

Review of Chen et al

Comments from the reviewer

This manuscript investigates the long-term (2005–2020) evolution and atmospheric impacts of primary brown carbon (PBrC) aerosols in China – a region marked by intensive human activity and substantial emission shifts over the study period. Using an internal mixing model, the authors comprehensively simulate PBrC surface and vertical concentrations, source contributions, direct radiative effects (DRE), and impacts on O₃ formation across the entire country. A key strength of this work is its nationwide scope rather than a narrow regional focus. While using the PBrC/OC ratio method leads to a recognized underestimation of the PBrC DRE, the authors adequately justify this approach. Overall, despite this limitation, I recommend accepting the manuscript for publication after minor revisions.

Comments are given below:

Major comments:

- 1) Page 12, Line 300-305: The discussion in this section and in other relevant parts (Lines 345-350) of the manuscript (e.g., the graphical abstract) seems counterintuitive. The manuscript reported that as PBrC decreases, its suppression of O₃ weakens – meaning PBrC's "braking effect" on O₃ formation is removed. This should actually contribute to the increase in O₃, but that is not the case it seems (look at graphical abstract). Please explain/clarify?
2. Please explain why PBrC and PM_{2.5} levels declined at different percentage rates between 2005 and 2020. While the authors briefly note that PM_{2.5} levels were dominated by the power and industrial sectors whereas PBrC was influenced mainly by agriculture, it remains unclear how these distinct sources caused the differing decline rates. Government clean air actions typically target regulated and organized sectors like industry rather than unorganized sectors like agriculture or residential heating; thus, further clarification on how these policy dynamics affected the respective emission trends would strengthen the discussion.

Minor comments:

Page 1, Lines 14 and 16: comma missing after “globally” and “underexplored in China”.

Page 2, Line 40: “Although the chemical consist of BrC remains some debates,” Confusing, rewrite it.

Page 3, Line 53: “in regional scale” is redundant.

Page 3, Line 56: “absorptions” should be “absorption”.

Page 3, Line 61: Year information is missing for the citation.

Page 7, Line 184: should be “remains poorly constrained...”

Page 7: Line 188-189: The sentence is confusing: “model’s performance in PM2.5 and gaseous O3 concentrations”.

Page 7: Line 188-189: should be “physical and chemical processes”

Fig. S4: AOD wavelength should be same (380 nm) for both simulated and observed values. Pls recheck.’

Fig S8: Type mistake. In think figure ‘b’ is for ‘TRAN’ not for ‘WSTE’.

Line 377: Typo: “stud3y”?

Line 378: Should be Figure S11. Please check.

Line 396: “insensitive”?