

Review on egusphere-2026-5074: “Black carbon mixing-state heterogeneity influences absorption enhancement: Results from a field study across three seasons”

By Yang et al. (2026)

The authors present a relevant study on mass absorption cross-section (MAC) of rBC by coupling the rBC concentration measured by a single particle soot photometer (SP2) with a multi-angle absorption photometer (MAAP) absorption coefficient. The measurements were performed at a highly characterized typical central European site, Melpitz, Germany between August 2021 and January 2022, being able to characterize the changes of the MAC and the particle mixing state during multiple seasons.

The results are of relevance for the community, since they test the hypothesis of integrating heterogeneity of the particle-to-particle coating and its relevance for the modeling of soot absorption efficiency. The measurements employed are of high quality, and well-integrated into the modelling aspect.

However, I have some comments on the analysis and data presented. Given the length and depth of the comments made by Reviewer #1, with which I concur, I have tried to not overlap them and add a few more important points that I feel should be considered.

Major comments

- **Mie simulations**
 - I would like some comment on the influence of the morphology and geometry of the particles and the limitations introduced by using a core-shell model to compute theoretical MAC values
 - On the same page, some more reasoning for the density and CRI used for the non-BC coatings and the rBC cores.
- **MAC computation:**
 - I agree with the higher robustness introduced by using a SMA regression to obtain the MAC, however, and as it is shown by the authors for some cases for summer and winter, the result is that when there are few points, or the range of the rBC concentration (mrBC in the manuscript) is small, the fit might not be as good as computing the MAC for each averaged interval.
 - Figure S2:
 - In line 143 – 144, it is stated: “Moreover, as shown in Fig. S2, the hourly-resolved MAC didn’t show a significant variation with the MRbulk, due to the broad variability in MAC within each MRbulk range, particularly at low MRbulk”. This is untrue, since the range where the cluster of values is has approx. the same range as in Figure 3. How much would Figure 3 change if it was obtained by binning the points from Figure S2 to the same MRbulk bins?
 - Figure S3:
 - The points are not shown, only the resulting fit appears, this has to be corrected to show both.
- **Results:**
 - **Section 3.3:** Lines 248-249: “In summer, high rBC mass was only observed at MRi < ~1.5”. How can this be deduced from this plot since rBC mass is normalized to the maximum? Include a supp figure without normalization? If presented somewhere else (Fig. S3?), specify.
 - **Sect. 3.4 – Sect 3.5 – Sect. 3.6:**

- I miss more connection between sections 3.4 and 3.5 and 3.6. Also, the end of sect. 3.5 is already commenting on the seasonal variability which is later further commented in sect. 3.6. I would suggest merging/streamlining these two sections.
- Figure 7 and 9 are somehow projections on the y-axis of the 2D histogram showed in Figure 4, grouped by seasonality and MRbulk in different ways. The information provided in Figure 4 should be better exploited in the text, since the 2d distribution shows better where the mode of the size of the rBC core is, and the differences that this implied for the MRi.
- Lines 329-331 *“This implies that the fraction of thickly coated rBC became higher compared to that of thinly coated rBC. In this phase, the enhancement of MAC was less significant compared to MRbulk < 2.”* and lines 337-338: *“[...] , whereas smaller MAC variability was associated with a more heterogeneous mixing state characterized by bimodal MDMR.”* Although the link is (apparently) with Figure 3, I think it would add to the discussion a link with the results shown in Figure 6 and the dependency of MAC with the rBC core diameter.
- **Section 3.7**
 - I would add another layer of uncertainty linked to the inherent limitations of the Mie model approach.

Minor comments

- In lines 107-109 the detection limit of the SP2 is set to 160 nm, however in lines 390 is stated to be 80 nm. Consistency is required. Were the limits of the LEO algorithm used to treat the SP2 data also introduced?
- In lines 207-210, authors state: *“Autumn exhibited a relatively narrow MRbulk (0.02 - 4.38) variation, and the median and mean MRbulk during winter were similar to those in autumn, but the higher fraction of large MRbulk may be associated with lower ambient temperature and higher residential heating emissions in the winter (Zhang et al., 2020; Yang et al., 2025).”* However, not all high values of mrBC and MR_bulk seem to be that well correlated with temperature, I would suggest checking its link with additional meteorological conditions that might be important too – stagnant conditions – as it is also shown in Figure S4.
- In Figure 1, I would encourage the authors to change the date notation from Month-Day-Year to a more European-friendly format, such as Y-M-D or D-Month abbreviated name-Y
- Figure 7, it is mentioned in the caption: *“while the coloured square markers indicate the MAC values (from Fig. 3) corresponding to different bulk mass ratio of coating to 345 core (MRbulk) intervals”*. There are no such as markers in this figure. Please either include them somehow, or correct this.
- Figure 8: How can MRi<0?
- I would encourage the authors to do a typo check on the document. There are several dots before references, or references without a space with the previous word (e.g., line 132, 164, 243, 306)