

Review on egusphere-2026-4423: “Photochemical ageing drives the browning of urban outflows through secondary brown carbon production” by Velazquez-Garcia et al.

The authors continue to exploit the data obtained by an impressive set-up of measurements with an extensively equipped airplane around the metropolitan area of Paris (France), as shown from their recent manuscript published in Velazquez-Garcia et al., 2026. The dataset is of great quality and provides good insight into the processes that aerosols particles emitted from a large urban site undergo after their emission into the atmosphere.

In particular, this manuscript focuses on the photo-chemical ageing of aerosol particles and their effects on their absorbing properties by using as proxies the relative variation within the plume of OA-to-BC, chemical compound tracers and the change in AAE of the particles. The manuscript is well structured and provides insightful results, however it requires a thoughtful review and clarity on the way the results are presented. A more in-depth analysis on what are the uncertainties and limitations of the measurements is also required.

Main comments

1. The black carbon (BC) used through-out the manuscript is derived from the SP2, therefore it should be referred to as rBC. This is relevant since the way BC is reported in the literature changes and marking-out the method it is measured provides context and allows for better comparability.
2. **Lines 186-190:** What is the measurement uncertainty linked with using extinction - scattering for deriving absorption? Especially under the conditions of very high SSA of the measurements. How could it potentially impact the determination of BC and BrC absorption, and the AAE with the ageing of the plume, as SSA increases?
3. **Lines 196:** Although a AAE value of 1 is used across many studies, have the authors considered using a more sophisticated and tailored to their area of study approach as the 1st percentile of the AAE distribution as described in Rovira et al. (2025)?
4. **Line 206:** “ Δ denotes an enhancement above background”. From this sentence, my understanding is that the enhancement is obtained as the measured BC and OA vs the “background” estimation provided by the CAMS database marked as “BC” regional. However, through-out the manuscript “background” is also used for the out-of-plume measurements as shown in Figure 1, or for the categorization of $\Delta\text{OA}/\Delta\text{BC}$ in Figure 2e. The use of this nomenclature leads to confusion and impairs the correct understanding of some of the results. In particular when trying to interpret $\Delta\text{OA}/\Delta\text{BC}$, since Δ is the difference between measurement and background, one would assume $\Delta\text{OA}/\Delta\text{BC}$ to be 0. This needs to be revised, since otherwise the reader has to be constantly making the adjustment between modeled regional background BC measurements and out-of-plume background measurements.
5. **Lines 261-264:** Since there are not that many individual flights, and the variation is larger between flights than between the different dominated scenarios, I would also include Figure S3 in the main manuscript.

Again, use of background and plume dominated is confusing and it is not completely clear how this is obtained, are whole flights marked as “plume” or “background” according to some weight taking into account the CAMS emissions modeling? Are the different parts of the flight separated? I figure it is the latter, but it is not quite clear.

6. **Figure 4:** This caption could be easily reduced by changing the description into, "Evolution of aerosol chemical and optical properties through the relationship between the Organic Aerosol enhancement vs oxidation state proxy bins as a function of a) photochemical age, b) C8 aromatics vs depletion of toluene and c) mean AAE values (450-635 nm)"

More importantly, it should be described why the bins don't match across the subplots. Is it data availability/temporal resolution of the x-axis?

"The box plots represent the distribution of data points per each $\Delta\text{Ox}/\Delta\text{BC}$ bin." Why are there points outside the box in the y-axis direction?

Also, what does the size variation of the points in Figure 4 represent?

7. **Lines 353 - 358 and lines 416-418:** The formation of SOA is estimated by the authors through the changes in the OA/BC ratio and the C8 depletion. The increase of the AAE is linked to the formation of absorbing SOA material, however it could also be due to the changes in the composition and amount of internally mixed OA with the BC cores during the plume ageing, not necessarily to the increase in absorption of the formed SOA. Furthermore, soot collapsing and shape changes in the soot particles can also lead to changes in the absorption efficiencies and their AAE (Forastieri et al., 2018; Corbin et al., 2022; Sipkens et al., 2024).
8. **Line 373:** It would be helpful to know to which measurements the different PC correspond to, to which periods in the plumes
9. **Lines 386 - 387:** It could also be due to the coating of BC with the formed OA and thus making the total BC look more "brown". As the authors also show in Velazquez-Garcia et al. (2026a) using the same dataset, particles become more thickly coated with the plume ageing using the particle diameter to rBC core diameter from the SP2, therefore this is a likely possibility.
10. **Lines 395 - 396:** It should be specified that the OA-to-BC ratio is used for the absorption efficiency of the organic material, not total absorption. Also, see latest work on this for pan-European measurements Rovira et al. (2026).

Minor comments

- Line 52: A reference to the estimated direct radiative effects of BrC is missing.
- Lines 202-205: Are there any studies where the dOA/dBC from mAMS and SP2 is also used? Please indicate them if so.
- Line 216: In Figure 2b, the emission ratios are shown for plume and background, not for urban and background as written in the text. Which is correct? I would suggest revising the nomenclature through-out the manuscript.
- Line 284: Since plume is not emitting, I would modify the sentence so that it just states that the emissions from the urban area are more concentrated in the plume – as per definition.

References

- Rovira, Jordi, et al. "A European aerosol phenomenology–9: Light absorption properties of carbonaceous aerosol particles across surface Europe." *Environment international* 195 (2025): 109185.

- Velazquez-Garcia, Alejandra, et al. "Observational evidence for relative humidity driving black carbon mixing state and absorption enhancement in urban outflows." *Geophysical Research Letters* 53.8 (2026): e2025GL121520.
- Corbin, Joel C., et al. "Size-dependent mass absorption cross-section of soot particles from various sources." *Carbon* 192 (2022): 438-451.
- Sipkens, Timothy A., and Joel C. Corbin. "Effective density and packing of compacted soot aggregates." *Carbon* 226 (2024): 119197.
- Forestieri, Sara D., et al. "Measurement and modeling of the multiwavelength optical properties of uncoated flame-generated soot." *Atmospheric Chemistry and Physics* 18.16 (2018): 12141-12159.