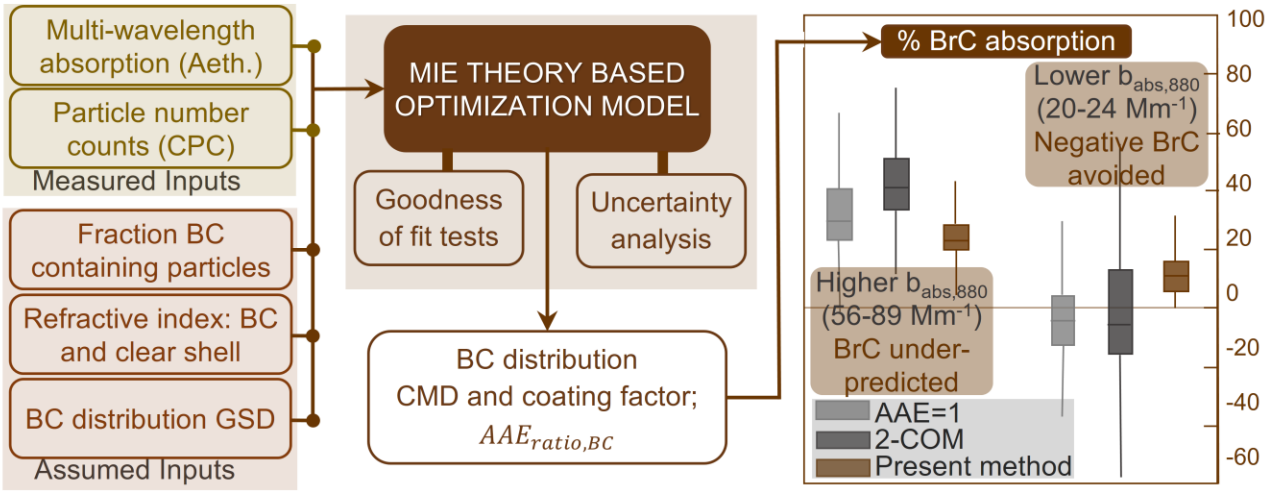
NCAP-COALESCE
CarbOnaceous AerosoL Emissions, Source apportionment & ClimatE impacts
Understanding scientific complexities related to carbonaceous aerosols focussing on issues underlying their origin and fate, and their role as drivers of regional climate change over India.

Research BRIEFS

Estimation of real-time brown carbon absorption

Taveen S Kapoor[1], Chandra Venkataraman[1,2], Chirantan Sarkar[1,4], Harish C. Phuleria[1,3], Abhijit Chatterjee[5], Gazala Habib[6], Joshua S Apte[7]

[1]Interdisciplinary program in Climate Studies, [2]Department of Chemical Engineering, [3]Environmental Science and Engineering Department, Indian Institute of Technology Bombay, Powai, Mumbai, India. [4]Department of Physics, Bose Institute, Kolkata – 700054, India. [5]Environmental Sciences Section, Bose Institute, Kolkata, India. [6]Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi, India. [7]Department of Civil and Environmental Engineering, University of California, Berkeley, Berkeley, United States of America.



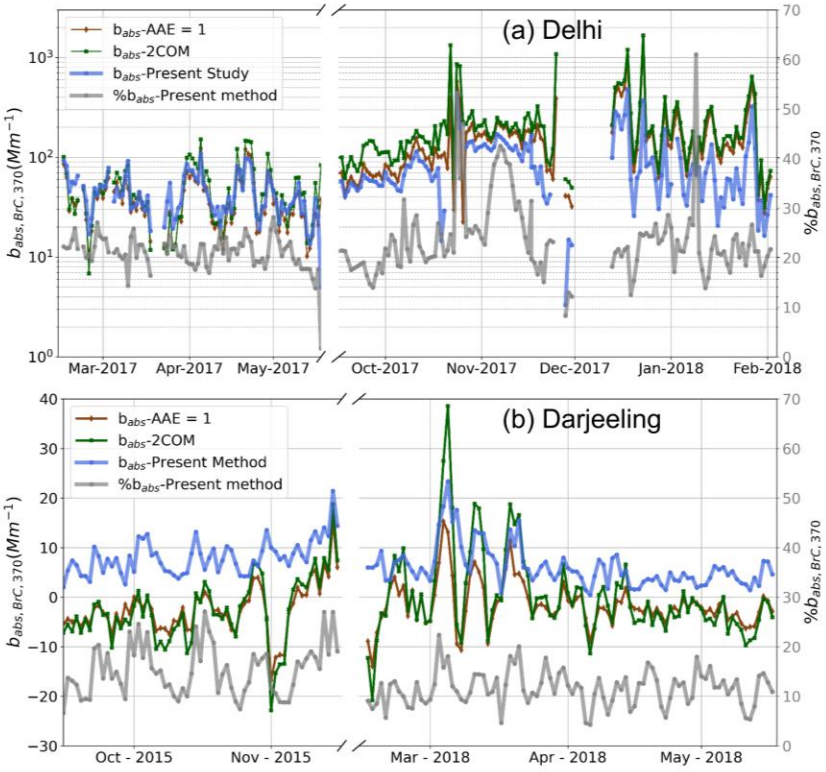
Key highlights:

- Mie model with spectral observational constrains to estimate brown carbon absorption.
- BrC estimates within 32% uncertainty; larger values during agricultural stubble burning.
- Estimates at distinct sites: Delhi 18-117 Mm^{-1} (15–29%); Darjeeling 2-12 Mm^{-1} (5–21%).
- Widely applicable to prevalent spectral absorption & particle count measurements.

Summary of your Research:

Methods to estimate absorption of brown carbon (BrC), a significant fraction of atmospheric absorption, rely on estimating the difference between total measured absorption at near-UV, and that of black carbon (BC). Extrapolation of absorption measured at near-IR wavelengths (assumed exerted by BC alone) use different assumptions of the wavelength dependence of absorption Ångström exponent (AAE_{BC}). Here, we develop an improved method exploiting real-time multi-wavelength absorption and particle count measurements in a Mie based optimization framework, incorporating spectral observational constraints (measured absorption at 880 nm

and $AAE_{880-660}$). An optimization approach, using a Mie model with core-shell and core-gray shell mixing schemes, is used to derive BC size distribution parameters (absorbing core diameter and scattering shell thickness). Goodness of fit (Mie optimization model vs. measurement) was R = 0.77–0.94 (near-IR absorption) and within 4%–30% for BrC estimation. A sensitivity analysis of input parameters (BC geometric standard deviation and refractive index) bounded estimated BrC of 32%. Application to a polluted urban site (Delhi) and a regional background site (Darjeeling) estimated BrC absorption (% contribution) at 370 nm as 18–117 Mm^{-1} (15%–29%) and 2–12 Mm^{-1} (5%–21%), respectively. Estimated BrC absorption was larger at the regional background site (Darjeeling) but smaller at the polluted site (Delhi) when compared to constant AAE and two-component approaches. Method efficacy is reinforced through larger estimated BrC absorption at Delhi coinciding with agricultural stubble burning periods in North India. The developed method uses multi-wavelength absorption observational constraints to improve the robustness of BrC estimation.



Take away/conclusion :

- A new method was developed to estimate BrC absorption; it is theoretically and observationally releavant and uses commonly available aerosol measurements
- Goodness of fit and sensitivity to input parameters as well as the core–gray shell mixing scheme provide robustness to the estimated BrC absorption.
- Application of the method to data from two contrasting sites revealed that the traditional methods are likely misattributing BrC absorption, and the misattribution is not always biased high or low.

Research Article

Citation

Kapoor, T. S., Venkataraman, C., Sarkar, C., Phuleria, H. C., Chatterjee, A., Habib, G., & Apte, J. (2022). Estimation of real-time brown carbon absorption: An observationally constrained Mie theory-based optimization method. Journal of Aerosol Science, 106047.

Link:
https://doi.org/10.1016/j.jaerosci.2022.106047

National Co-ordinator

(NCAP-COALESCE Project)
Interdisciplinary Programme in Climate Studies

Indian Institute of Technology, Bombay
Powai, Mumbai-400076, India

Phone: 91-22-2576-5141

https://ncapcoalesce.iitb.ac.in/