Black and Brown Carbon from UV-Vis Spectrophotometry of SPARTAN Filters

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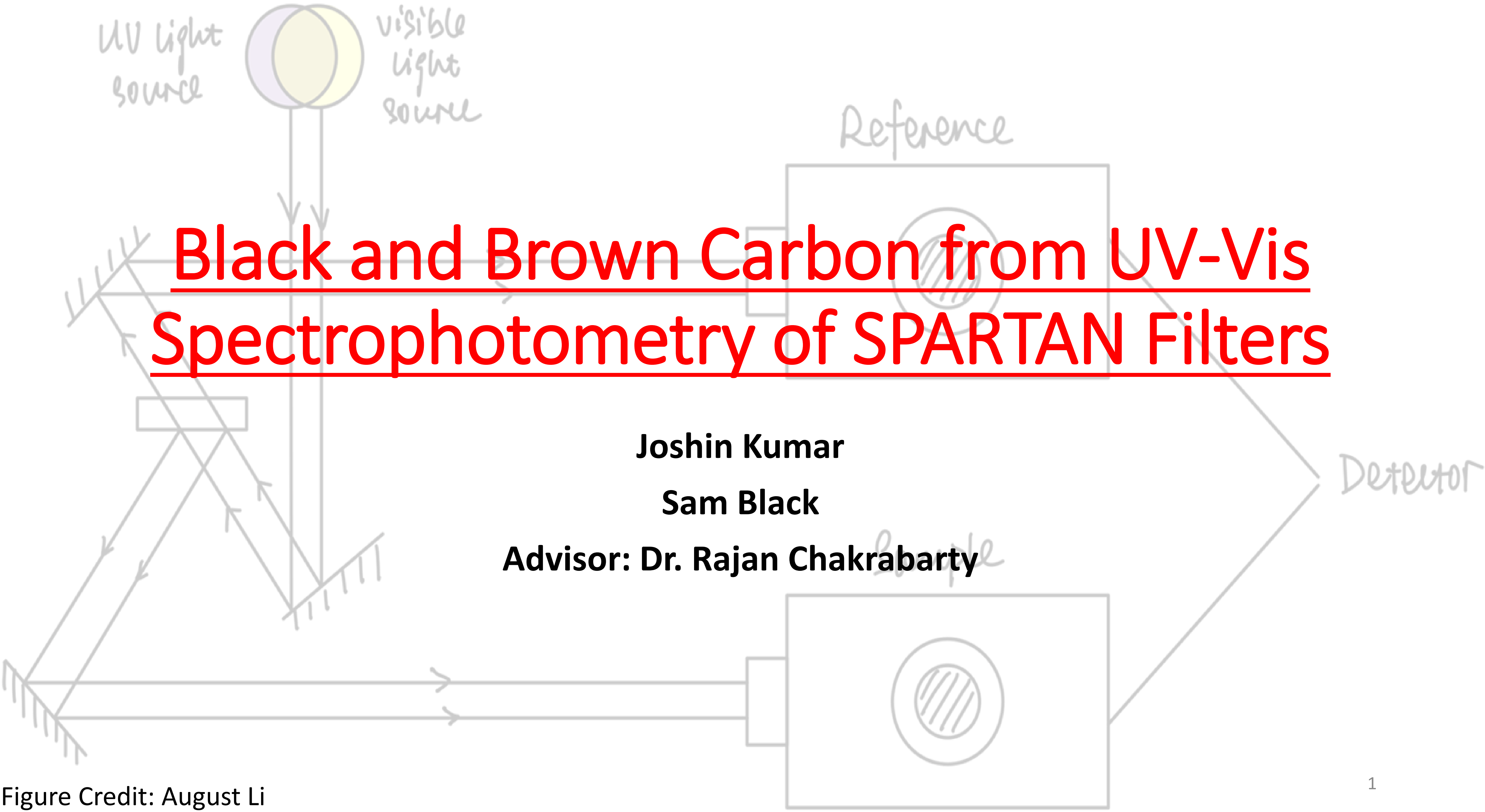


Figure Credit: August Li

What do we do with SPARTAN filters at our Lab?

- Obtain the filters from Dr. Randall Martin's Lab
  Thank you, Chris!

- Analyze the filters using LAMBDA 365 UV/Vis Spectrophotometer:
  - For each filter, obtain Reflectance(R%) and Transmittance(T%) values over the wavelength range 300-900nm

- Calculate B_{abs} and MAC on wavelength range 300nm-900nm

- Calculate BC Mass from an empirical relationship using MAC

- Calculate AAE using B_{abs} values

- Calculate residual B_{abs} by interpolating B_{abs}@900nm and subtracting it from B_{abs}@403nm [Brown Carbon]

Calculating B_{abs} and MAC using R% and T% values from UV/Vis

- Normalize R% and T% values based on blank runs [~100% R and T]
- Calculate Optical Depth:

$$\mathrm{OD_s} = \ln\left(\frac{1 - R_s}{T_s}\right).$$

- Calculate B_{abs} and MAC values:

$$b_{abs} = \left[0.48(\mathrm{OD_s})^{1.32}\right]\frac{10^9 A_s}{Q \times t_s}.$$

$$\mathrm{MAC} = \left[0.48(\mathrm{OD_s})^{1.32}\right]\frac{A_s}{m},$$

Citation: Pandey, A., Shetty, N.J. and Chakrabarty, R.K., 2019. Aerosol light absorption from optical measurements of PTFE membrane filter samples: sensitivity analysis of optical depth measures. *Atmospheric Measurement Techniques*, *12*(2), pp.1365-1373.

Calculating Black Carbon Mass

- Assuming that Elemental carbon (EC) is the only material that absorbs light at 900nm, the mass fraction of EC (f_{EC}), can be estimated with:

$$f_{EC} = MAC_{Calculated\_900nm} / MAC_{Analytical\_EC\_900nm},$$

where $MAC_{EC,900} \approx 4.58$ m^2/g is the analytical value of MAC for EC at λ = 900nm.

- This calculated f_{EC} is then multiplied with PM2.5 to obtain the Black Carbon mass.

UV-Vis Data Processing Pipeline

Raw Data 1:
Percentage Reflectance and Transmittance from UV-Vis Spectrophotometry of Filters

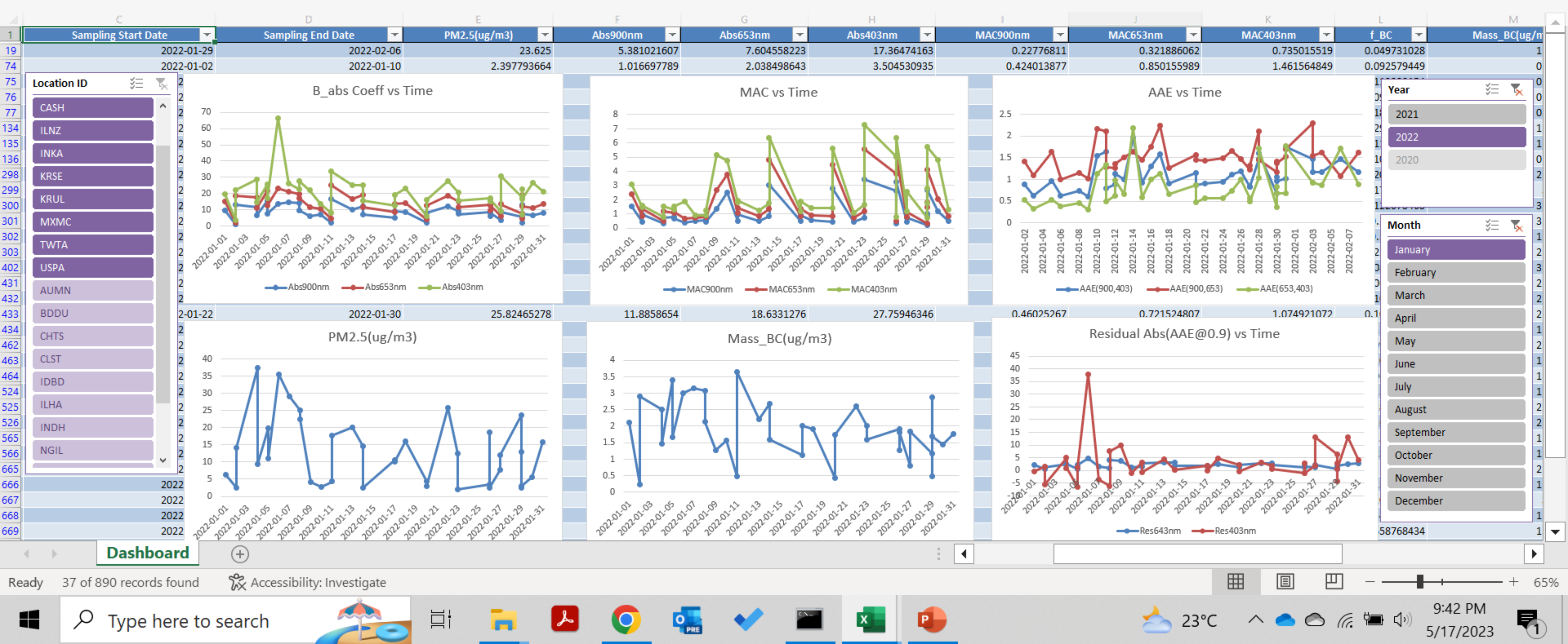
Raw Data 2:
Aerosol Mass Deposited and Metadata of Filters

Python code to both clean data and perform calculations

Dashboard to visualize the calculated quantities across different locations and time

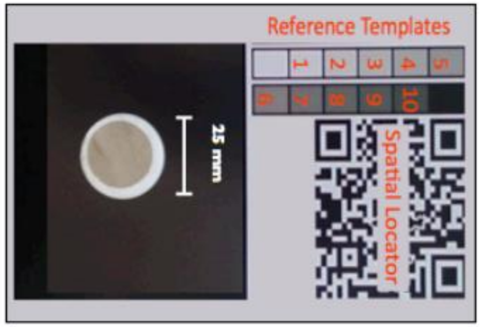
Python code (Jupyter Notebook) for UV-Vis data processing is openly available on GitHub.
Link: https://github.com/joshinkumar/SPARTAN-Filters-UV-VIS-Data-Analysis-Python-Code

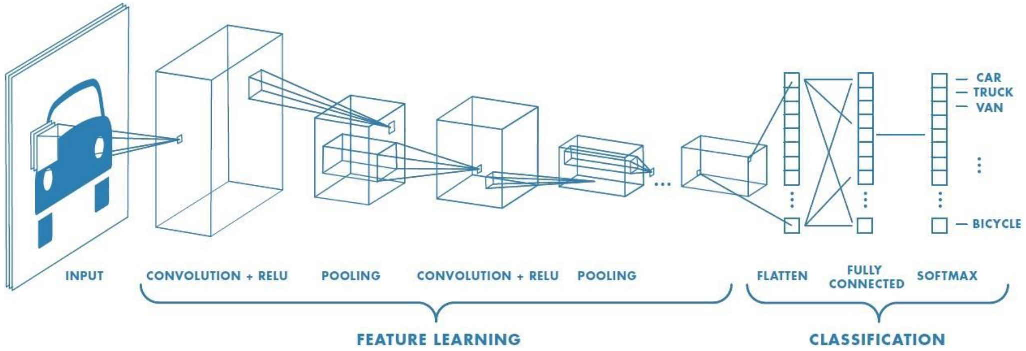
An online dashboard that provides public access to monthly uploaded timeseries data of Absorption, MAC, and BC mass derived from SPARTAN filters.



Proposed work: Application of Machine Learning to connect Images of SPARTAN filters with PM2.5 concentrations

- Assumption: The color of the filter is a function of PM2.5 concentration.
- Step I: Train a deep learning model (Convolutional Neural Network (CNN)) using RGB channels from images of filters and respective PM2.5 concentrations. This pre-trained model will be used to predict PM2.5 using new filter images.
- Step II: Click an image of the new filter with the reference color template.
- Step III: Upload the image to the SPARTAN website and obtain the PM2.5 concentration prediction from the pre-trained deep learning model.





PM 2.5

Thank you!

Questions?

References:

- N Ramanathan: http://www.cas.ucsd.edu/personnel/vram/about/icamp/N_Ramanathan.pdf

- Pandey, A., Shetty, N.J. and Chakrabarty, R.K., 2019. Aerosol light absorption from optical measurements of PTFE membrane filter samples: sensitivity analysis of optical depth measures. *Atmospheric Measurement Techniques*, *12*(2), pp.1365-1373.

Comparing measurements: SPARTAN vs IMPROVE

- Step I: Calculated Babs of SPARTAN PM2.5 samples at λ = 633nm (IMPROVE's HIPS He-Ne wavelength)

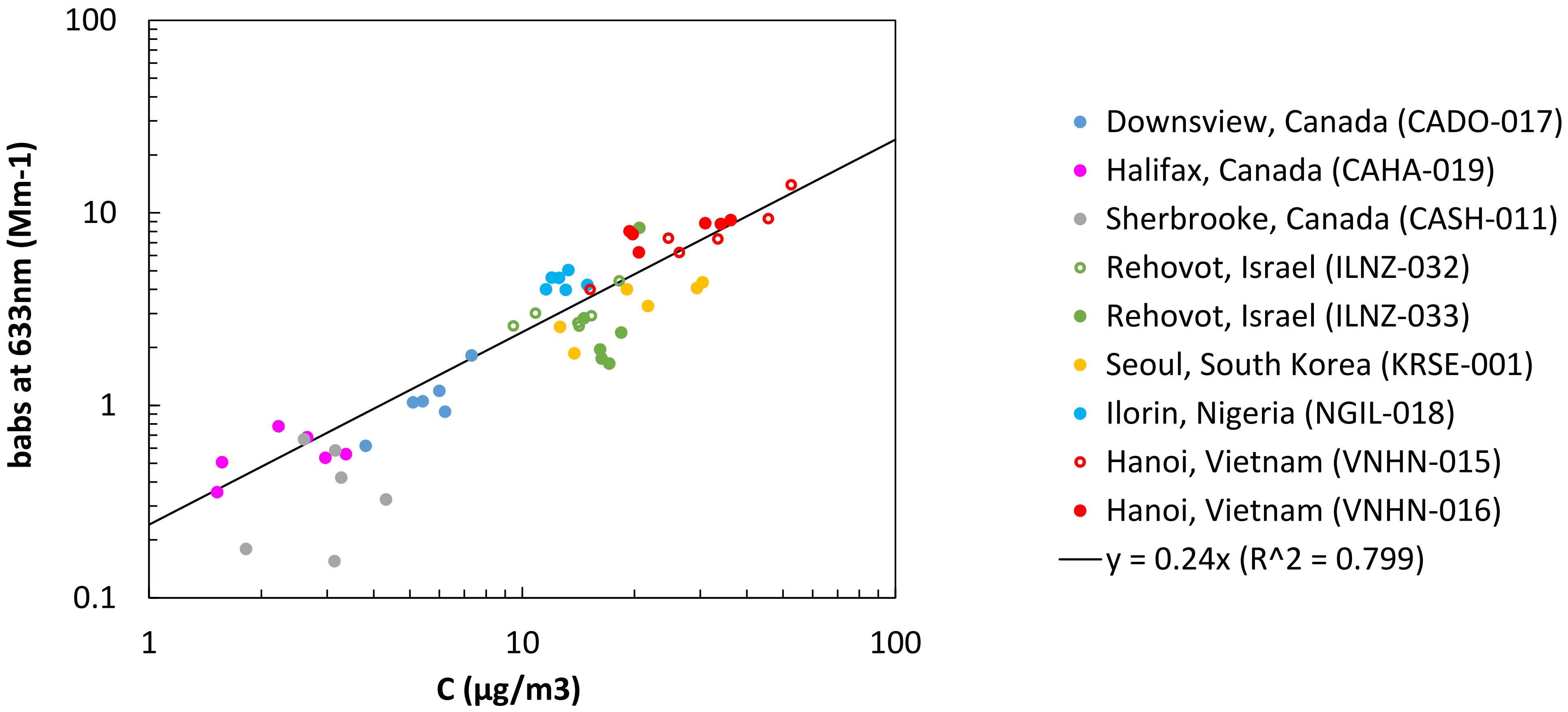


Figure 1. Absorption coefficient b_{abs} of PM2.5 at a wavelength of 633nm versus PM2.5 concentration *C*. Solid line follows the best linear fit, parameterized with an average ***MAC*** value of about **0.24 m^2/g.**

Comparing measurements: SPARTAN vs IMPROVE

- Step II: Calculated Babs of IMPROVE PM2.5 samples using HIPS measurements.

Using empirical power-law relationship (Pandey et al., 2019): $b_{\text{abs}} = \beta f_{\text{abs}}^{\alpha} \left(\frac{A}{V}\right)^{1-\alpha}$

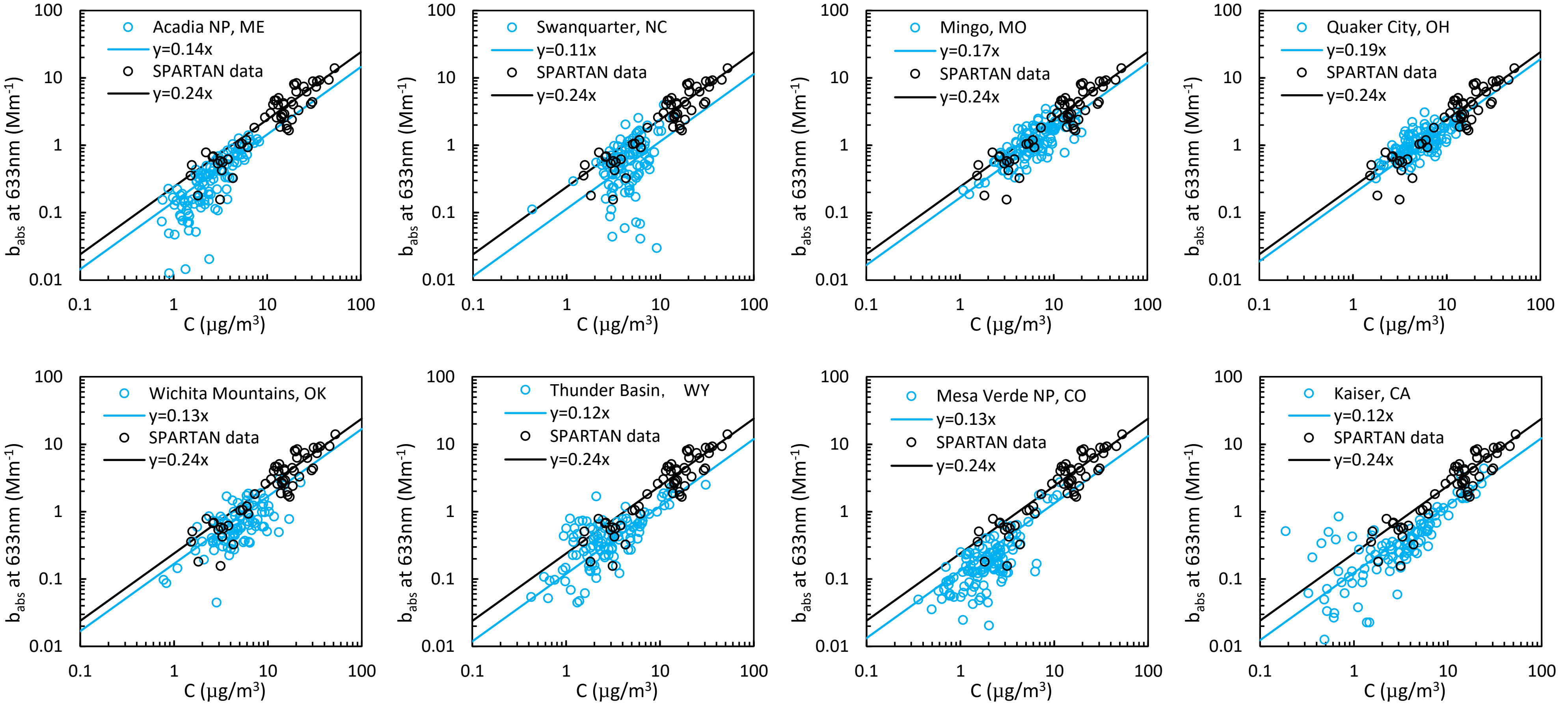


Figure 2. The linear relationship between b_{abs} and C. SPARTAN dataset is compared with that determined from eight IMPROVE sampling sites.