We sincerely thank both reviewers for their thorough evaluation of our manuscript and for their valuable comments and suggestions. Reviewer 1's insights highlighted several unclear sections and weaknesses, which we believe we have addressed in the revised manuscript. Similarly, reviewer 2's detailed feedback was instrumental in improving the clarity and robustness of our study. We believe that these revisions have improved the overall quality of our work, and we greatly appreciate the reviewers' contributions to this process.
In the response, we have used red font for the reviewer's text, and black font for the authors' response. Please note that references to specific lines in the manuscript correspond to the author's track changes file.

REVIEW

Veratti et al.,

Source attribution and estimation of black carbon levels in an urban hotspot of the central Po Valley: An integrated approach combining high-resolution dispersion modelling and microaethalometers

ACP

STAGE 2

General comments

Veratti et al. describe an interesting combination of in-situ monitoring and modelling application to a mid-sized city in the Po valley. The results clearly demonstrate the need to treat the contribution to black carbon (BC) of biomass burning (BB) and traffic (the sole source of fossil fuel – FF) on different spatial scales.

The manuscript is well written (even if somewhat long-ish) and deserves publication after the comments below are addressed. It may become a tool for many municipalities to analyze the sources of primary air pollution and measure the efficiency of abatement.

The especially important comments are the ones that need to be addressed at:

L 148-151

L 491-495

L 587-647

L 634-636

L 638-642

Supplement, Fig. S10

Specific comments

1) Lines 20-26: The terminology on BC and EC can be shortened and Petzold et al. (2013) cited.

The text has been shortened and only the essential information has been retained. See lines 20-26.

2) L 38-51: When discussing the climate effects of BC, cite the latest IPCC report.
The citation to the latest IPCC report has been added, Line 44.

3) L 75, "This approach…": This sentence needs to be replaced by a longer explanation of how filter absorption photometers work. There is a difference between the true absorption measurement (such as photoacoustics or photothermal interferometry) and proxy measurements with filter photometers. Parametrization of corrections needs to be addressed only in the context of the multiple scattering parameter – value 1.3 is used later on.
A more comprehensive explanation of the functioning of absorption photometers has been incorporated into the introduction of the main text. See lines 80-94.

4) L 85: Add the revision of the EU Air Quality Directive, as it requires BC measurements to be taken.
A reference to the revision of the EU Air Quality Directive has been added (lines 111-115).

5) L 109-111, "… or attempted to apportion the sector-specific contribution": This is unclear. Apportionment means ascribing a measured parameter to sources. I think the authors mean: the contribution of sources in the model to ambient concentrations at a site. Please reword.
The sentence has been rephrased (lines 140-141).

6) L 131 and elsewhere: The temperature inversions are mentioned – please add plots demonstrating this in the Supplement.
In the supplementary material, vertical profiles of soundings conducted at S. Pietro Capofiume, located 50 km from the Modena urban area (see Figure 1 of the main text), are presented for January 3rd, 4th, 13th, 14th, 18th, and 19th, 2021, at 00:00 and 12:00 GMT, spanning from Figure S8 to S10.

7) L 142: The inlet temperature of 30 C may lead to losses in BrC and/or coatings from aerosol. There needs to be some explanation on the use of such a high temperature for winter measurements.
The decision to maintain an inlet temperature of 30°C for winter measurements was based on practical considerations. Due to space limitations in the two cabinets, we used existing glass manifold inlets originally designed for reactive gas monitors, which naturally maintain the inlet air at 30°C. This configuration was applied consistently to the MA200s throughout the sampling period to mitigate the effects of humidity variations during aerosol sampling. Previous studies have shown that rapid changes in relative humidity can significantly alter the absorption coefficient of filter-based instruments (Düsing et al., 2019), so our aim was to minimize these effects. As an additional benefit, this approach could reduce to some extent the uncertainties associated with the comparison of simulated and measured BC concentrations (see comment number 12 and related answer).

8) L 148-151: The "additional" correction factor of 1.3 needs a thorough explanation – see comment above (L 75). The MAC values, as reported in the Supplement are quite high when compared to the ones in the literature and the ACTRIS recommended ones (~10 m2/g at 635 nm). An explanation on the choice of the multiple scattering parameter 1.3 and the MAC values, and at least a comparison with the published ones (Zanatta et al., 2016; Savadkoohi et al., 2023) is required.
We have further elaborated on the explanation of the multi-scatter correction factor, expanding on the details provided in the introduction (lines 80-94). We have also provided additional clarification on the rationale for selecting a Cref of 1.3 (lines 184-199). In addition, we have included supporting information on the use of default MAE values in our study (lines 200-205).

To address concerns regarding MAE values, we have performed a comprehensive comparison with the published literature, using data from sources such as Zanatta et al. (2016) and Savadkoohi et al. (2023; 2024). This comparative analysis is detailed in Table S1, where the MAC values used in our study are compared with those reported in the existing literature. It is noteworthy that, although the MAE values for Modena tend to be higher than those reported elsewhere, they fall within the range observed by Gilardoni et al. (2020) and Mousavi et al. (2019) in studies conducted in the Po Valley. Furthermore, our MAE value at 880 nm is consistent with values reported for other European urban areas such as Athens (Savadkoohi et al., 2024), Zurich and Bern (Grange et al., 2020), as well as urban traffic and background locations in Leipzig and Prague for MAE values at 637 nm (Savadkoohi et al., 2024).

9) L 152-158: Was the aggregation of the data achieved by recalculation or averaging? The Bigi et al. (2023a) paper is not clear on that. Additionally, Bigi et al (2023b) was in the meantime accepted in ACP.

The data aggregation process involved recalculating the original data on a 5-minute basis, after which they were averaged to derive hourly values.

10) L 177, "… by multi-wavelength fitting of 1 …": "… by multi-wavelength fitting of Eq. 1 …"?

Yes, there was a typo in the original version of the manuscript. The text has been amended (line 241).

11) L 187, Table 1: Is the "sensor height" meant above ground? If so, please mention.

Yes, 'sensor height' refers to the height of the sensor above the ground. The text has been revised accordingly. (Table 1).

12) L 201-202 and elsewhere: BC was treated as inert in GRAMM-GRAL and NINFA. While this is true for BC, it is not true for the coatings that might accumulate on the BC particles. These coatings increase the MAC and the response of filter photometers overestimated the BC mass concentration (Kalbermatter et al., 2022). The Po valley is a location where BC is coated fast. Modelling the coatings is extremely difficult, but the authors should estimate the uncertainty induced by potential coatings.

We acknowledge that neglecting the accumulation of coating material on BC particles could lead to an overestimation of BC mass concentration, especially for emissions originating outside Modena for which aging processes likely occur. This is a limitation of our current study, as our hybrid modeling system treated BC as inert. As the reviewer pointed out, modeling the mixing state, layer thickness, and composition remains a major challenge (Curci et al., 2019).

Global studies report a range of BC absorption efficiency enhancement (Eabs), with the most relevant range for urban environments falling between 1.2 and 1.6 (Moffet et al., 2009; Bond et al., 2006; Liu et al., 2017; Schwarz et al., 2008). While our analysis indicates that roughly half of the modeled BC concentrations originate from Modena itself, where we assume minimal coating effects (especially for the traffic location), it's plausible that BC from surrounding areas undergoes aging, potentially increasing absorption. To account for this uncertainty, we investigated the effect of varying the MAE within a range of ±20%, reflecting half of the documented Eabs enhancement range. The results of this sensitivity analysis are presented between lines 800 and 828 in the main text and in Table S3 of the supplementary material.

13) L 222, "… 10 nm to 40 m.": I suspect that the authors did not mean spectacularly giant aerosols – µm?

Yes, there was a typo in the measurement unit. The text has been revised. Line 279.

14) L 287, "City emissions" subsection: The description of how EFs were obtained is fairly detailed which is to be commended. The Supplement lists EF diurnal profiles in Fig. S10, but without the unit. It would be wise to report the EF values somewhere, especially in light of comments below.

For traffic emissions, emission factors (EFs) depend on vehicle speed, which varies from street to street. This makes it difficult to summarize a representative emission factor for the whole city. However, to provide more insight into the EFs for different fuel types and Euro emission standards, Figure S15 in the supplementary material shows the exhaust EFs used in this study as a function of driving speed.

For traffic non-exhaust emissions, representative EFs are given in the newly added section 4.2.4. The EFs for traffic re-suspension, according to the methodology used, are given in Table 2 and section 2.5.1 of the main text. Emissions from other sectors were derived from the INEMAR (2023) local emission inventory and therefore derived from annual total expressed as tons per year, but for completeness, representative emission factors and their associated 95% confidence intervals used to derive total emissions reported in the inventory, are given in Table S2 in the supplementary material.

15) L 438, “Meteorology” subsection: This section is very detailed and lacks the parameter which is mentioned as being important later on: the PBL height. Consider moving some of it in the Supplement and adding PBL comparison here.

We agree with the reviewer that the PBL height is a crucial meteorological parameter influencing dispersion processes, making its assessment essential for local-scale modeling. Unfortunately, direct measurements of the PBL height in Modena are not available, making a direct comparison with modeled values impossible. However, we recognize the importance of this parameter and have taken steps to address this limitation within our study.

To provide useful information on the ability of the employed modeling system to reproduce the PBL height, we compared the simulated PBL height, as predicted by NINFA, with estimates derived using the bulk Richardson number from sounding data at 00:00 and 12:00 GMT in the nearby area of S. Pietro Capofiume (Fig. 1). These comparisons are detailed in the revised manuscript (lines 593-624), ensuring that the assessment of this critical parameter is adequately represented.

Additionally, to offer insights into whether GRAL can realistically reproduce the PBL height, we have included a qualitative comparison of the PBL height simulated by GRAL. This analysis indicates that on most days, GRAL produces values close to the observations conducted in the rural area of S. Pietro Capofiume, suggesting that the results may be realistic. However, there are limited episodes during nighttime (00:00 GMT) from 15 February to 7 March 2020 and during daytime (12:00 GMT) from 26 December 2020 to 21 January 2021 where the PBL height is likely overestimated.

Since the comparison between the simulated PBL height by GRAL and observations is qualitatively discussed, we have opted to keep the related plots in the supplementary material (Fig. S5 and S6). The discussion has been added to the main text at lines 593-624.

16) L 491-495, Fig. 4, Fig. 5, L577: The explanation about the thermal inversions and nearby sources causing high BC concentrations at the traffic site sounds overly simplistic. There is an obvious spike in 1-hour averages (!) also at the background station on 2 Jan 2021 and other periods of high concentrations appear at both sites as well. This seems like a meteorological effect, possibly non entirely linear. It may be that the models simply do not capture well the extreme events, this is known to happen with (more or less) linear models (see also comment below on the EFs). The discussion needs to be expanded, taking advantage of suggestions below.

We have critically analyzed the results, focusing more on the meteorological aspects that may have contributed to the high concentration peaks in Modena, and have extended the discussion accordingly.

In the revised version of Section 4.2.1, we have emphasized the challenges faced by the GRAL model in accurately simulating the PBL height over urban areas. While GRAL generally agrees with observations at 00:00 GMT and 12:00 GMT, it struggles to reproduce realistic PBL heights during certain sporadic episodes, particularly under neutral conditions at night. This limitation could hinder the model's ability to capture the very stagnant meteorological conditions typical of the Po Valley.

We acknowledge that different concentration spikes are present at both the stations and this is likely to result from complex meteorological phenomena that can occur in the study area. These meteorological situations are difficult for linear models such as GRAL to capture accurately, especially during extreme events. Based on your suggestions, we have expanded the meteorological discussion in our manuscript. In particular, we have detailed how factors such as strong inversion layers, temporary reductions in wind speed and complex urban meteorology contribute to elevated BC concentrations. The revised text highlights these factors more comprehensively and addresses both observed and modeled discrepancies.

Despite the meteorological explanations, certain concentration peaks, such as the one observed on 4 January, were recorded only at the traffic site and were dominated by fossil fuel contributions. This suggests the presence of local sources, such as high-emitting vehicles passing nearby or idling in nearby car parks. While we acknowledge the limitations of the GRAL model, we also believe that local sources may play a significant role in these specific cases.

Changes in the main text have been reported at lines 652-692.

17) The timeseries in Figs. 4 and 5 should include eBC separated into BC_ff and BC_bb. Makle the figures larger in y-direction for transparency.

Figure 4 and 5 have been modified following the reviewer's suggestion. The figures now display eBC and simulated BC divided by FF, BB and the sum of the two. In addition, the y-axes have been adjusted to better reflect the station concentrations, enhancing clarity and transparency.

18) In addition, the regressions between BC, BC_ff, BC_bb should be shown. They have been performed as results are discussed in the text later on.

The linear regression analyses comparing total modeled and measured BC concentrations, along with those specifically for Biomass Burning-derived BC and Fossil fuel-derived BC, have been integrated into the main text between lines 813 and 828. These analyses are also visually represented in Figure S13 and further detailed in Table S3 for reference.

19) L 525: What is the "inherent underestimation of the traffic flows". Please elaborate. I understand that traffic counts are available.

Simulated traffic flows from the PTV model were combined with historical traffic measurement data from 400 induction loops for traffic light control on the urban and suburban road network, as well as radar Doppler data collected in winter 2016 near the urban traffic station, to estimate typical traffic patterns for both holiday and working days. In response to the reviewer's comment, we compared the traffic data estimated from this combination of simulation and measurement with actual traffic flows measured by 45 induction loop sensors located at traffic lights near the two monitoring stations. The comparison results confirmed the hypothesis of traffic underestimation between 18:00 and 21:00 GMT on 36 out of 57 simulation days. The text has been modified between lines 725 and 729.

20) L 548-549, Fig 6: The reason for the 1-hour delay in the model relative to measurements needs to be investigated in more depth.

The one hour delay reported in Figure 7 mainly affects holidays rather than working days. We believe that the main factor contributing to this overestimation is the emissions modulation profile used for holidays (Figure S12), which appears to be inaccurate for the Christmas period. The traffic emission profile for these simulations, as previously mentioned, is derived from historical traffic measurement data from induction loops and radar Doppler data collected in winter 2016. These data are representative of average traffic situations rather than specific events like Christmas, and may not capture the unique and variable traffic patterns typical of that time of year. Additionally, the modulation profile for BB seems also to produce delayed BC concentrations with respect to observations during the holiday period, suggesting it may not accurately represent the behavior of

domestic activities during Christmas. Conversely, we did not observe the same one-hour delay during working days, making it more difficult to attribute this concentration delay to meteorological conditions.
A brief explanation has been added to the main text at lines 750-751.

21) L 551-554: The "divergent results" should be investigated and the analysis repeated for the time period shared between both stations. Do the differences remain?

As suggested by the reviewer, we have repeated the analysis for the time period common to both stations. The results indicate that at the traffic site, the model's performance is similar to that at the urban background site. Specifically, we observed a mean bias (MB) of 0.42 µg m^{-3}, corresponding to +16% of the normalized mean bias (NMB). The Pearson correlation coefficient between modeled and observed values is 0.34, which closely aligns with the statistics reported for the urban background site. This behavior can mainly be attributed to three episodes where the model failed to accurately capture the daily trends. Between 27-28 December 2020 and on 6 January 2021, the model likely failed to reproduce local meteorological conditions, leading to high concentration estimates for most hours of these days. Conversely, the overestimation observed between 4 and 5 January 2021 was driven by the BB component at both stations. This may suggest that the concept of heating degree days, used to assign daily BB emissions, was not accurate for this specific episode.
The previous considerations have been added to the main text at lines 757-766.

22) L 567: The reference to Figs. S1 and S2 is wrong. Please correct.

The original reference was intended to reflect the different temperatures measured in Modena during both simulated periods, rather than the daily modulation profile of BB emissions. Therefore, the incorrect references have been removed (Line 778).

23) L 587-647, "4.2.3 Dispersion modelling based source apportionment": The Snakey plots are an important visualization tool. It is unclear what are the sources of the uncertainty (for example 52%+/-10% for city contribution to BC). Some of the uncertainties are very small. Please elaborate.

To enhance clarity, we have added details about the uncertainty in each simulated contribution (see lines 874-885). The reference value shown in the graph represents the average result across all simulated scenarios, while the corresponding uncertainty reflects the standard deviation, which captures the spread of these scenarios. We have also updated the total uncertainty for contributions at both urban and background scales. This was done using the root sum of squares method, which is commonly used to combine uncertainties in linear sums. Assuming that the uncertainties are independent, that the relationship between the quantities being summed is linear and that the uncertainties follow a Gaussian distribution, the uncertainty of the sum is calculated as the square root of the sum of the squares of the individual uncertainties.
The results of this analysis show that the standard deviation between simulations performed at the regional scale is generally lower than the same quantity at the city scale, especially for BB emissions. This indicates that when assessing the transport of emissions from regional sources to an urban area of interest at a horizontal resolution of 3 km, the spatial distribution of emissions in the surrounding area becomes a less critical factor. Furthermore, at the same scale, the influence of different BC speciation factors appears to have a secondary effect on long-range transport.

24) L 595-596: Please add an online movie of the maps sowing modelled spatial distributions of diurnal profiles for BC_ff and BC_bb. This is super interesting.

A movie illustrating the diurnal variability of Fossil Fuel - BC, Biomass Burning - BC, and their combined sum for the two simulated periods has been included in the supplementary material.

25) L 634-636: I am very skeptical about the attribution of 50% of BC to non-exhaust emissions. This requires at least a paragraph of explanation, not a single sentence. This result is extreme and highly unexpected. At least street cleaning schedules need to be used to semi-quantitatively explain this with measurements.

In response to this concern, we have added a new section, 4.2.4 Contribution of Traffic Sources, to our manuscript (lines 888-941) to provide a more comprehensive explanation of the methodology used to estimate non-exhaust emissions. While our findings are consistent with those reported by Lugon et al. (2021), which used the same EMEP/EEA methodology, we acknowledge that attributing 50% of BC to non-exhaust emissions might seem extreme. Significant uncertainties are still associated with BC non-exhaust emission factors, particularly for tire emissions, which have a broad range of estimates in the literature.

To address these uncertainties, we tested additional scenarios for each component (tire, brake, and road wear) using correction factors derived from recent direct estimates of tire emissions (Charbouillot et al., 2023; Harrison et al., 2021), brake emissions (Kim et al., 2022; Lyu and Olofsson, 2020) and road surface emissions. The results showed that applying a correction factor derived from recent literature significantly alters the estimated contributions: tire wear emissions decreased from 20% to 5%, brake wear concentrations increased by 1%, and road surface emissions varied from 5% to almost negligible, depending on the correction factor applied. Although these additional scenarios do not provide definitive results, they help outline the range of uncertainties associated with non-exhaust emissions.

A semi-quantitative analysis of street cleaning material was not feasible, as this material was not collected during the sampling period. Furthermore, street cleaning in Modena is limited to certain pedestrian roads where outdoor markets occur, which are not representative of typical busy streets.

26) L638-642: Similarly, the attribution of 19% of BC to Euro 4 vehicles (15% of the fleet) is simplification that does not hold. The authors cire a paper (Jezek et al., 2018) which has shown that 2/3 of the BC emissions are caused by ¼ of the vehicles. Treating the emissions linearly is blatantly wrong. There are super-emitters in the fleet which contribute disproportionately and using the fleet composition as the argument to attribute emissions to Euro 4 vehicles is wrong. Additionally, this is an important conclusion (as noted by the authors – it is included in the abstract) and therefore requires an extended explanation.

As mentioned above, we have added a new section 4.2.4 Contribution of traffic sources to the main text. This section provides additional details on the methodology used to estimate exhaust emissions (lines 942-968).

The representative emission factors for the two simulated vehicle classes (light duty and heavy duty vehicles) were calculated by averaging the EFs of all subcategories, weighted by a combination of fleet composition and estimated annual mileage per vehicle class. This integrated approach allows the fleet composition to be adjusted to reflect the actual average presence of vehicles on the road. The same method is used to calculate the contribution of each sub-category (vehicle type, fuel and Euro standard) to the total emissions of both light and heavy duty vehicles. In addition, emission factors are calculated on the basis of vehicle speed to reflect the real traffic situation.

Our approach also takes into account super-emitters, such as pre-Euro1 diesel vehicles. However, their limited presence in the fleet and the low number of kilometres they travel per year result in a smaller contribution compared to other categories, such as Euro 4 diesel cars. Although the EFs of Euro 4 diesel passenger cars are lower than those of vehicles with older emission standards (Euro 3, Euro 2, etc.), their significant share in the actual fleet composition (number of registered vehicles adjusted by annual mileage per vehicle class) leads to a significant contribution from this vehicle class.

27) Supplement, Fig. S10: What is the source of the diurnal profiles? Were they measured? How?

The diurnal profiles for industrial activities (SNAP 3) and other mobile sources (SNAP 8) were sourced from the emission model Emisurf2020 (https://www.lmd.polytechnique.fr/chimere/), which is commonly used with the chemical transport model CHIMERE (Menut et al., 2021). The diurnal profile for non-industrial combustion (domestic heating activities) was derived from previous modeling studies focusing on the Po Valley (Veratti et al., 2023). The traffic diurnal profile for highways (SNAP 7 - highway) was deduced from direct vehicle counts conducted by Anas S.p.A., the Italian company responsible for road infrastructure, managing the network of national highways and motorways (https://www.stradeanas.it/it/le-strade/osservatorio-del-traffico/archivio-osservatorio-del-traffico). The urban traffic modulation profile (SNAP 7 - urban) was deduced from direct traffic measurements conducted in the city using data from historical traffic measurement data from 400 induction loops devices and radar Doppler data collected in winter 2016 (Ghermandi et al., 2019).

28) Supplement, Fig. S10: What is the source of the fleet composition? Please cite a reference.

The fleet composition, including the number of registered vehicles for each class, was obtained from the ACI website (http://www.aci.it/laci/studi-e-ricerche/dati-e-statistiche/autoritratto.html). The estimates for the number of kilometers traveled by each vehicle category were sourced from the ISPRA website (https://emissioni.sina.isprambiente.it/inventario-nazionale/). Both references have been added to the text (lines 386 and 387).

References

Bigi, et al.: Aerosol absorption by in-situ filter-based photometer and ground-based sun-photometer in an urban atmosphere, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-174, 2023a.

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Veratti et al., presented a study on the source apportionment of black carbon levels in the city of Modena (Po Valley, Italy). By combining multi-wavelength micro-aethalometer measurements and a hybrid Eulerian-Lagrangian modelling system, the authors decoupled both the emissions sources (i.e., residential biomass burning and fossil fuels) as well as the "geographical" contribution (i.e., inner city versus background) of black carbon.

The paper is well organized and easy to follow. The analysis is clearly presented with an appropriated level of details, and both the methodology and the statistical analysis are sound. Additionally, the study confirms the importance of residential wood combustion to the air quality levels in the Po Valley, which also goes along with previous modelling source apportionment studies (Jiang et al., 2019).

I only have few minor comments before the paper can be accepted in its final form, mainly to enrich and further corroborate the analysis and to make this study more useful to the scientific community, especially for what the chemical transport models are concerned:

Minor comments:

- What is currently missing in the manuscript is a more detailed comparison of the results presented here against other European sites. The authors claims that the site is "a representative example of a medium-sized urban area in Europe", but it would be nice to provide more comparison with literature data in order to further strength this claim.

To support the hypothesis that Modena can be considered a representative example of a medium-sized urban area in Europe in terms of eBC levels and source contributions, we have included a comparison of the outcomes of our study with those of other European cities that exhibit similar eBC levels and FF and BB partitioning at both traffic and background sites. The text has been expanded accordingly at lines 535-545 and 552-563.

- The authors made use of a high-resolution emission inventory derived from local agencies. Those kinds of datasets are usually more challenging to obtain compared to already compiled global anthropogenic emissions data sets, such as, e.g., CAMS (and related ones). A brief comparison of the datasets used here (e.g., only the total emissions) against coarser datasets, could provide precious information to the modelling community about the levels of agreement with other emissions data, and therefore on future modelling application on the Po Valley.

We have included a comparison of the annual BC emissions for the Emilia-Romagna region using the INEMAR 2017 dataset and other common European and global emission datasets, such as CAMS-REGv4.2, EDGARv6.1, and EMEP, in the main text. This comparison is summarized in Table 4. Additionally, we have added a description of the comparison results to the manuscript at lines 450-468.

- Since the Eulerian approach is built on the CHIMERE model, I would suggest spending some more work on the previous evaluation studies performed on CHIMERE. The model has actively participated in numerous model intercomparisons exercises e.g., EURODELTAIII (Bessagnet et al., 2016) and AQMEII, and I think it would be beneficial to this study, and to the past modelling intercomparison efforts, to briefly comments on previous modelling results.

We appreciate the reviewer's suggestion and have included a detailed discussion of previous evaluation studies of the CHIMERE model in the manuscript. Specifically, we have reported the results of the main statistical metrics achieved by CHIMERE compared to observations during the simulation of EC, gaseous species (NO2, O3 and SO2), PM10 and PM2.5. This includes results from the EURODELTAIII (Bessagnet et al., 2016; Mircea et al., 2019) and POMI (Pernigotti et al., 2013) intercomparison exercises. The additional text has been inserted in lines 297-318.

- I think there is no mention in the manuscript regarding how the BC mass is distributed over the size distribution. As far as I am aware, CHIMERE centres the distribution of BC at 200nm with a 1.2 sigma, which is a proper guess for background BC concentrations. Is it the case (and representative) also for this study? Or does the size distribution of BC differ between what is applied in the city and what is considered as background?

Yes, the reviewer is correct that the main text lacks this specific detail. As suggested, simulations with the CHIMERE model used a BC mass distribution centered at 200 nm, with a sigma of 1.2. This setup aligns with previously reported experimental studies analyzing BC distribution at various urban and rural sites (Li et al.. 2023; Ning et al. 2013; Schwarz et al., 2008). In contrast, the Lagrangian particle dispersion model GRAL uses a less sophisticated approach for simulating aerosols. Specifically, BC emissions are treated as PM2.5, with deposition processes based on this particle size following the VDI guidelines (VDI 3945-3). Relevant details have been added to the main text at lines 279-280 and 337.

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During the revision of the main manuscript, we identified and corrected additional errors, which are summarized below:

- "Po Valley" has been changed to "Po valley" to use a lowercase "v".
- The x-axis label of Figure 3 was incorrectly shifted by one day. This error has been corrected.

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