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Multi-wavelength optical measurement to enhance thermal/optical analysis for carbonaceous aerosol

L.-W. A. Chen et al.

Correspondence to: L.-W. A. Chen (antony.chen@unlv.edu)

Table S1. List of abbreviations and acronyms used in the paper.

Abbreviations/Acronyms	Descriptions
A	Filter sampling area
ATN, ATN_{λ}	Transmittance attenuation (general, at wavelength λ)
BC, BC_d	Black carbon (general, diesel elemental carbon equivalent)
BrC	Brown carbon
CV-RMSR	Coefficient of variance of root mean square residual
EC, ECR, ECR_{λ}, ECT, ECT_{λ}, [EC]	Elemental carbon (general, reflectance adjusted, reflectance adjusted at wavelength λ, transmittance adjusted, transmittance adjusted at wavelength λ, areal concentration on filter)
He	Helium
IMPROVE	Interagency Monitoring of Protected Visual Environments
MAE, MAE_{λ}, $MAE_{\lambda,EC}$	Mass absorption efficiency (general, at wavelength λ, of elemental carbon at wavelength λ)
M_{λ}	Multiple scattering effect coefficient at wavelength λ
Ne	Neon
OC, OCR, OCT, OCR_{λ}, OCT_{λ}	Organic carbon (general, reflectance adjusted, reflectance adjusted at wavelength λ, transmittance adjusted, transmittance adjusted at wavelength λ)
PM, $PM_{2.5}$	Particulate matter (general, less 2.5 μm aerodynamic diameter)
POC	Pyrolyzed organic carbon
R, LR, LR_{λ}, FR, FR_{λ}	Reflectance (general, laser relative, laser relative at wavelength λ, filter absolute, filter absolute at wavelength λ)
RD	Relative difference
T, LT, LT_{λ}, FT, FT_{λ}, $FT_{\lambda,i}$, $FT_{\lambda,f}$	Transmittance (general, laser relative, laser relative at wavelength λ, filter absolute, filter absolute at wavelength λ, filter absolute at wavelength λ before thermal analysis, filter absolute at wavelength λ after thermal analysis)
TC	Total carbon
TOA	Thermal/optical analysis
TSA	Thermal/spectral analysis
V	Filter sampling volume
α, $\alpha(\lambda)$, α_{BC}, α_{BrC}	Absorption Ångström exponent (general, at wavelength λ, of black carbon, of brown carbon)
b	Regression intercept
b_{abs}	Absorption coefficient
m	Regression slope
p	T-test p value
β_{λ}	Shadowing effect coefficient at wavelength λ
λ	Wavelength
τ_a, $\tau_{a,\lambda}$, $\tau_{a,\lambda,BC}$, $\tau_{a,\lambda,BrC}$	Absorption optical depth (general, at wavelength λ, at wavelength λ due to black carbon, at wavelength λ due to brown carbon)

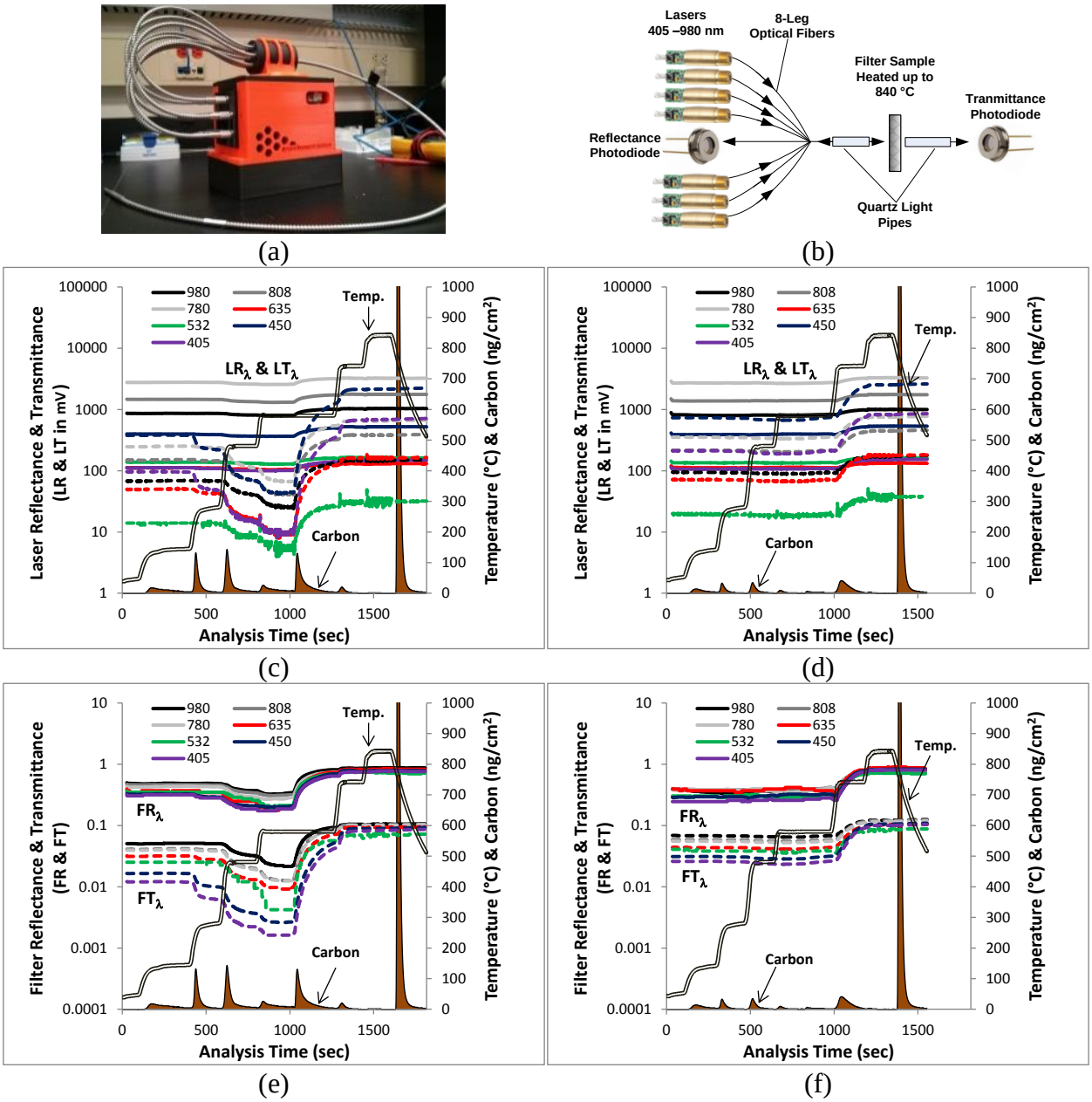

Figure S1. Configuration of (a) the multi-wavelength module and (b) interface to a thermal/optical carbon Analyzer. Example of typical thermal/spectral analysis (TSA) thermogram for: (c) Fresno ambient and (d) diesel exhaust samples. Laser reflectance (LR_λ, solid lines) and transmittance (LT_λ, dashed lines) at 7 wavelengths (405, 450, 532, 635, 780, 808, and 980 nm) are reported in millivolts (mV) as detected by the photodiodes. Absolute filter reflectance and transmittance (FR_λ/FT_λ) for (c) and (d) are shown in (e) and (f), respectively, after calibrating LR_λ and LT_λ against reflectance and transmittance measurements by the Lambda 35 integrating-sphere spectrometer. FR_λ is between 0.1 and 1 (i.e., 100%) while FT_λ is generally <0.1 (10%). The temperature steps follow the IMPROVE_A protocol: OC1 (140°C), OC2 (280°C), OC3 (480°C), OC4 (580°C), EC1 (580°C), EC2 (740°C), and EC3 (840°C) with oxygen introduced at the beginning of EC1. The last carbon peak corresponds to the internal methane standard.

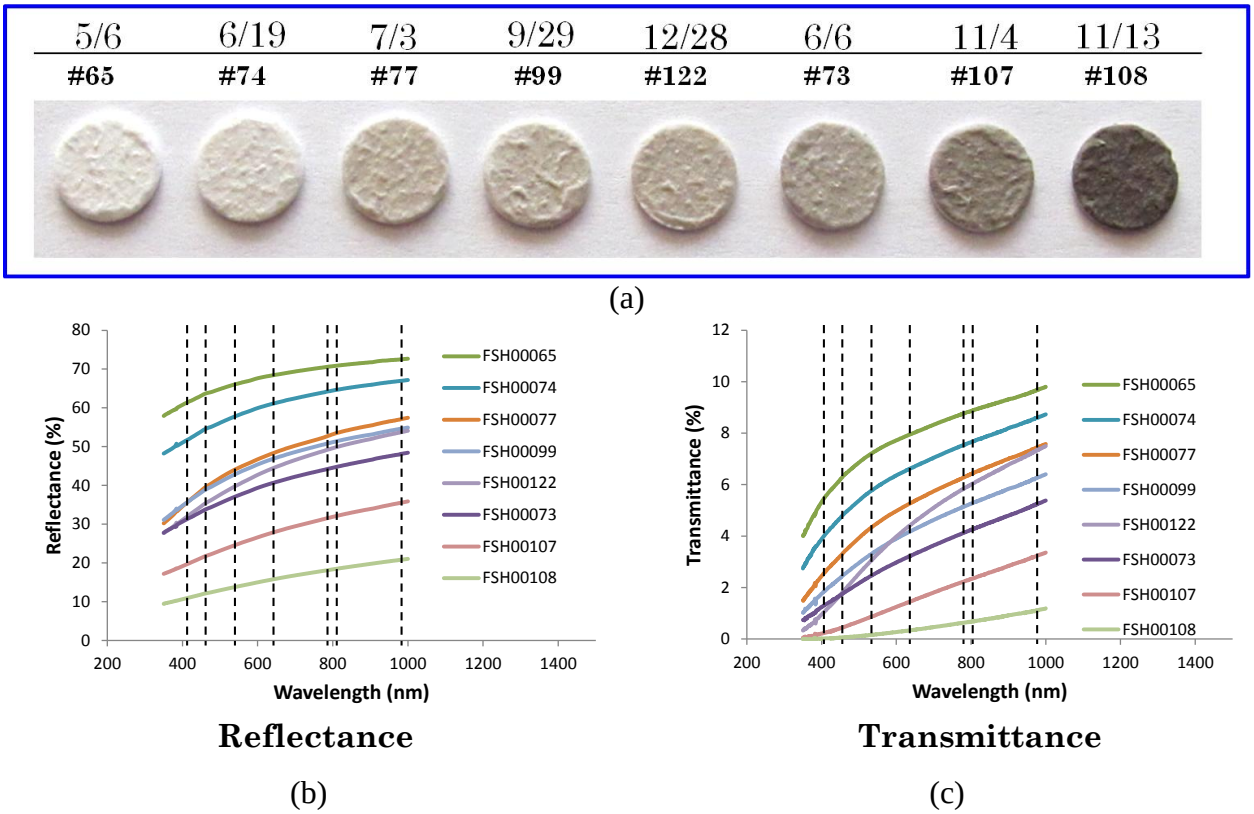

Figure S2. (a) Fresno Supersite $PM_{2.5}$ samples acquired from year 2003 serving as transfer standards for calibrating the reflectance and transmittance measurement of a multi-wavelength carbon analyzer. Also shown are the spectral (b) reflectance and (c) transmittance of these samples as quantified by an integrating-sphere spectrometer (Lambda 35, Perkin Elmer, Massachusetts, USA). Dashed lines correspond to wavelengths of the thermal/spectral analysis by the multi-wavelength carbon analyzer.

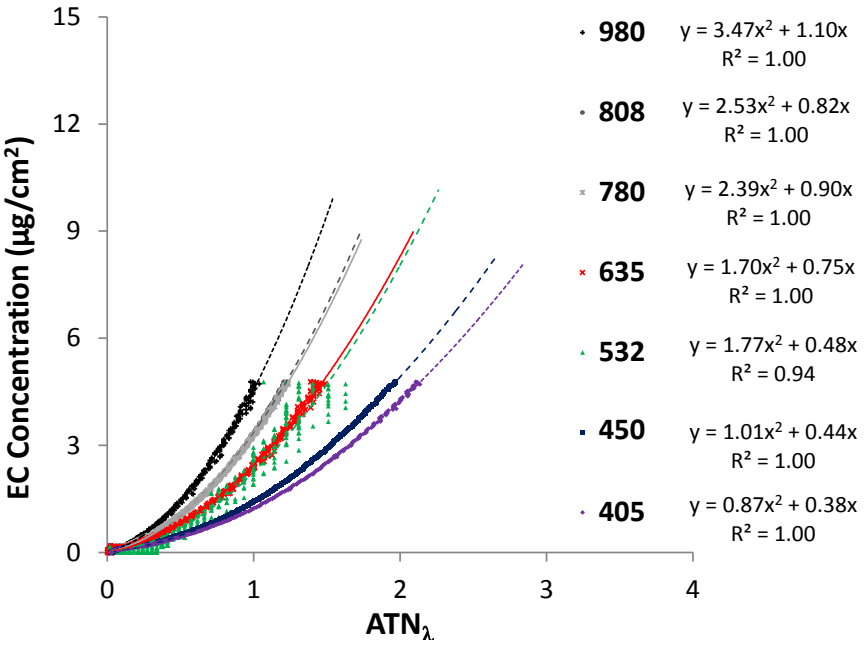

Figure S3. Calibration of ATN_λ of the 7-wavelength carbon analyzer with EC loading ([EC]) measured during the EC2 step of IMPROVE_A analysis of a diesel exhaust sample (CIFQ074, acquired from the Gasoline/Diesel Split Study). Regressions are based on Eq. (6).

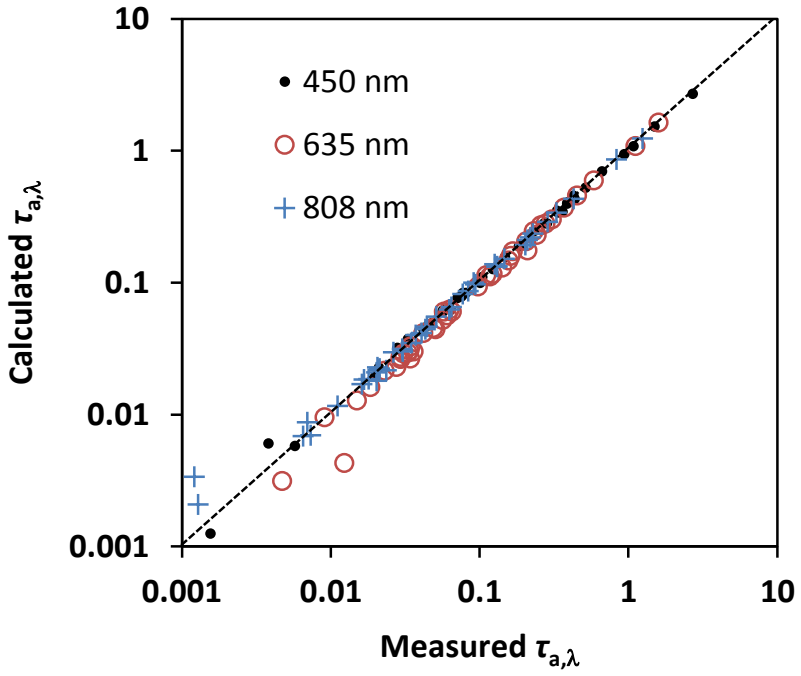

Figure S4. Measured $\tau_{a,\lambda}$ (450, 635, and 808 nm are shown) compared with $\tau_{a,\lambda}$ fitted from Eq. (7) assuming a two-component model. All samples in this study are included.

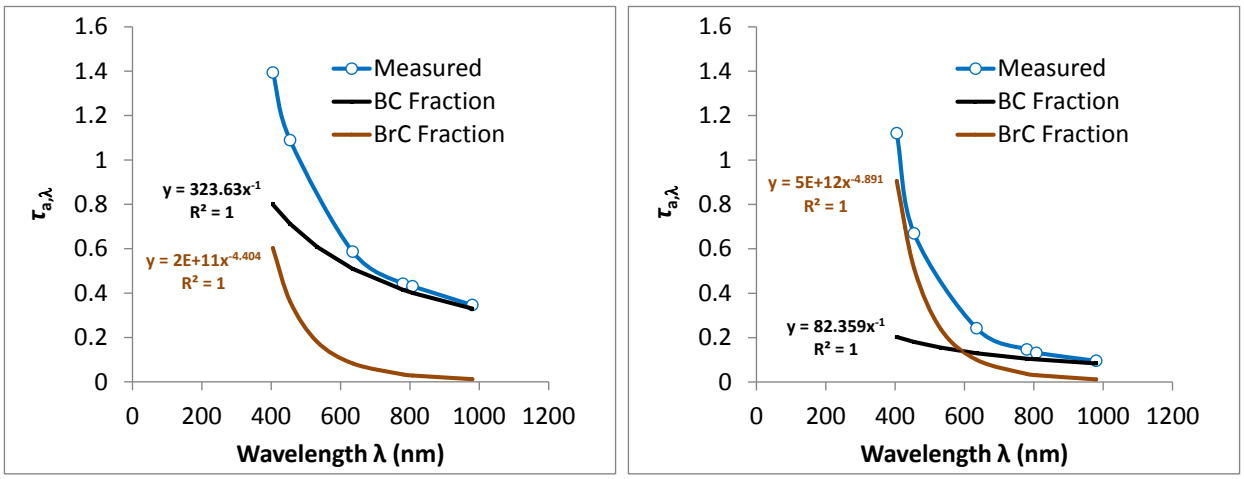

Figure S5. Decomposition of measured absorption optical depth ($\tau_{a,\lambda}$) from (a) Fresno ambient and (b) Reno wildfire samples into the BC and BrC contributions based on their distinct spectral dependence of light absorption. See text for details.