

Correspondence to Anonymous Referee #3

The authors extend their appreciation for the constructive feedback received from Anonymous Referee #3. Below, we present the responses to every comment, with the referee's remarks in blue font and the authors' responses in black.

Comments to the manuscript: “Optical properties and simple forcing efficiency of the organic aerosols and black carbon emitted by residential wood burning in rural Central Europe” by Cuesta-Mosquera et al.

In this manuscript the Authors present the results from a winter measurement campaign performed in a rural European site strongly affected by RWB emissions and characterized by strong thermal inversions. The site location and emission characteristics allow for a robust optical characterization of RWB OA. The results from a simple forcing efficiency estimation are also reported.

The manuscript is well written and the results consistently reported. The paper can be published in ACP after some minor revisions reported below.

- 7, line 171: Has the article about the harmonization factor H been published at the time of this review? Can the authors provide some more information? One reference about H (1.76) is Savadkoohi et al., 2023 (<https://doi.org/10.1016/j.envint.2023.108081>).

Response: Many thanks for the recommendation and the reference to Savadkoohi et al., 2023. The paper discussing the Harmonization factor is still not available. However, we have included a reference to a report from ACTRIS where the harmonization factor is introduced (Müller and Fiebig, 2021, <https://www.actris-ecac.eu/particle-light-absorption.html>). Furthermore, we have referenced Savadkoohi et al. (2023) as a study case where the AE33 absorption coefficients are harmonized using the H factor from ACTRIS.

Further information about the harmonization factor H has been included in the revised version of the manuscript (see lines 186 to 199).

- In this manuscript the signal at 950 nm is used as reference to calculate eBC, MAC and to separate BC and BrC contribution to absorption in the 370-880 nm spectral range. Normally the 880 nm signal is used for these objectives as a compromise between excluding the absorption from OA and having a good signal-to-noise ratio. By using the 950 nm as reference, automatically a small OA absorption at 880 nm is allowed, whereas OA absorption is usually (in literature) excluded at this wavelength. Can the authors provide some more details about the choice of using the 950 nm?

Response: The decision to use 950 nm as a reference wavelength to calculate eBC mass concentrations, aimed to extend the wavelengths available to calculate optical properties, including the AAE, do BC/BrC apportionment and estimate Simple Forcing Efficiency. Given the large pollution and light absorption measured at Loški Potok, we consider that the signal-to-noise ratio in the near-IR is not an issue in our study.

- It might be more useful to present in figure 3d the first derivative of the potential temperature with horizontal lines highlighting weak, strong, unstable, neutral conditions.

Response: Thanks for this observation. Figure 3d was modified to show the potential temperature gradient.

- Equation 13: Is there any specific reason why an AAE of 1 was used?

Response: We used $AAE_{BC} = 1$ as an approximation based on the generalized use among the aerosol scientific community. Nevertheless, we understand that AAE_{BC} might range predominantly between ~0.8 to 1.4; this deviation was included in our calculations of uncertainty for the apportioned light absorption coefficients of BC and BrC.

- 17. Lines 379-389: Here the authors present the Angstrom exponent of BrC absorption that was calculated between 370 and 590 nm. Thus, the BrC absorptions calculated at 660 and 880 nm were excluded from the BrC AE calculation. In fact, the authors explain that if the BrC AE is calculated between 370 and 880 nm, then a 50% overestimation of BrC absorption at 370 nm (obtained from equation 14) is observed.

However, it would be useful if the authors could provide more details about how they “simulated” the BrC absorption at 370 nm using the calculated BrC AE. If I well understand, the “simulated” BrC absorption at 370 nm was calculated from the BrC at 880 nm using the BrC AE from 370 and 880 nm and this “simulated” BrC absorption at 370 nm overestimates by 50% the BrC absorption obtained using equation 14. Consequently, the best simulation of BrC absorption at 370 nm was obtained using the AE from 370 and 590 nm. Thus, the BrC absorption at 370 nm was simulated from the BrC absorption at 590 nm using the AE calculated from 370 and 590.

Is the procedure described above the one used by the authors?

It would also be useful if the authors could explain in more detail the reasons why the absorptions at 660 nm and 880 nm were reasonably excluded. The authors report that this could be due to the presence of internally mixed aerosol particles. However, since the procedure described here and used to separate the absorption by BC and BrC is widely used, more details regarding why one needs to go down two wavelengths (from 880 to 590 nm) to calculate the AE should be given.

Response: To determine the light absorption coefficients of BrC in the whole spectrum, we assume that the total absorption corresponds to the contributions of BC and BrC (Eq. 1), and use the mathematical expression describing the AAE (Eq. 2):

$$b_{abs}(\lambda) = b_{abs,BC}(\lambda) + b_{abs,BrC}(\lambda), \quad (1)$$

$$\frac{b_{abs,BC}(\lambda_1)}{b_{abs,BC}(\lambda_2)} = \left(\frac{\lambda_1}{\lambda_2}\right)^{-AAE_{BC}}, \quad (2)$$

To solve the system of equations, we assume that $AAE_{BC} = 1$, and that the total absorption in the near-IR is totally attributed to BC. Therefore, if we take λ_2 as 950 nm (near-IR), we have that:

$$b_{abs,BC}(950 \text{ nm}) = b_{abs}(950 \text{ nm}), \quad (3)$$

Now equation 2 can be rearranged as follows,

$$b_{abs,BC}(\lambda_1) = b_{abs}(950 \text{ nm}) * \left(\frac{\lambda_1}{950}\right)^{-1}, \quad (4)$$

And $b_{abs,BrC}(\lambda)$ can be expressed as:

$$b_{abs,BrC}(\lambda_1) = b_{abs}(\lambda_1) - b_{abs,BC}(\lambda_1), \quad (5)$$

Where λ_1 would be any wavelength and the apportioned light absorption can be calculated for the range 370 to 880 nm.

The apportioned BrC light absorption coefficients are fitted through power law in order to calculate AAE_{BrC} . For this, we initially used the range of wavelengths covered by the AE33 and obtained $AAE_{BrC,370-880 \text{ nm}} = 5.5$. Nevertheless, the fitting along the whole spectrum produced a significant overestimation of the $b_{abs,BrC}$ at 370 nm, one of the most important wavelengths in our study to report

OA optical properties, given the significant contribution of BrC to shorter wavelengths absorption. Consequently, we estimated AAE_{BrC} for two segregated intervals: 370 to 520 nm and 590 to 880 nm. The slopes from each wavelength range are comparatively different, which is a clear indicator that one single AAE for BrC might not be representative; furthermore, existing studies have demonstrated that AAE_{BrC} is strongly wavelength-dependent (Hoffer et al., 2006; Utry et al., 2014). To improve the representation of the slope change, we have modified Fig. 7a using a log-log scale:

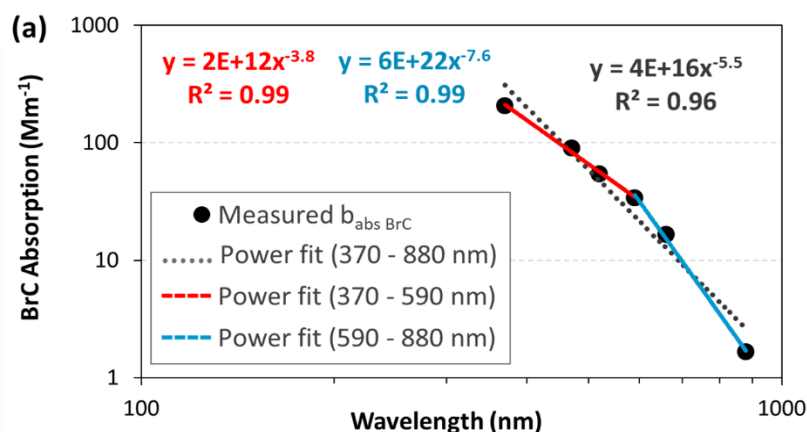


Fig. 7a: Power law fittings of the BrC absorption spectra in log-log scale

The value of AAE is an indicator of aerosol chemical composition and is presumably influenced by the aerosol size. The impact of AAE_{BrC} calculated from segregated wavelengths has been studied. For instance, Utry et al. (2014) obtained improved correlations between the particle modes and geometric mean diameters, levoglucosan/total carbon ratio, and OC/EC ratio using an AAE_{BrC} computed for the range of 355 to 532 nm; in contrast, comparatively poorer correlations were obtained when AAE_{BrC} was estimated for the spectral range 266 to 1064 nm. We have this reasoning in the manuscript (see lines 418 to 424).

References

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