Preliminary Research: Improving Monitoring of Rural Aerosols to Mitigate Human Health Impacts

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Introduction

The Surface Particulate Matter Network (SPARTAN) collocates IMPROVE-like aerosol filter measurements at the surface with AERONET measurements of columnar aerosol properties. A principal goal of this network is to "address the current gaps in knowledge of global $PM_{2.5}$ concentrations" (About SPARTAN).

In their recent paper, *Global Spatial Variation in the PM2.5 to AOD Relationship Strongly Influenced by Aerosol Composition*, Zhu et al. used SPARTAN data to investigate the relationships between aerosol composition and η (2024).

$$\eta = \frac{PM_{2.5}}{AOD} \quad \text{(Equation 1)}$$

(van Donkelaar et al. 2010)

This study uses an IMPROVE station and an Aeronet Cimel Sun photometer, as a pseudo-SPARTAN site to find η at the Department of Energy's Southern Great Plains Atmospheric Radiation Measurements site (ARM SGP).

This study is a first step towards understanding and predicting rural air quality by assessing both harvest-time and day-to-day aerosol production. Harvest-time produced aerosols are especially important in efforts to prevent human health impacts. Wang et al. found that rural cellular oxidation potential levels (toxic) are similar to that of urban areas, though rural levels are dominated by agriculturally produced aerosols (Wang et al. 2022).

While studies addressing cellular oxidative potential levels of aerosols in various communities are immensely informative, they are difficult to pursue. Producing an η value specific to aerosol composition can help protect rural communities and improve air quality monitoring by addressing qualitative risks that cannot be observed by mass concentration alone.

Data & Methods

Data:

- Since AERONET does not provide AOD data at 550 nm, we obtained AOD at all available wavelengths surrounding 500 nm (440 nm, 500 nm, and 675 nm).
- $PM_{2.5}$ is all particulate matter with a diameter smaller than 2.5 microns.

Methods:

We used an Angstrom relationship in a log log function to interpolate AOD at 550 nm from AOD at the bounding wavelengths.

We did not specifically address events where significant elevated layers disproportionately contribute to AOD measurements over mass concentration. Rather, we used a bi-fit regression excluding statistical outliers to properly produce our η value for nose level aerosols.

Results

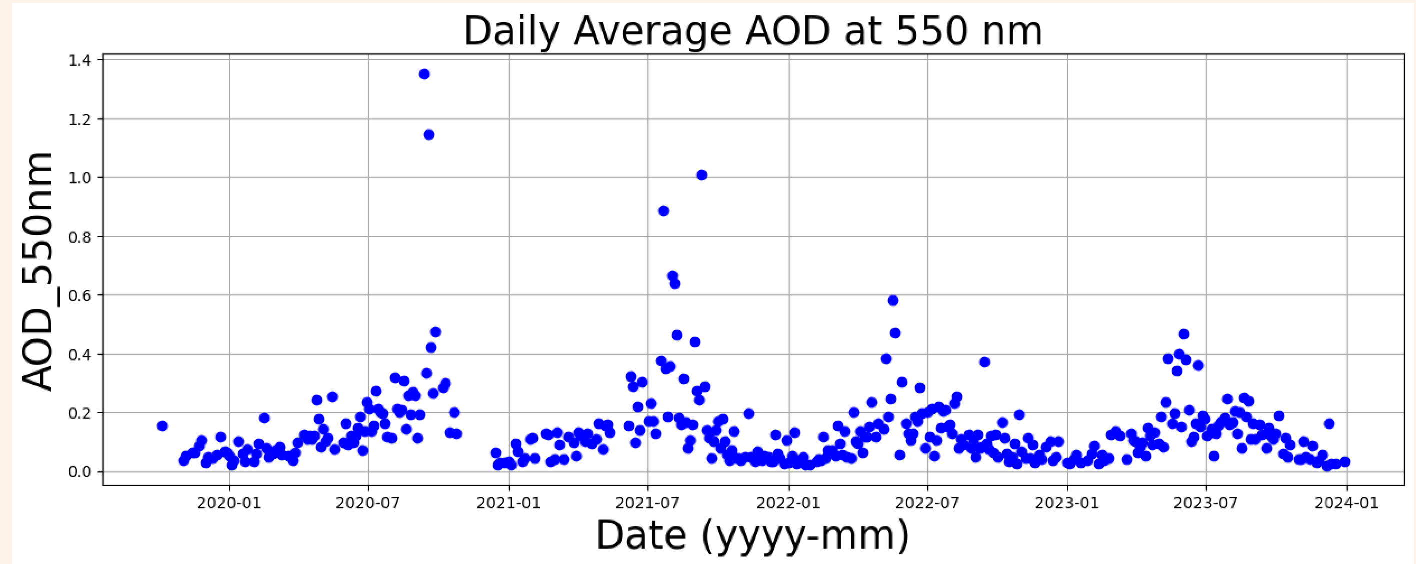

Figure 1. Daily average AOD at 550 nm for the ARM_SGP site (10/3/2019-12/31/2023)

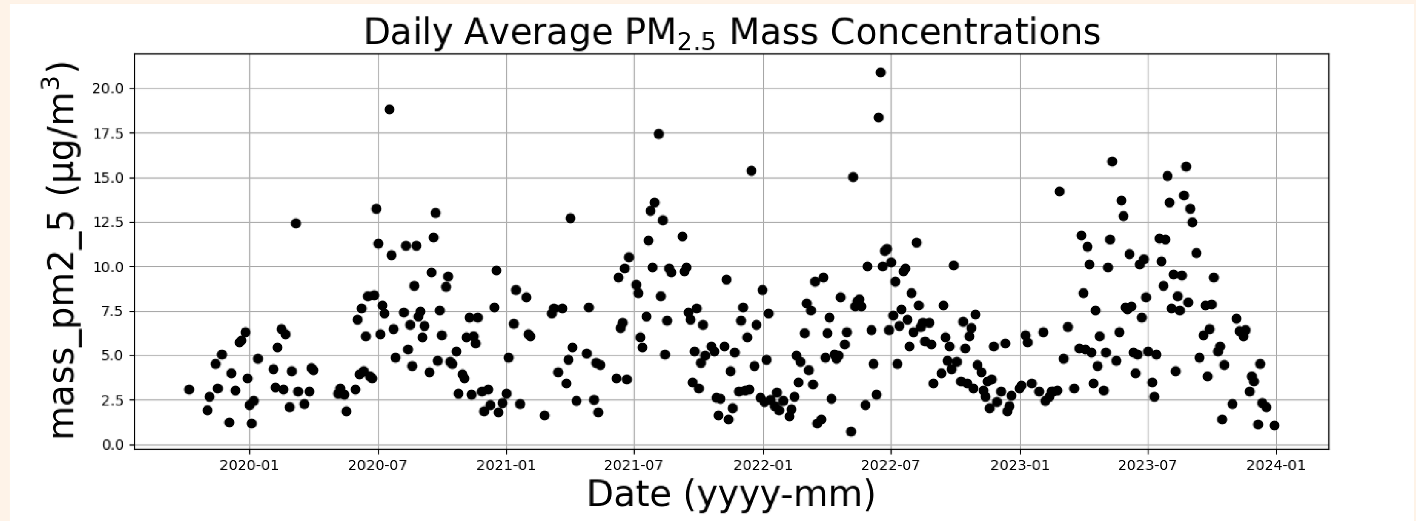

Figure 2. Daily average $PM_{2.5}$ Mass Concentrations for the ARM_SGP site (10/3/2019-12/31/2023)

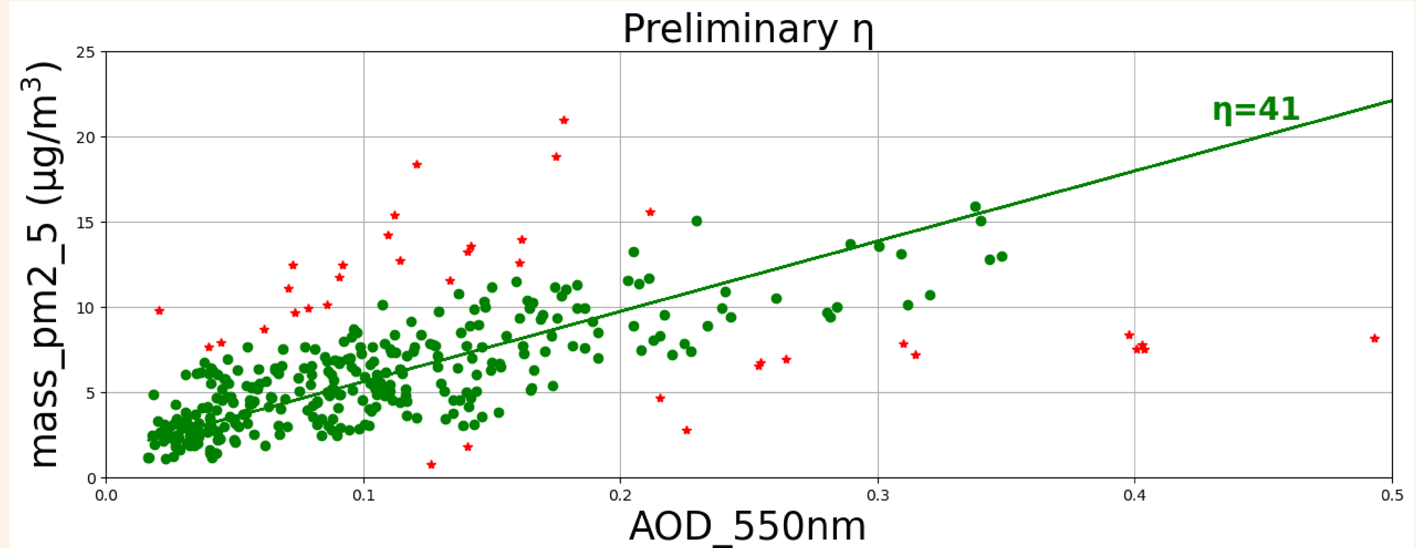

Figure 3. Preliminary η for the ARM_SGP Site (10/3/2019-12/31/2023)

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Conclusion/Discussion

We found $\eta = 41\ \frac{\mu g}{m^3}$. This falls within the range of η = ~30-60 $\frac{\mu g}{m^3}$ for North America (Zhu et al. 2024).

Our future work will:

- Refine this value by using the Aeronet SDA output to correlate fine-mode AOD with mass concentration
- Explore correlations for the most prevalent and most hazardous chemical constituents at the surface with columnar AOD (Figure 4)
- Explore seasonal trends and year-to-year differences
- Use ground-based lidar to exclude cases where significant elevated layers contribute to AOD measurements but not the surface mass concentrations

Our ongoing field campaign (SPICE) will allow us to use hourly-averaged mass concentration from a beta attenuation monitor (BAM) and hourly-averaged AOD to get higher resolution data.

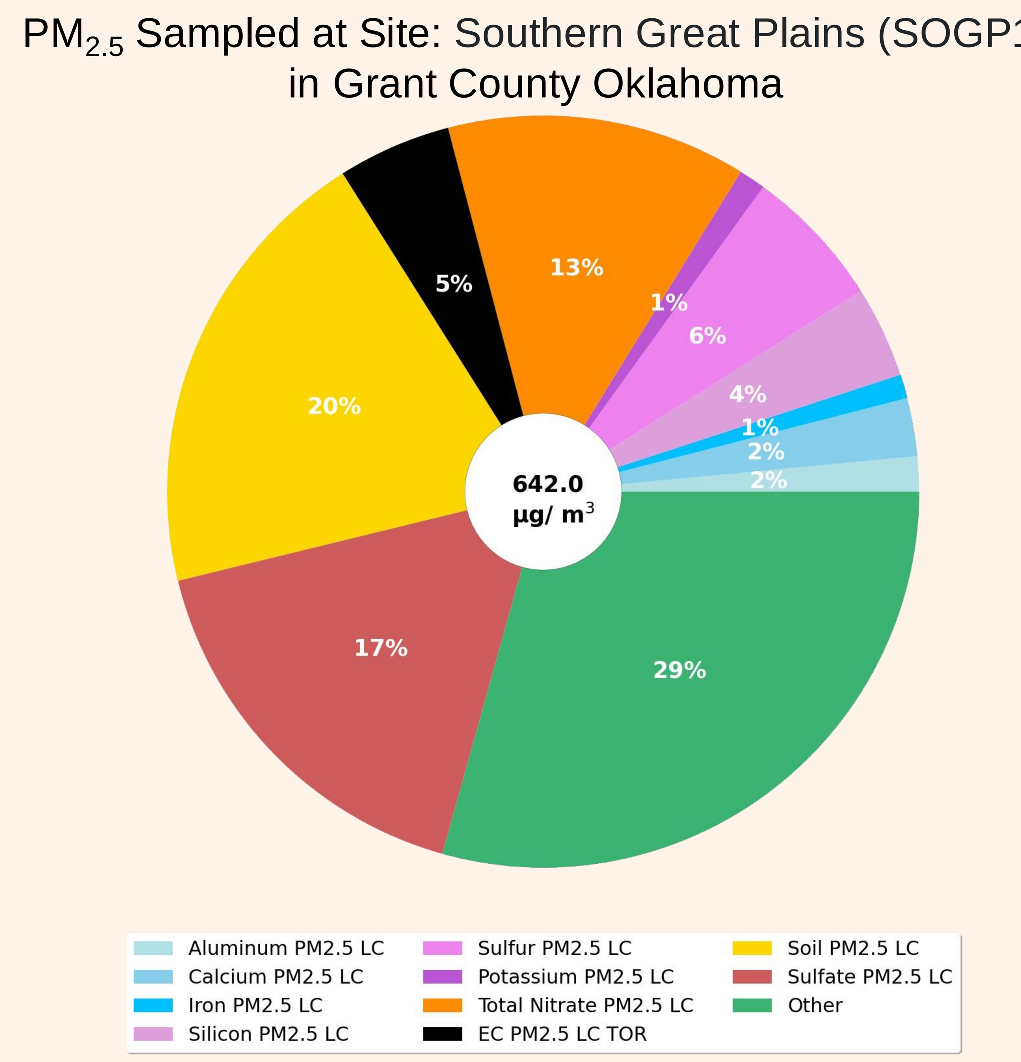

Figure 4. $PM_{2.5}$ speciated mass concentration for 2023 from IMPROVE data. (Airdata, site 400539000)

References

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About SPARTAN. *Spartan*. https://www.spartan-network.org.

AirData website File Download page. https://aqs.epa.gov/aqsweb/airdata/download_files.html#Daily.