak

The equation for the Significant Tornado Parameter:

$$STP = (sbCAPE/1500\ J\ kg^{-1}) * ((2000-sbLCL)/1000\ m) * (SRH/150\ m^2\ s^{-2}) * (BWD/20\ m\ s^{-1})$$

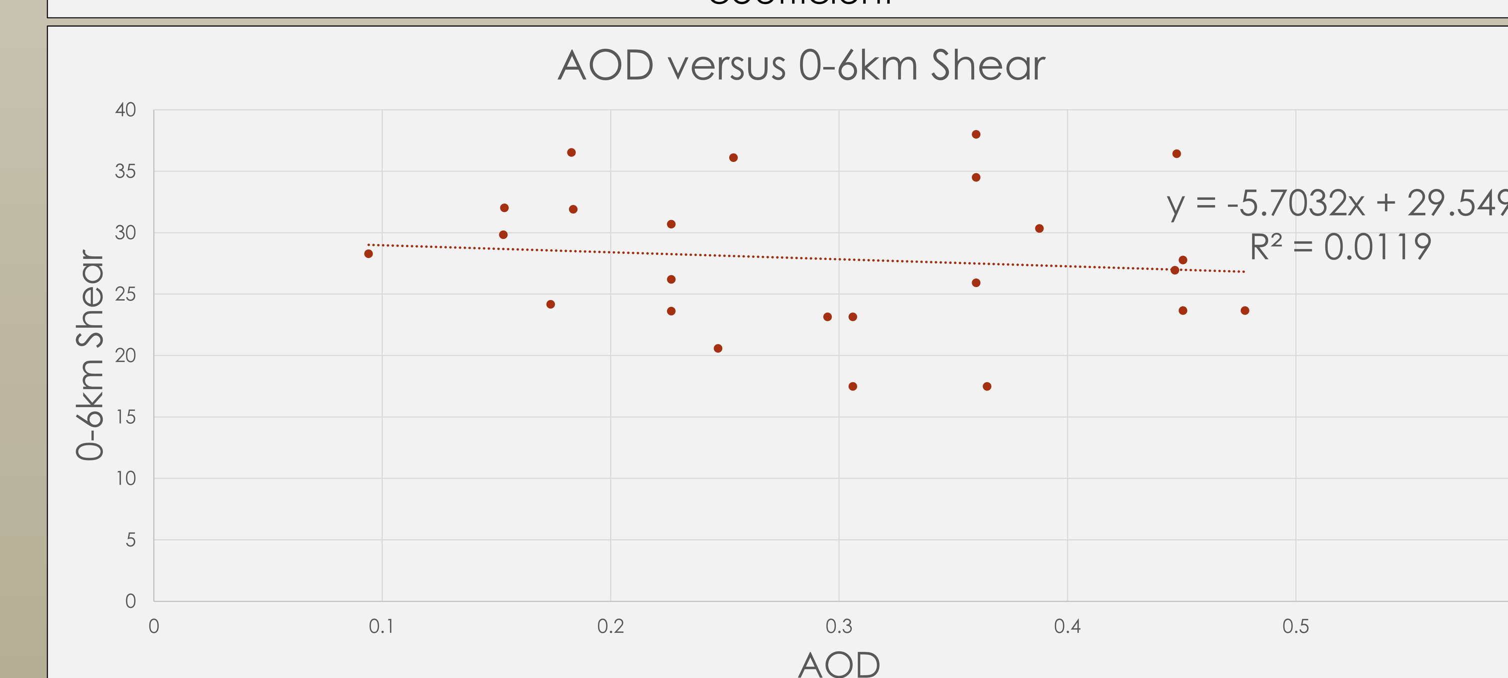

Figure 6: AOD plotted against 0-6km shear with linear regression equation and correlation coefficient

III. Results

- sbLCL and 0 to 6 km Shear show no correlation with AOD
- STP has a weak positive correlation with AOD
- sbCAPE and SRH also show weak positive correlation with AOD

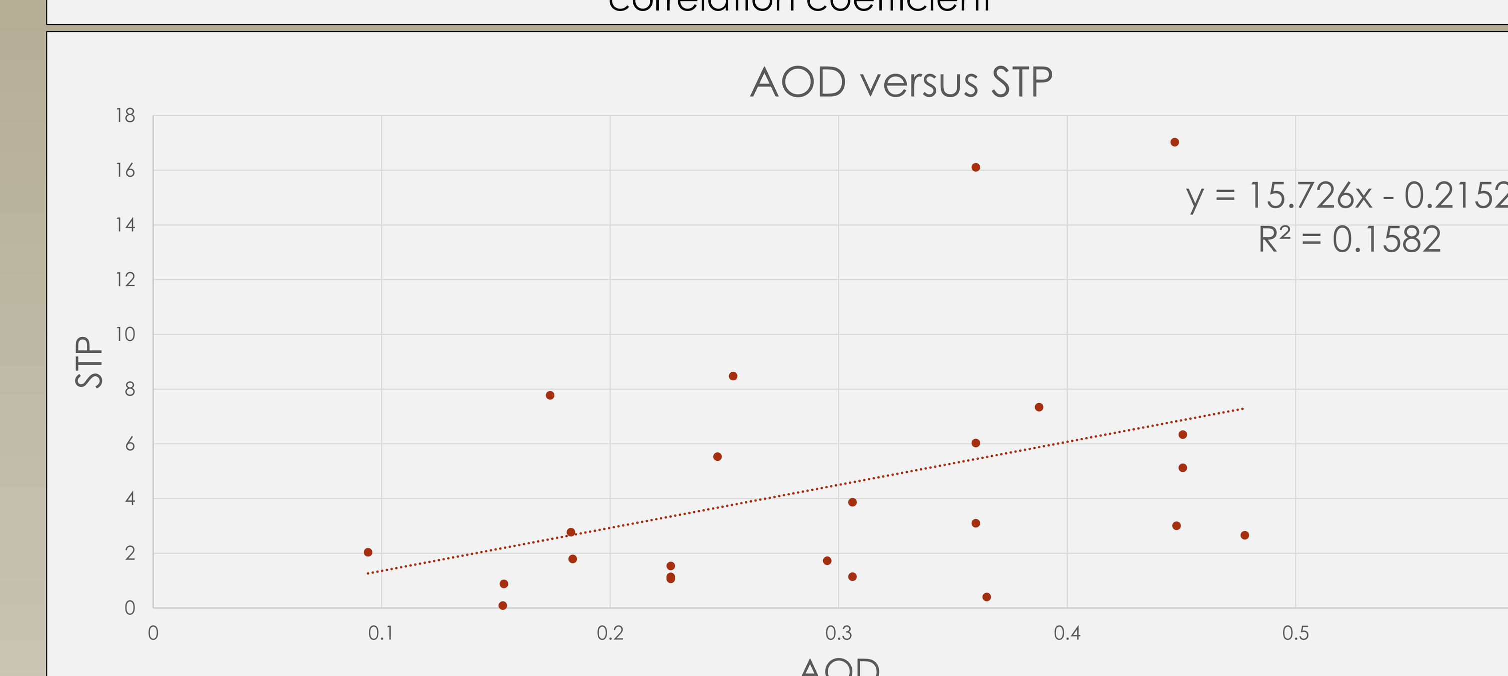

Figure 7: AOD plotted against STP with linear regression equation and correlation coefficient

IV. Conclusions/Future Research

- The absence of clear correlation between the STP parameters and AOD suggests
  1. The mechanism by which biomass burning aerosols from central America affect "super" outbreaks could be different from that of "regular" tornado outbreaks
  2. The result is an artifact of our data analysis
- More data analysis is needed with AOD retrievals from both morning and afternoon overpasses, vertical profiles of biomass burning aerosols, and detailed exploration of each term comprising the STP equation
- Future research should also compare events analyzed during the biomass burning season with events analyzed outside of season, with a more thorough analysis of the upper level dynamics

Acknowledgements: A special thanks to Dr. Meskhidze for advising, NC State University Office of Undergraduate Research for providing support for this research as well as for travel, SPC, Giovanni NASA, University of Wyoming, and Google Earth