Reviewer Comments

Divergent Trends of Black and Brown Carbon Driven by Anthropogenic Emissions and Open Biomass Burning Across Asia

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General assessment

This manuscript examines BC and BrC trends across Asia during 2012-2019 using GEOS-Chem and RF-SHAP analysis, and evaluates the associated radiative effects. The regional contrasts are relevant to understanding the consequences of emission controls. However, the treatment of BrC photobleaching and the evidence supporting trend attribution require further assessment. I recommend major revision.

Major comments

1 BrC photobleaching

Section 2.1.2 and lines 295-297. Photobleaching is omitted, but the conclusions state that its influence on the multi-year trend is limited because the effect is unlikely to vary substantially across years. This assumption needs support. The proposed seasonal redistribution of burning could change exposure to sunlight, ambient conditions, and atmospheric aging, making the effective bleaching influence variable. Please assess whether the regional trends and BrC/BC radiative ratios remain consistent under plausible bleaching treatments, at least for representative years or contrasting seasons, and revise the claims of robustness accordingly. Please also consider differences in bleaching susceptibility among BrC components, including strongly absorbing fractions that may resist bleaching (e.g., Jiang et al., 2026, doi:10.1021/acs.est.5c11955).

2 SHAP analysis and trend attribution

Section 2.3 and Fig. 3. Mean absolute SHAP values describe feature importance across the dataset. Large values can arise from seasonal variability or individual fire events and do not by themselves identify the drivers of the 2012-2019 trend. Please demonstrate how the SHAP results support the trend attribution, for example by examining the temporal evolution of signed SHAP contributions. State the spatial and temporal definition of each RF sample and the sample size. Since random splitting can place correlated observations in both training and test sets, please assess the stability of performance and feature rankings when entire years are held out.

3 Trend uncertainty

Section 2.2. Please state the STL settings and explain how statistical significance was determined. Regression on a smoothed trend component may underestimate uncertainty when serial dependence is ignored. Report trend confidence intervals using a method that accounts for temporal dependence, and assess sensitivity to the selected years. This is particularly relevant to Southeast Asia, where the eight-year record includes substantial ENSO-related fire variability.

4 Interpretation of burning restrictions

Sections 3.2.1 and 4. The manuscript links seasonal redistribution and increases in OBB to straw-burning restrictions. Please provide directly relevant evidence if available. Otherwise, present this policy link as a possible explanation and soften causal wording in the abstract and conclusions. A shift in burning season should also be distinguished from an increase in annual emissions.

Minor comments

1. Section 3.3. Please state clearly that the increasing ratio of BrC to BC radiative effects in East Asia reflects largely maintained BrC absorption together with declining BC absorption.
2. Fig. S2f. Specify the observation periods for each BrC dataset and limit claims of long-term trend validation to the periods covered by the measurements.
3. Table S5. The factor of two used to convert extract absorption to ambient-particle absorption is noted in the spreadsheet. Please describe this conversion in the Methods and briefly discuss its applicability and uncertainty for water and methanol extracts.
4. Section 2.4 and Fig. 1c. State whether the 365 nm observations were converted to 370 nm before comparison and, if so, which wavelength dependence was used.
5. Fig. S4b. For East Asian BrC, the anthropogenic trend (-0.039) plus the OBB trend (+0.023) gives -0.016, whereas the total trend is reported as -0.011 $\mu g\ m^{-3}\ yr^{-1}$. Please reconcile these values or explain how the trend estimation procedure produces this difference.
6. Sections 3.2.1 and 3.2.2. The OBB-related BrC and BC trends in Sect. 3.2.1 should cite Figs. S4b and S4a, respectively. The anthropogenic BrC and BC trends in Sect. 3.2.2 should cite Figs. S4d and S4c, respectively.
7. Fig. S6 caption. Correct the panel references to BC in panels (a), (c), and (e), and BrC in panels (b), (d), and (f).
8. Fig. 4a. Revise the panel title to identify the trend in the ratio of BrC to BC radiative effects. The current title, "Trend of BrC/BC", suggests a mass ratio.
9. Table S3. The wavelength 550 nm appears twice with different refractive-index values. Please correct the wavelength labels and confirm the values actually used in the optical calculations.
10. Text S2. Please verify and correct the reported Nanjing observation-site coordinates, particularly the latitude of 38.21°N.
11. Fig. 1 caption and Fig. S2f. Use the absorption-coefficient unit Mm^{-1} ($10^{-6}\ m^{-1}$) consistently and correct the notation "$M \cdot m^{-1}$".
12. Section 2.3, Fig. 3, and Fig. S6. Clarify whether the feature labeled "Anthro-BRsec" represents aromatic VOC emissions, as described in the Methods, and use consistent terminology.
13. Proofreading. Correct "Altough" to "Although" (line 178), "Chian" to "China" (Supplement cover), and remove the extra "t" in "obtained from t" (line 309). Repair the GEOS-Chem DOI links in lines 63 and 305 to https://doi.org/10.5281/zenodo.5500536.