Sources and Light Absorption Properties of Black Carbon over Delhi

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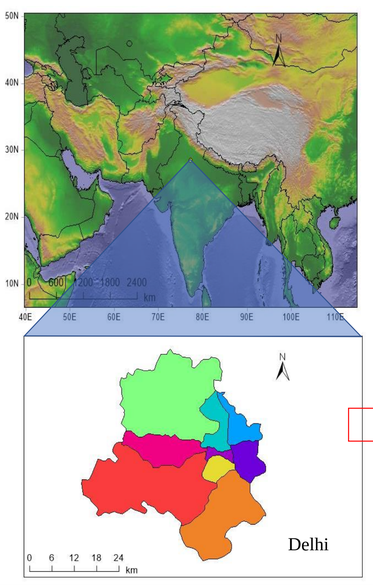
Introduction

Black carbon (BC) has a strong light-absorbing property and high concentration in the atmosphere that makes it an important atmospheric pollutant. It is a second-largest heating agent after CO_2 and play an important role in climate change. It is a product of incomplete combustion of fossil fuel (FF) or biomass, e.g., vehicular emission, forest fire, agricultural waste residue burning, etc. Globally, biofuel, FF, and biomass burning (BB) sources contributes 20%, 40% and 40% to the total BC in the atmosphere, respectively. These fractions can significantly alter for typical urban or rural locations, where vehicular emission dominates in the urban environment and BB dominates in the rural environment. BC and brown carbon (BrC) are key absorbing components of aerosols, formed during the burning of carbon-containing material and positively impact climate radiative forcing.

The BC source apportionment and bifurcation of its sources into BC_{bb} and BC_{ff} is important to understand its properties, and this will help in policy formation for BC abatement. The monthly and seasonal variations of all the properties are discussed in detail to understand the temporal variation of BC sources and their climatic effects. This study will be useful to the government agencies to understand the BC sources and help better communicate with the general public and make them aware of the health benefits of good air quality and adverse health effects of bad air quality.

Methodology

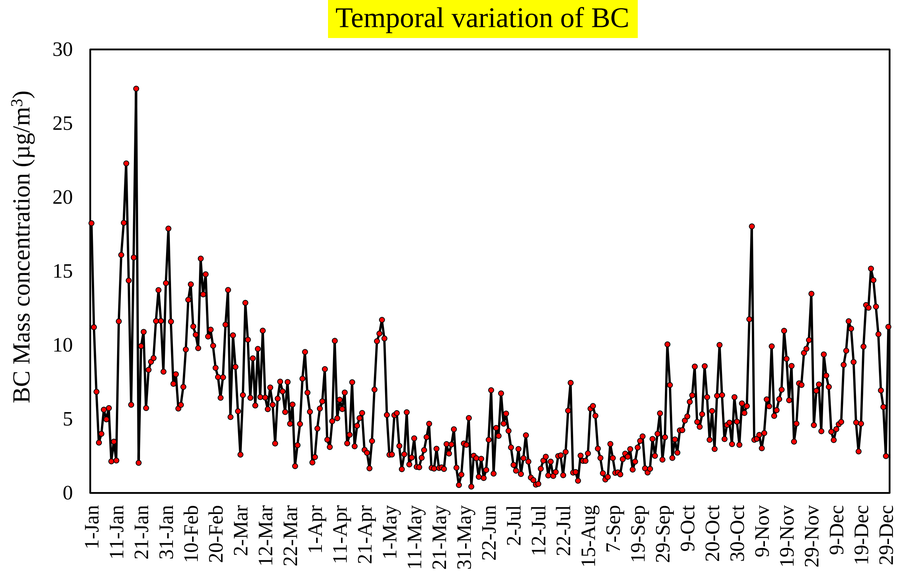


The BC concentration was measured over Delhi (28.5457° N, 77.1928° E) in the Indian Institute of Technology Delhi (IITD) campus from Jan to Dec 2021. The site is around 100m away from the major road and does not have any major industry in the vicinity. Delhi is situated in the upper Indo-Gangetic Plain (IGP) region, where the average temperature rises up to 45°C during summer (Ss) and dips to 9°C during winter (Ws) season. Whereas, the monsoon (Ms) season is a rainy season known for heavy rainfall and high wind speed. The BC concentration was measured with Magee Scientific's® aethalometer (AE33). It measures light attenuation at 370, 470, 520, 590, 660, 880, and 950 nm which is linearly proportional to the BC concentration.

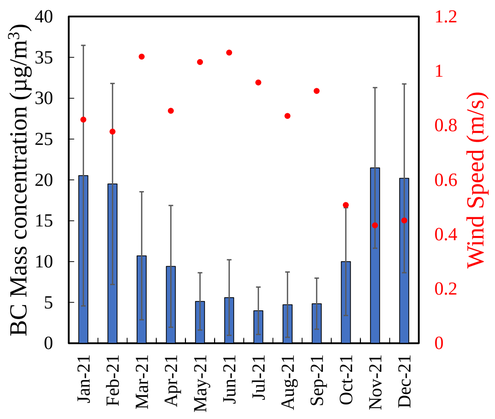
AE33 Aethalometer

Results and Discussion

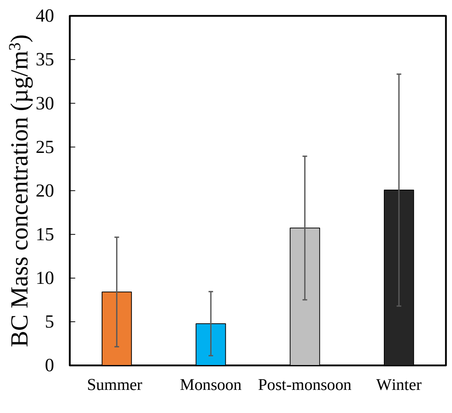
Temporal variation of BC



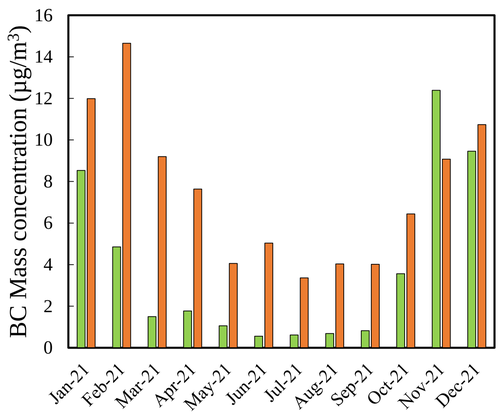
Monthly variations of BC mass concentration and wind speed



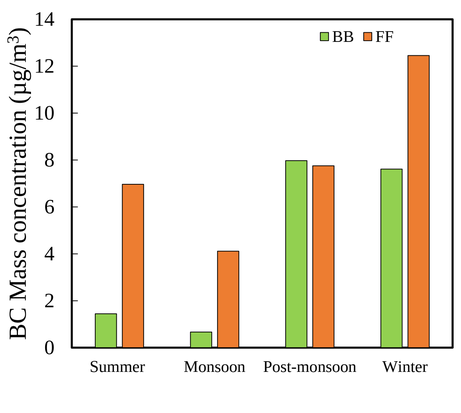
Seasonal variations of BC mass concentration



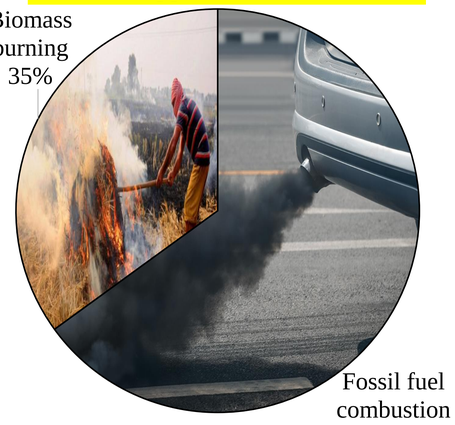
Monthly variations of BC_{bb} and BC_{ff} mass concentration



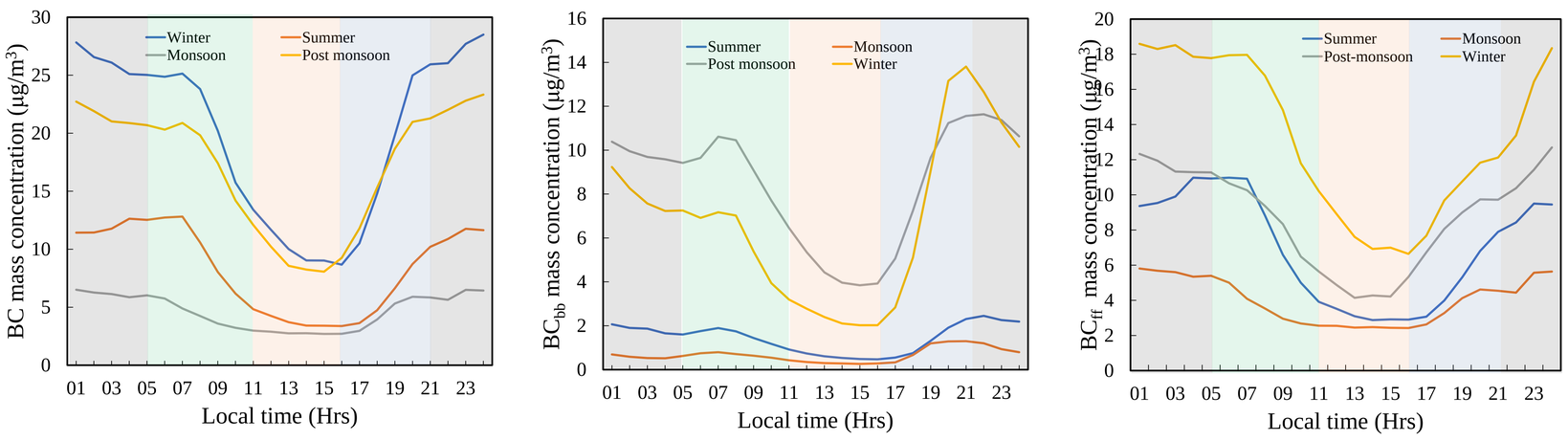
Seasonal variations of BC_{bb} and BC_{ff} mass concentration



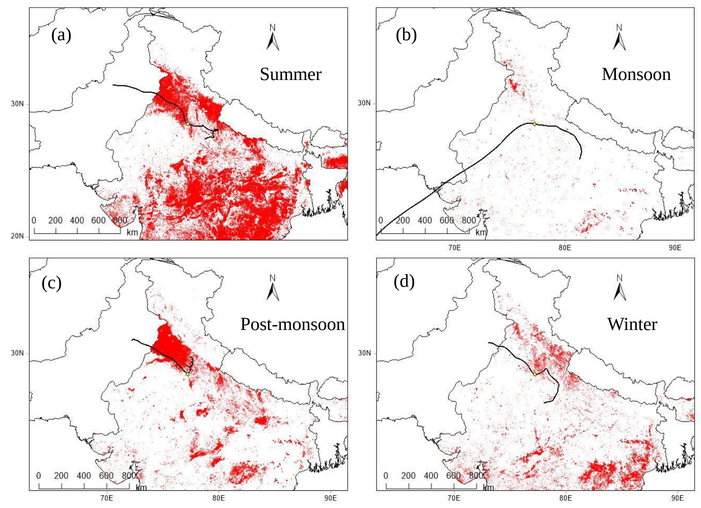
Yearly averaged source apportionment



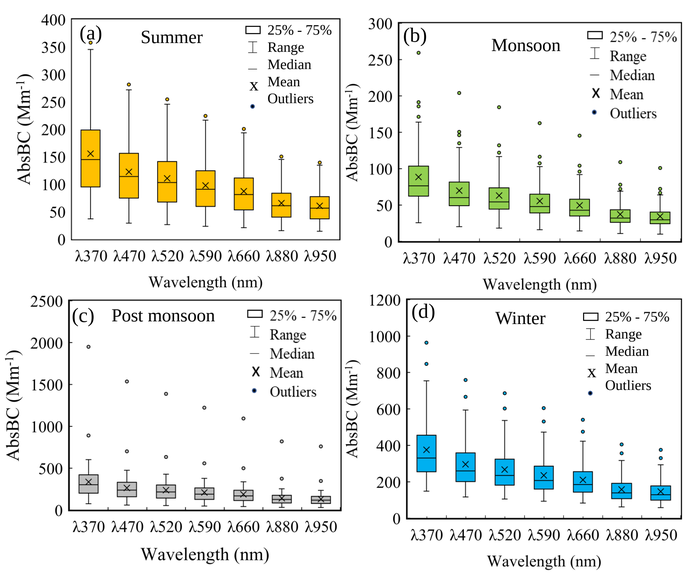
Diurnal variations of BC, BC_{bb} and BC_{ff} mass concentration



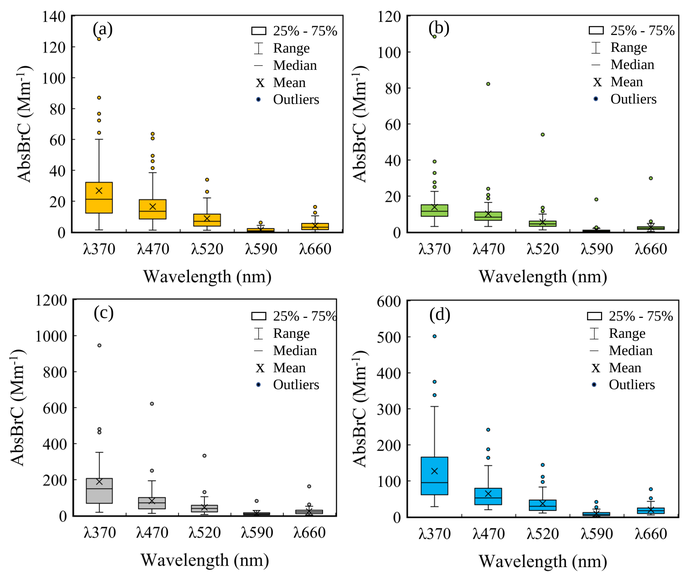
Cluster analysis and fire counts



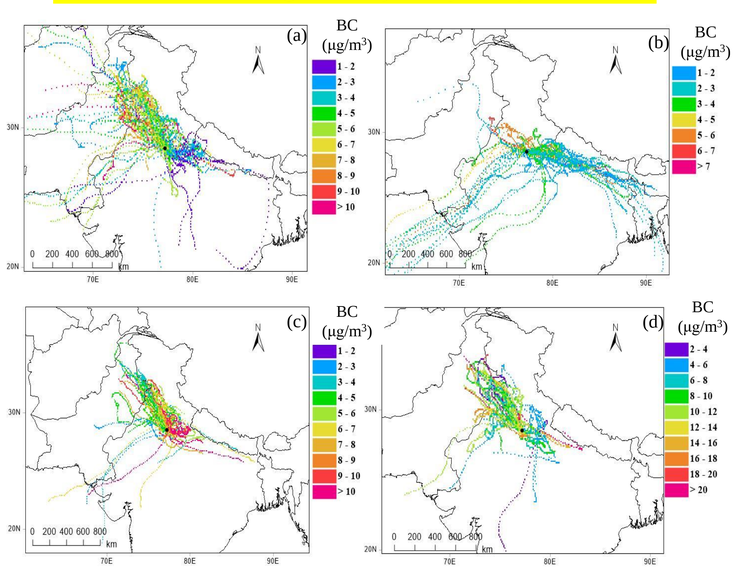
Seasonal variation of BC light absorption



Seasonal variation of BrC light absorption



Concentration weighted trajectory analysis of BC



Conclusion

This study shows the sources, and trajectory analysis of BC and light absorption properties of BC, and BrC over Delhi from January to December 2021. The annual averaged BC concentration was 5.9 ± 4.1 µg/m³ with significant monthly and seasonal variation. The BC is very high during November, December, January, and February and low during May to September 2021. The highest BC concentration is observed during winter season followed by post-monsoon, summer and monsoon seasons. BC concentration during April 2021 is higher compared to March and May 2021. BB events in Punjab, Haryana, Uttar Pradesh and Eastern Pakistan emit BC in large quantities, increasing the BC concentration over Delhi during April, October, and November. Strong diurnal variations in BC, BC_{bb} and BC_{ff} are observed during winter, post-monsoon, and Ss season, while the diurnal variation is weak during the monsoon season. BC and BC_{ff} showed a similar diurnal pattern, while BC_{bb} showed a distinct pattern with two prominent morning and evening peaks. These peaks are due to the burning of dry leaf, wood, and solid waste for heating purposes and household cooking. During the entire study, BC is dominated by BC_{ff} except for November 2021. During November 2021, BB in northwest and eastern regions increases the BC_{bb} concentration over Delhi. The health risks associated with BC are highest during winter season, followed by post-monsoon, summer, and monsoon seasons. Among the selected health issues, the risk is highest for DLF followed by LBW, CM, and LC. The light absorption by BrC is significant in the UV region and decreases remarkably in the visible region, while Abs_{BC} is contributed significantly to Abs throughout the spectrum. Abs_{BC} is highest during the Ws season, while Abs_{BrC} is highest during the post-monsoon season.

Acknowledgement

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