CAIRGO BIKE

Variation of the exposure to black carbon according to the transport mode: research study

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Reviewer : Olivier Brasseur

A Fanny, cycliste convaincue partie trop tôt, dont l’énergie et l’enthousiasme permanent auront longtemps porté vers l’avant le projet Cairgo Bike

This project is co-financed by the European Regional Development Fund through the Urban Innovative Actions initiative

CONTENT

This report aims to present the processings that were carried out on the data that were collected by Cairgo Bike participants, the results of these measurement campaign and the analyses that were developed based on this data set and other ones related to the Brussels cycling infrastructure.

RESEACH STUDY GOAL

This study research aimed to highlight the benefits of cycling compared to car driving in terms of exposure to atmospheric pollutants. Its results could contribute to implement regulations which would develop further the Brussels cycling infrastructure and encourage any regional public actor or professional structure dealing with mobility to carry out projects that could provoke a wider shift from cars and vans to cargo bikes.

TARGET GROUP

This report addresses to the Urban Innovative Actions programme, which is an initiative of the European Union that provides financings to its members states in order to develop solutions to urban issues. The results of this study research concerns all Brussels public structures that are supposed to implement actions on the domain of mobility as well. Any research or public structure that focuses on air quality or mobility could also take an interest in these results.

1. Project framework

Since urban transport is recognized as a major source of air pollution in the Brussels area (*61 %* NO_2 and *57 %* black carbon emissions in 2019), and as the Brussels Capital Region planned a full diesel ban by 2030 and is committed radically improving air quality its inhabitants inhale, the regional Mobility and Road Safety Minister Elke Van den Brandt supported the realization of the Cairgo Bike project that was imagined by Brussels Mobility, which is the government department of the Region that is responsible for infrastructure and transport. Other findings have triggered this will : in 2017 research estimates showed *50 %* of services could be delivered by cargo bikes and *75 %* of private trips could be done with the same mean of transport. The project course lasted from July 2020 to September 2023.

Cairgo Bike forms a wide project that assembles many partners, as well public as private structures. All their logos appear on the figure 1. Here is a brief description of their different roles in the project.

- Brussels Mobility : coordinates the project and provides the required communication
- Brussels Environment : carries out this environmental study about the differences in terms of exposure to air pollution depending on the transport modes
- BePark : proposes secure cargo bike parking on public roads and by particulars
- Brussels Economy and Employment : provides grants to professionals who want to carry out their activities with a cargo bike
- Cambio : proposes an offer of secure shared cargo bikes
- Parking Brussels : provides secure parking for cargo bikes on public roads
- Pro Velo : gives cycling lessons for individuals and lends them cargo bikes for free
- Remorquable : provides bicycle trailers to borrow with the principles of the sharing economy
- Urbike : finds solutions to replace vans by personalized cargo bikes for professionals and follow them with trainings
- Vrije Universiteit Brussel Mobilize : mobility and logistics research centre that conducts socio-economic studies about the project achievement

Figure 1 : Partners panel of the Cairgo Bike project

All of the partners took advantage of fundings that were provided by the European Regional Development Fund and in particular the Urban Innovative Actions (UIA) initiative.

2. Participants selection

As this way of working had been planned, citizens who measured the exposure to black carbon pollution were chosen from the participants to the cargo bike trial sessions that were organized by the non-profit association Po Velo. Pro Velo proposed two bike trial sessions for each municipality of the Brussels area, that lasted two weeks and that included seven or eight bikes that were made available for free during this period. This association was responsible for the first selection, that had to take into account criteria which were defined by the Vrije Universiteit Brussel, as this university carried out socio-economic studies based on the participants' data. After these first choices, Brussels Environment selected some of the participants who would wear a black carbon aethalometer during all of their trips, whatever the transport mode they used. From all of the lists, Brussels Environment chose the participants who had mentioned they used a car the most frequently, as the comparison between the bike and this travel mode is the essential subject of this research. The two following points had to be checked : each aethalometer user had to mention in the first Pro Velo survey that he or she agreed to wear a device that collected geolocalised data and the person could not smoke, as the tar and the tobacco combustions produce a wide quantity of black carbon particulates. Since the project partners noticed there existed a massive success of the bike trial sessions, additional dates were planned, and the new participants had then to pick up the bike at the Circularium, a co-working space. The table 17.1.1 in the appendixes shows the dates of the different bike trial sessions for which some participants used an aethalometer.

For different reasons, the target in terms of number of citizens, could not have been reached (difficulties to find enough interested people, they did not always fill in their logbooks even if they had agreed to participate, delivery delay of the first aethalometers due to the covid pandemic and preparing individual reports with personalized mapping of the trips took too much time). 98 citizens collected data that were operable and that appear in the general data set which was processed in the framework of this report.

The appendix 17.2 consists of a handbook for the handling of the MA200 aethalometer, which is the new version of portable devices for the black carbon concentrations measurement. As a delivery delay of these devices occurred, models of the previous version of portable devices were lent to the first participants, *i. e.* the aethalometer AE51, that does not include any registration of geolocalised data. The following pictures correspond to AE51 and MA200 models, respectively.

Figures 2a and 2b : AE51 and MA200 aethalometers models. The working of the AE51 aethalometer implies the filter has to be changed manually (see the little white piece in the front of the device), contrary to the one of the newest version of aethalometer.

As for the professionals, Brussels Environment faced other difficulties. At first, the professional structures that were taught by the cooperative Urbike (that organized personalized training sessions to help them to choose the right cargo bike and equipment) were chosen to wear an aethalometer during two or three weeks. The use of the measuring device was often considered as an additional psychological charge and since their shift from vans to cargo bikes was a really important step in the development of their activities, they refused to participate at this environmental study most of the time. Afterwards, a new strategy was applied : Urbike adviced Brussels Environment to collaborate with professionals who had already taken advantage of its expertise successfully. An important constraint restricted the possibilities : the participants had to use the vans as well, and not only cargo bikes in order to make a comparison possible. 13 professional participants contributed to the study and it involved public as well as private organizations.

3. Personal data management

In the framework of the data management, Brussels Environment prepared several documents in order to respect the General Data Protection Regulation. As the collaboration between Pro Velo, the VUB and Brussels environment implied transfers of individuals' personal data, a large three-party agreement and a privacy statement were drawn up to inform them the different reasons why they were collected and the processings that would be applied. These two documents can be found in the appendixes 17.3. The French version of the agreement and the Dutch version of the privacy statement are presented.

4. Outcome dissemination and participation in communication events

As a group with managers of Urban Innovative Actions projects was created in order to regularly meet each other to explain the advance state of their tasks and to find solutions together, Brussels Environment presented twice the principle and the course of the environmental study that was carried out in the framework of Cairgo Bike. These two sessions occurred in June 2021 and September 2022. These meetings are called "UIA air quality club" and include all the projects that are financed by this fund and the subject of which is related to the improving of air quality.

In the framework of exchanges between the three different Belgian regions and as a result of the incentive of the World Health Organization, the National Environment and Health Action Plan (NEHAP) regularly proposes sessions of presentations and Brussels Environment was invited to detail the principle of the Cairgo Bike project and to discuss the first outcome of the environmental study in October 2021. The appendix 17.4 shows the first slide of the this presentation.

In October 2022, a meeting was organized with the BRAL, an non-profit association that is specialized in sciences popularization. The dissemination of the results was indeed an important subject, as a wider shift of vans and cars to cargo bikes could trigger a substantial improvement of the city air quality. That is why the UIA article and examples of virtual maps and graphs of the individual reports were used by the BRAL to diffuse the first results and the possibility to lend a cargo bike for free. The UIA article was written by Brussels Environment and the UIA expert. This text evokes the measurement campaign and the first results and is to find here.

5. General measurement principle of the aethalometers

The two different generations of aethalometers that were used in the framework of this project, the AE51 aethalometer as well as the MA200 model, are characterized by the same optical method. The total black carbon amount is calculated from the change of an infrared beam intensity that passes through a filter. The longwave length is *880 nanometers* and is common to the two different models. As the dropped particulates on the filter absorb some light, the intensity of the transmitted beams gets weaker and there exists a link between the number of black carbon particulates on the filter (thus the black carbon concentration) and the light intensity drop of the transmitted beam. The figure 3 shows the amount of black carbon particulates on the filter at two different moments *t1* and *t2* : since they accumulate on it, the transmitted light intensity decreases.

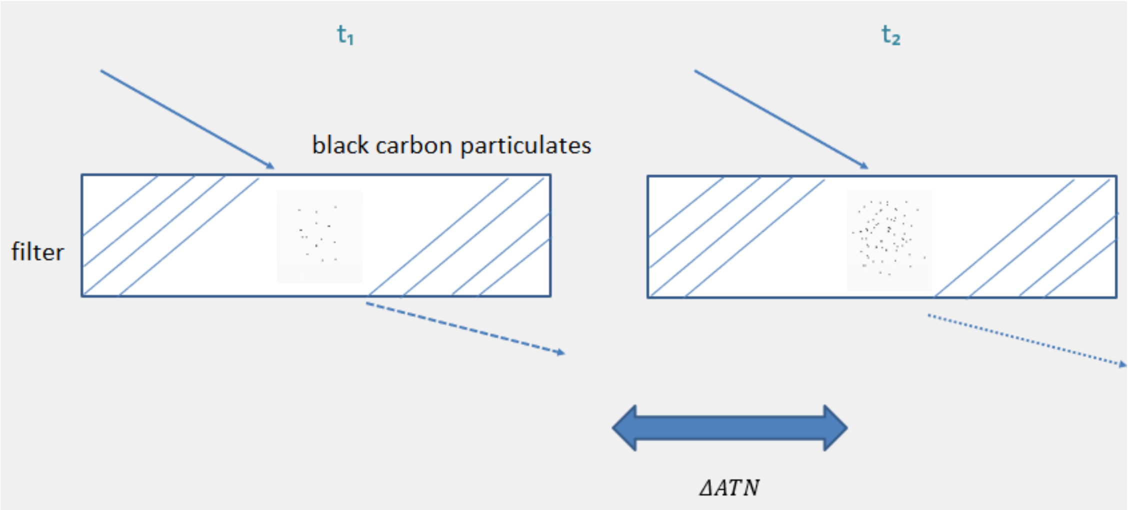

Figure 3 : Description of the optical method employed in the aethalometers to calculate the black carbon concentrations. The uninterrupted lines represent the incident infrared beams that are released by the device and that pass the filter. The discontinued lines correspond to the transmitted beams and their intensity decreases as the particulates accumulate on the filter.

In fact, the black carbon concentration is calculated on the basis of the attenuation change with time (ΔATN), *i. e.* the variation of the light intensity which is transmitted through the filter that collects the particulates. Virkkula *et al.* (2007) identified the formula that describes how to obtain the black carbon concentration :

$$BC = \frac{\sigma_{abs}}{\alpha_{abs}} = \frac{1}{\alpha_{abs}} \frac{A}{Q} \frac{\Delta ATN}{\Delta t} \qquad \text{(equation 1)}$$

where σ_{abs} is the absorption coefficient ; α_{abs} is the mass absorption cross section ; *Q* the air flow that reaches the filter ; *A* the filter area the particulates drop on ; *t* the time ; and *ATN* the attenuation

As the attenuation describes the decrease of light transmission through the filter due to the absorption by the particulates, this parameter is mathematically defined on this way :

$$ATN = -\ln\frac{I}{I_0} \qquad \text{(equation 2)}$$

where the argument of the neperian logarithm (*ln*) is the ratio between the transmitted light intensity *I* at a given moment and the intensity of the light that is transmitted initially I_0. The attenuation is thus a parameter that implies its absolute value decreases with time until the use of a new filter.

6. Measurement principle : particularities of the AE51 aethalometers

The following graph was established in the framework of a scientific paper about the aethalometers data processing for devices from the generation of the AE51 model. It shows the initial attenuation does not always equal zero, contrary to what the attenuation formula could make think ($I = I_0$ on a new filter that is theoretically perfectly clear, so that the logarithm equals *0*.) Depending on the parameters settings, some aethalometers are characterized by an initial attenuation that is different from zero and that doesn't affect the concentrations data quality. (Hagler *et al.*, 2011)

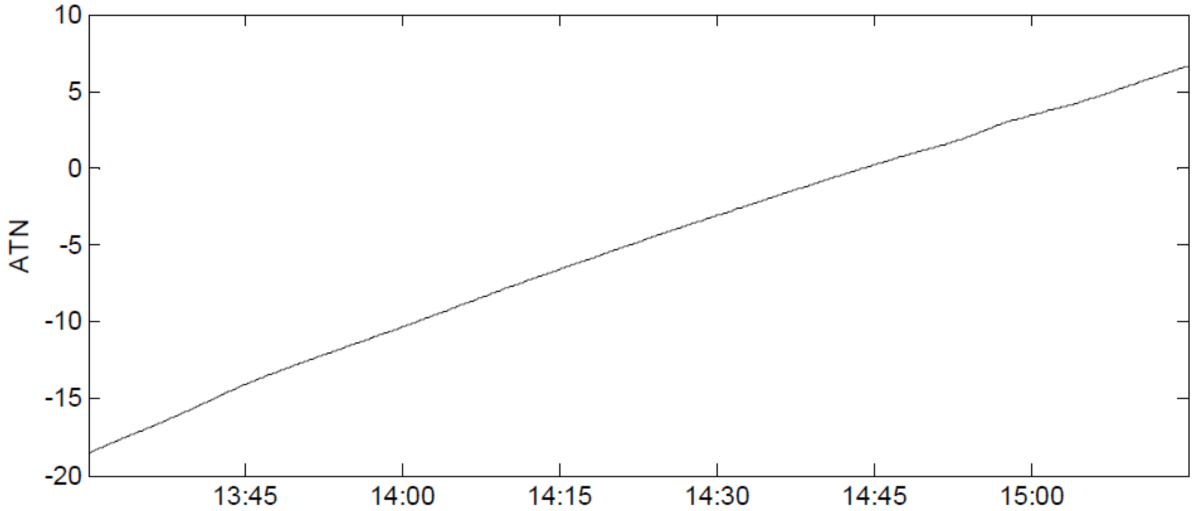

Figure 4 : Evolution of the attenuation with time for an AE51 aethalometer (modified from Hagler *et al.*, 2011)

It seems thus there exists another formula that defines the attenuation, which is more general :

$$ATN = a - \ln\frac{I}{I_0} \qquad (equation\ 3)\ ;$$

a is a value that depends on the device model.

That is why the initial value of the AE51 aethalometers was very variable during the measurement campaign and was included between about *-20* and *+17*. The data from the participants who used the same device were often characterized by similar initial attenuation values. That testifies the initial values can be different from zero due to the device setting without any bad handling of the device and the filter. However, the initial attenuation for the same participant (thus the same device) sometimes varied slightly depending on the day. That could be explained by the fact the filters state is not perfect, since they don't have exactly the same transparency. As the concentration at a moment *t* is calculated from the attenuation difference between *t* and *t-1*, that does not affect the data quality : the consequence of deposit of fine particulates is a light absorption, whatever the transparency state of the blank filter. The filter of this aethalometers generation has to be handled by the user, who has to change it regularly (once per day in the framework of this study). The working of the newest portable aethalometer does not imply any filter that can be removed from the device.

Another difference with the new MA200 model consists of the phenomenon known as the loading effects. Contrary to the MA200 aethalometers, the model AE51, that was conceived previously, could make a correction necessary, due to these loading effects on the filters. Concentrations could indeed be underestimated as a filter saturation occurs.

As different particulates settle on the filter, black carbon that absorbs the employed wavelength as well as other aerosols which scatter this light, an alteration of the absorption filter occurs, and as a consequence, the black carbon concentration gets underestimated as a filter saturation can happen, *i. e.* as the attenuation value is very high (Virkkula *et al.*, 2007). Nevertheless, the obtained results showed any correction due to this loading effect was necessary. For each participant, during each day, *i. e.* for a sole filter, the indoor air concentrations (thus low concentration levels) were compared : the following graph presents a comparison for different days between the mean of the whole indoor air concentrations and the mean of the concentrations in the same conditions but which correspond to the attenuation values above the *90th* percentile of this parameter. There does not exist any trend that would highlight lower concentrations for the highest attenuation values. For this reason, no correction due to this loading effect was judged relevant. The table 17.5.1 in the appendixes takes back all these data.

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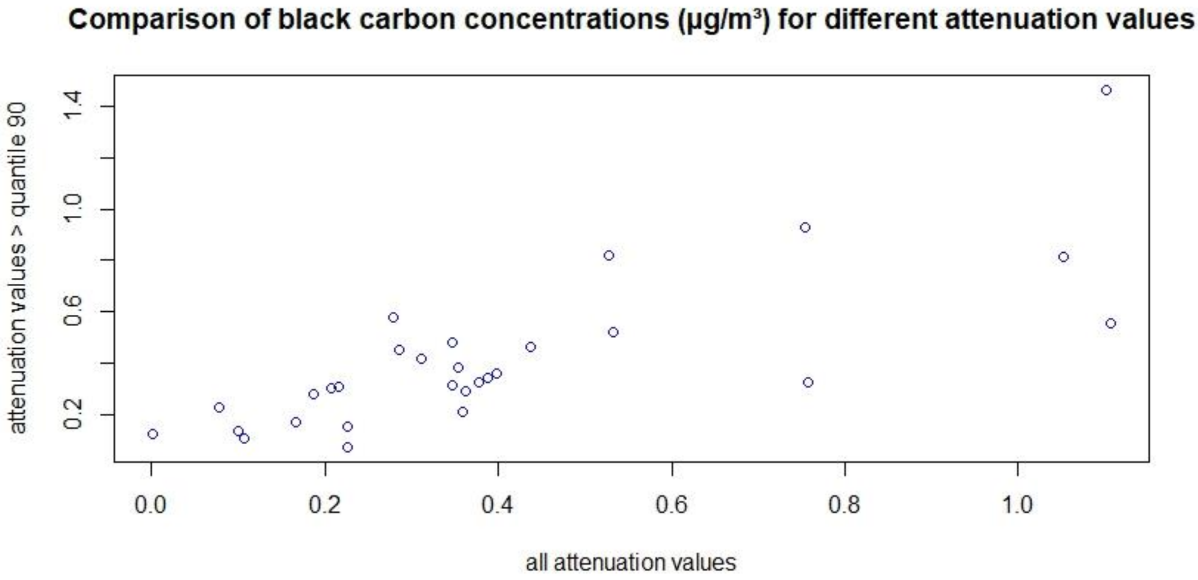

Figure 5 : Comparison of mean indoor air concentrations per day and per participant. The horizontal axis represents general daily mean concentrations in indoor air conditions and the vertical axis takes into account the mean concentrations of the part of the same data sets the attenuation of which is higher than its *90th* percentile. Each point corresponds to one participant and one day, as they changed the filter at the beginnings of a new measurement day. If there existed an underestimation of the black carbon concentrations for the highest attenuation values, many points would probably be gathered in the lower part of the graph.

Beyond this study, it seems that the underestimation of the black carbon concentrations from AE51 aethalometers due to the filter loading effects do not require any correction for attenuation values that are lower than about *52* (if the initial value equals *0*) (Masey *et al.*, 2020).

7. Measurement principle : particularities of the MA200 aethalometers

A first enhancement of this new generation of aethalometers is related to the filter itself : it consists of a strip of a cartridge tape that reaches a new section when approaching the saturation state, so that the filter is kept perfectly clean instead being touched by the user, and as a consequence, the initial value of the attenuation for each section systematically equals zero.

Furthermore, the most important improvement is the application of the “dual-spot” method : the attenuation is measured on two spots S1 and S2 with different sample flows thanks to an orifice that changes the air flow (see figure 6). The air flow is measured by two flowmeters that are placed near the valves : the first one (mass flowmeter 1) takes into account the air that passes through S1, and the second one (mass flowmeter 2) concerns the total flow. The flow through the spot S2 is thus easily calculated as the difference between the total flow and the flow through S1. As the rate of accumulation depends on the sample spot, the magnitude of the resulting saturation is different, the two results are combined to provide the compensated particle light absorption and the black carbon concentration. When the attenuation gets a certain threshold, an automatic tape advance occurs and measurement starts on a new clean spot (Drinovec *et al.*, 2015).

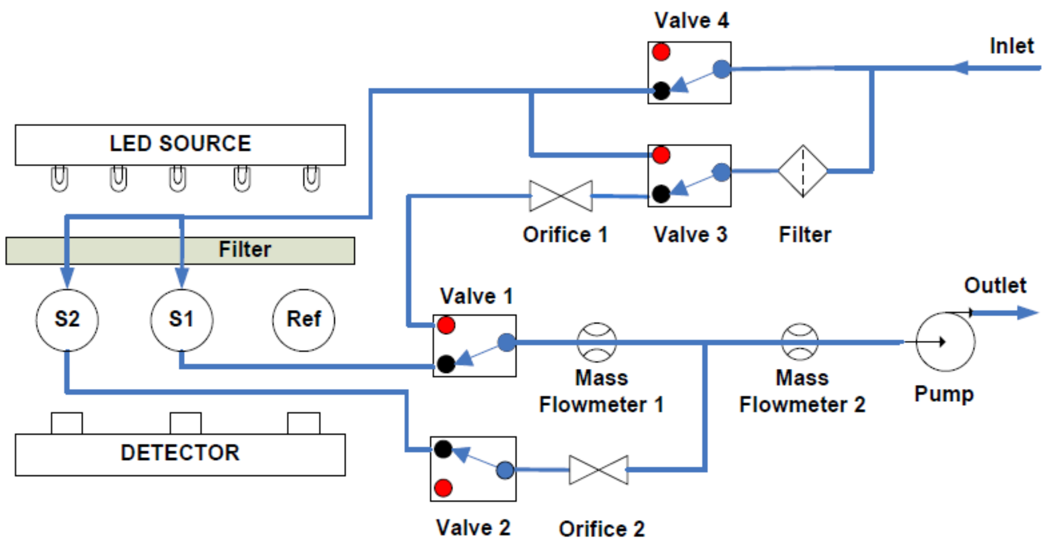

Figure 6 : Flow diagram of the dual-spot method (Drinovec *et al.*, 2015). The orifices allow to generate two different air flows that reach the two sample spots S1 and S2 from an unique inlet flow. The different rates of accumulation on the two spots induce an offset of the resulting saturation so that the compensated light absorption is detected.

8. Data processing

As older aethalometers had to be used at the beginnings of the measurement campaign and as two different measurement timebases were tested, several steps occurred with the aim of making the data cleaner and the following sections detail them.

8.1. Status codes

As the data files from the aethalometers include a column relative to the status of the device, these information were used in order to detect concentrations data which could be seen as invalid. The different error codes that appeared in the original data set and their meanings are shown hereunder. These codes only refer to the aethalometer AE51, since no lines from the MA200 data files included an error code.

Status codes in data files from the aethalometers	Meanings
4	change filter ticket / sense signal out of range
8	optical signal feedback out of range
64	flash memory full

Table 1 : Status codes that appeared in the data from the measurement campaign. All the data points that were characterized by these codes were removed from the data set.

All the concentrations data the lines of which showed one of these status codes were removed in the framework of the definitive processed data set. The number of these lines only counts for *0,01%* of the AE51 data, which is insignificant, and only eleven participants used these aethalometers. This observation is reassuring as for the devices quality.

8.2. Correction of the concentration gaps

As the AE51 aethalometers had not been used for a long time, and probably not been calibrated, it appeared from the intercomparisons that large gaps existed between the different models. The two next figures show the outcome of an intercomparison session. The second graph shows data which were smoothed on a *20 minutes* base and that allows to highlight these gaps. The appendix 17.6 takes back different graphs showing the intercomparisons, as well for the AE51 as for the MA200 aethalometers.

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The same measurement from the same model is sometimes included in different graphs in order to compare all the devices (as all the data could not appear on the same graphic).

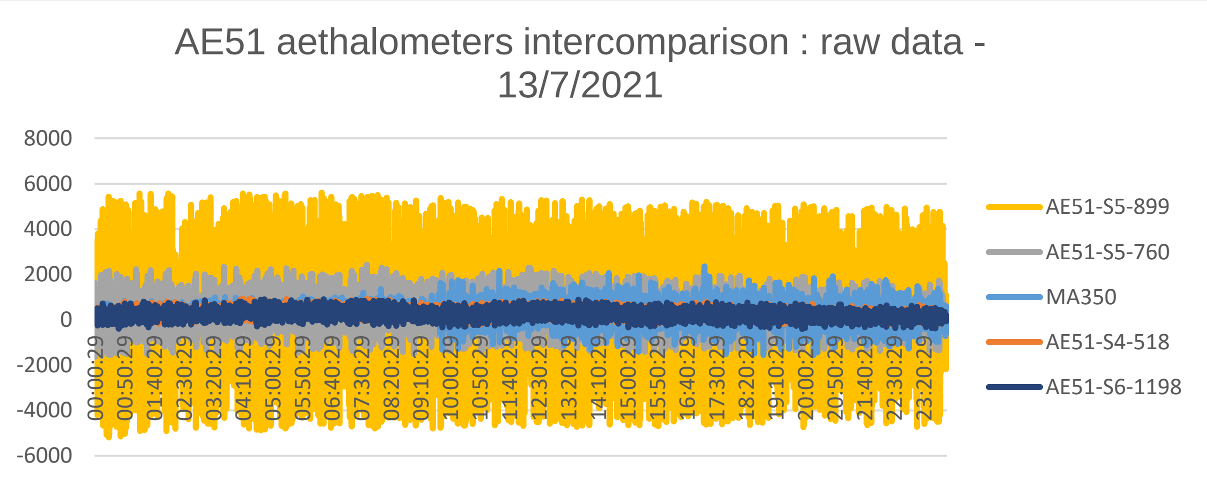

Figure 7 : AE51 intercomparison - raw data for a *30 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*. MA350 device is another aethalometer that is designed by the same manufacturer and that is not portable.

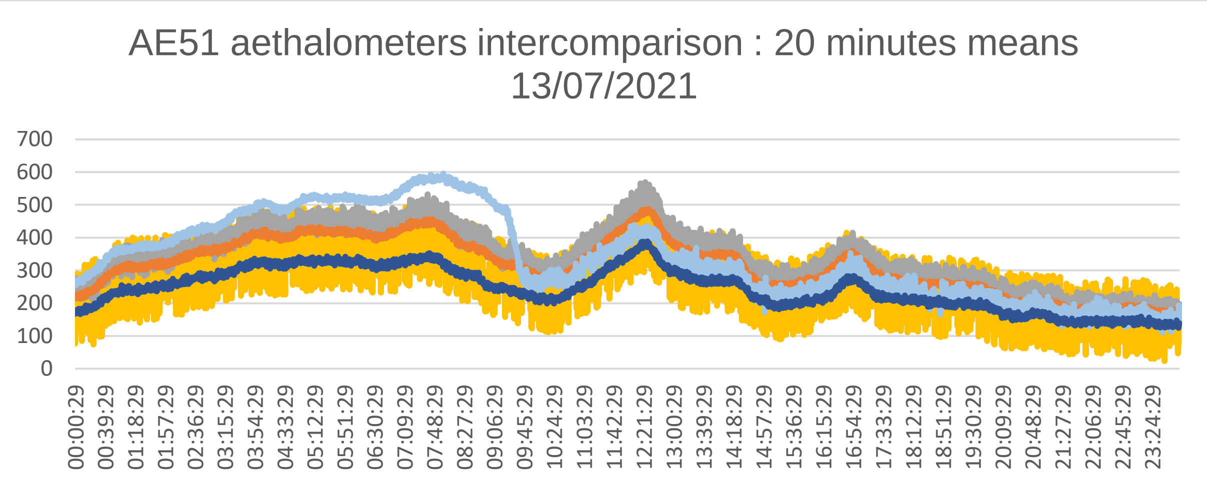

Figure 8 : AE51 intercomparison - *20 minutes-smoothed* data for a *30 seconds* timebase. Each concentration value corresponds to the mean of a *twenty-minutes* raw values. The black carbon concentrations are expressed in *ng/m³*.

One can note from these trials (appendix 17.6) that the two measurement timebases *30* and *60 seconds* which were applied during the project did not show the same trend for the same device, that is why graphics were carried out with these two different parameters settings.

A corrective factor was applied on the data of all used AE51 aethalometers and the tables 17.6.1 and 17.6.2 in the appendixes show the reasoning based on the ratio between the mean concentration of each aethalometer and the general mean concentration. The following AE51 models with the following timebase values models were used during the measurement campaign and were thus subjected to a correction :

- S4-518 at a *60 seconds* timebase,
- S5-760 at a *60 seconds* timebase,
- S5-899 at a *30 seconds* timebase,
- S6-1198 at a *60 seconds* timebase,

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- S6-1199 at a *60 seconds* timebase,
- S6-1375 at a *30 seconds* timebase,
- S6-1375 at a *60 seconds* time-base,
- S6-1377 at a *60seconds* time-base,
- S6-1382 at a *60 seconds* time-base.

8.3. Concentrations data smoothing

As the first black carbon sampling sessions occurred at two different timebases, *i. e. 30* and *60 seconds*, in order to figure out which one was the most relevant in the framework of this experiment, it has been noticed the data files from the aethalometers with the lowest timebase showed noise that seemed to be too high.

The three following graphs are examples of times series of black carbon concentrations that were sampled during a participant’s cargo bike trial and during aethalometers intercomparisons. All these data were registered by MA200 aethalometers. The intercomparisons data come from the same model, as mentioned in their titles. It appears that the signal amplitude is lower with a *60 seconds* timebase, as we could expect it.

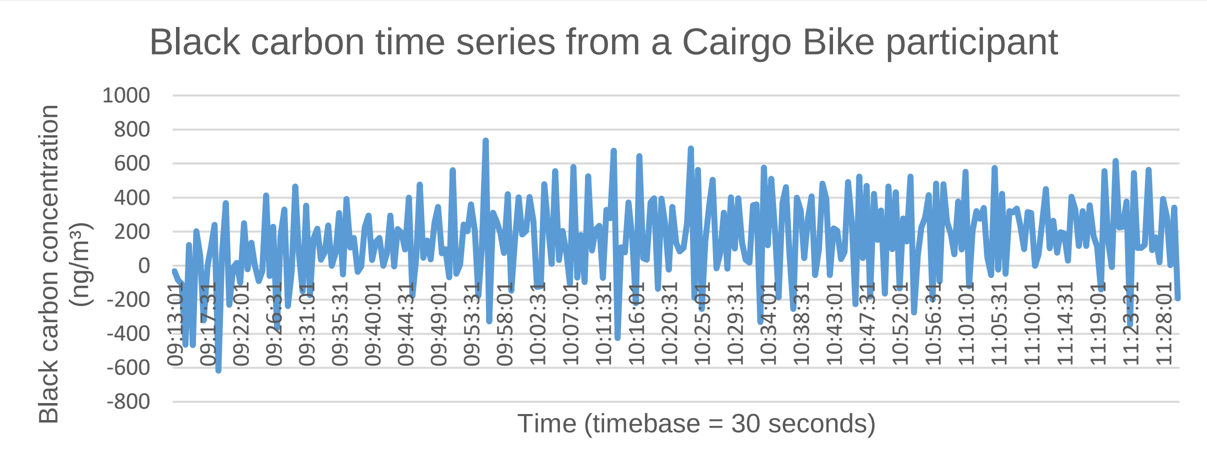

Figure 9 : Time series of black carbon concentrations from a Cairgo Bike participant whose the aethalometer was setted with a *30 seconds* timebase

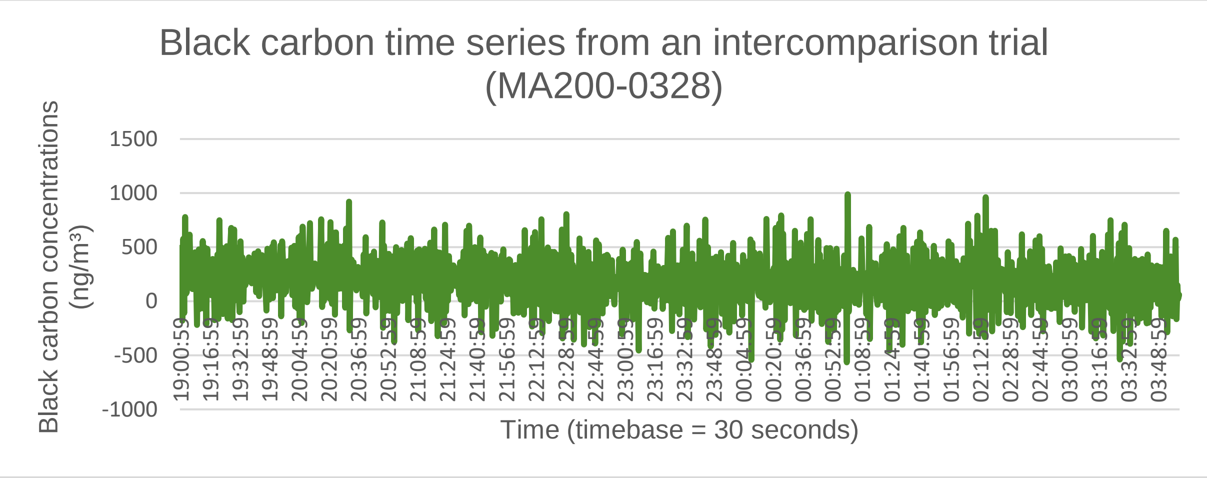

Figure 10 : Time series of black carbon concentrations from an intercomparison trial of aethalometers with a *30 seconds* sampling timebase

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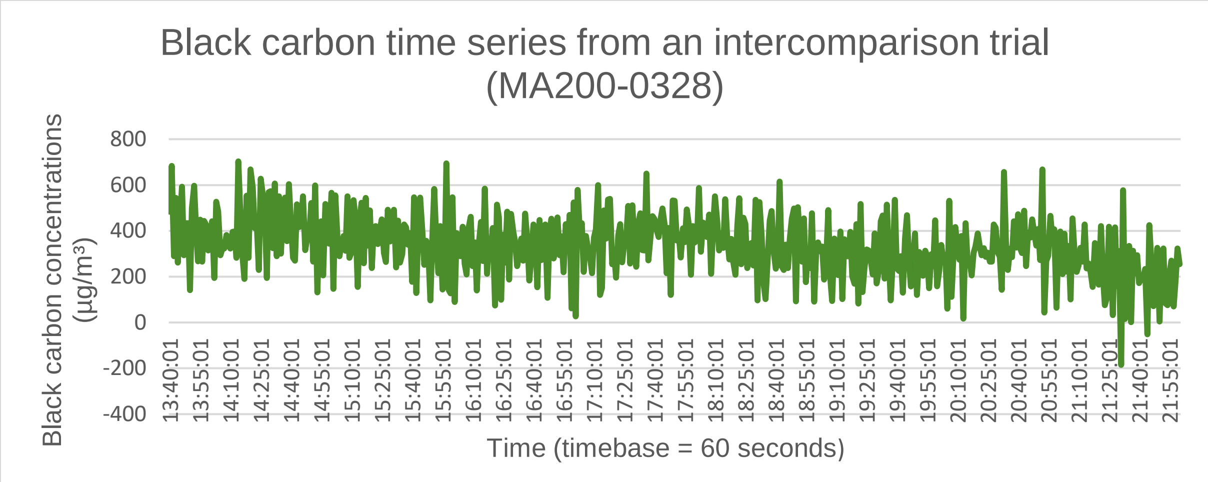

Figure 11 : Time series of black carbon concentrations from an intercomparison trial of aethalometers with a *60 seconds* sampling timebase

Different mathematical processings are suggested by the company that develops the AE51 and MA200 aethalometers to smooth concentrations recordings and they are available on its website. As the Optimized Noise-reduction Averaging algorithm is the only one that takes account of the attenuation (the other ones are pure mathematical methods that can be applied regardless of the device characteristics), this "ONA" processing was chosen. Here is the principle of this algorithm, that was developed by Hagler *et al.* (2011) :

- The user specifies a minimum change in attenuation ΔATN_{min}, that implies an adjusted timebase $\Delta t'$.
- In the case of high black carbon concentrations or long intrinsic timebases, all attenuation variations ΔATN taken into account are greater than this ΔATN_{min} value. If the timebase is very low or the concentrations are weak enough, then the ΔATN values are less than ΔATN_{min}.
- In this later case, the time series is adjusted so that the time interval is smoothed (its value increases) to reach a value that enables the attenuation variation to reach the ATN_{min} value.
- The concentrations are averaged on this new interval time $\Delta t'$.

At the end of this new time interval $\Delta t'$, the ATN must be the last occurrence of that value in the time series for the same sample spot and that is why the frequency of the negative concentration values are reduced as a return to the same value later in the same time series would trigger a negative attenuation variation ΔATN (see equation 1). Given that the attenuation is reseted to a lower value when the filter tape turns to a new spot (the advancing filter tape is automatic for the MA200 aethalometers so that different tape spots can appear on the same data file), the processing window is confined to the region of a single filter spot.

In the framework of this study, the increment value of *0.01* was applied when the data were processed with the ONA algorithm. This threshold is indeed the one that is suggested on the company website to start to use this processing and the obtained outcomes were satisfactory. The figures 12a and 12b show the times series of black carbon concentrations from a participant journey, respectively before and after the ONA-smoothing. The oscillations are regular and the signal amplitude is weaker thanks to this processing.

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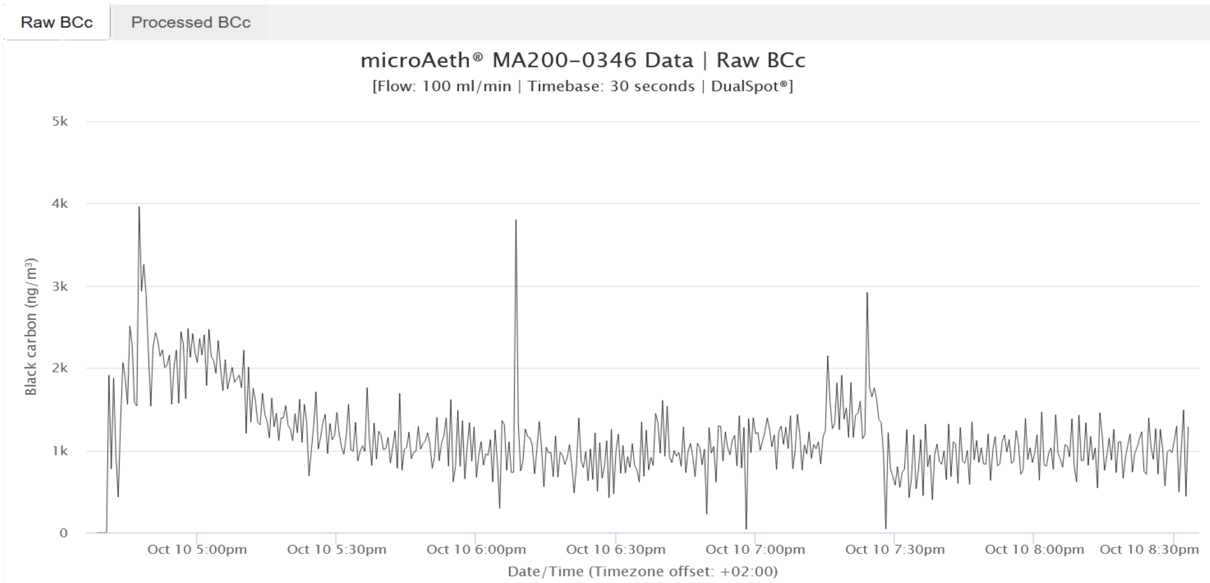

Figure 12a : Graph of the time series of raw black carbon concentrations from the website of the aethalometer furnisher

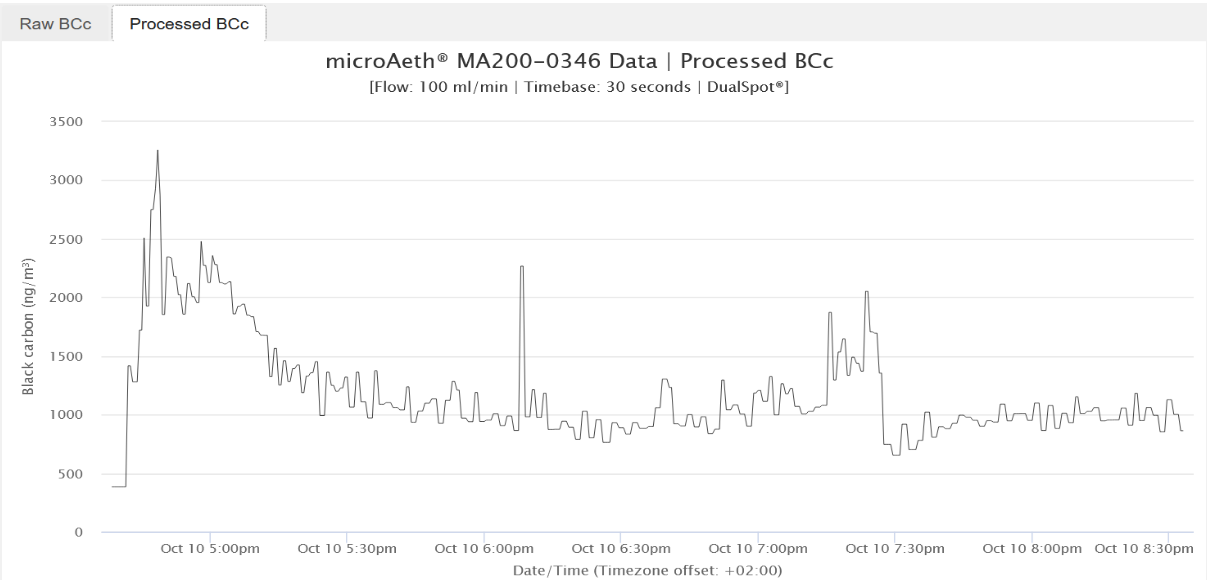

Figure 12b : Graph of the time series of ONA-processed black carbon concentrations from the website of the aethalometer furnisher

Hagler *et al.* (2011) have demonstrated the "ONA" processing is efficient and relevant in different measurement test cases, and notably for mobile and indoor data sets.

8.4. Seasonal correction factors

Considering the fine particulate matter dispersion and the exposure to these pollutants are very variable with the meteorological conditions, no comparison of the data could have been carried out without taking this parameter into account, as the measurement campaign lasted from May 2021 to April 2023. A corrective factor was applied on the concentrations data of all trips for each date. The data from the telemetric measuring network of Brussels Environment were used to get one factor per day that takes account of the meteorological conditions that were responsible for these daily concentrations. Each of these daily concentrations was compared to a general factor related to the whole measurement

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campaign period in order to smooth the data and avoid misinterpretation due to their meteorological variability.

The following steps were established to find the corrective factor of each day :

- The minimum value of the black carbon semi-hourly concentrations from the four stations was isolated (the telemetric network includes four stations that measure instantaneous black carbon concentrations at a semi-hourly frequency). This operation was applied to all days between the 01/05/2021 and the 30/4/2023.

$[BC]_{min} = \min\ ([BC]_{\text{station 1 semi-hour}}\ [BC]_{\text{station 2 semi-hour}}\ [BC]_{\text{station 3 semi-hour}}\ [BC]_{\text{station 4 semi-hour}})$

- The daily means of all these minima were calculated.

$$[BC]_{day\ min} = \frac{[BC]_{00:30\ min} + [BC]_{01:00\ min} + \ldots + [BC]_{24:00\ min}}{48}$$

- For each day, the mean of the last results on the whole period 01/05/2021-30/04/2023 was divided by each daily result.

$$corrective\ factor = \frac{\frac{[BC]_{01-05-2021\ min} + [BC]_{02-05-2021\ min} + \ldots + [BC]_{30-04-2023\ min}}{732}}{[BC]_{day\ min}}$$

The minimum values (first step) allow to take into account a context of very low emissions, which is similar to the background concentrations (environment located far from any pollution source).

This daily corrective factor was multiplied by all the positive concentrations data for each date. Given that this correction would have had an opposite effect on the negative concentration values (decreasing them instead of increasing them, or the reverse situation), it was not applied on these data. Only *3.557* data points out of the *45.820* measures from the whole data set of the recorded trips are negative values. They count thus for *7,8 %* of the data set and not applying any seasonal correction on these measures can be seen as reasonable.

As the period takes into account entire years, there is no need to adapt the calculation because all the twelve different months (and their different meteorological situations) have the same weight in this method.

The tables in the appendix 17.7 show concentrations of the telemetric measuring network and the corrective factors that were taken into account.

8.5. Outliers management

As the high positive concentrations values could correspond to physical realities (the measurement timebases were *30 seconds* and most of the time *60 s*, which implies some instantaneous concentrations can easily be isolated with a different value from the others), there were not systematically moved off.

Nevertheless, some values clearly seem to be too high. According to the litterature (Moreno *et al.*, 2015 ; Bogaert and Heene, 2016), *45 µg/m³* could be a relevant threshold for trip recordings, and the higher values have thus to be moved off as they are absurd. Consequently, the following sections do not include these high values. The figure 13 shows an example of time series from a participant where an outlier can be observed. All the outliers which have been moved off appear on the figures 17.8 in the appendixes. Looking at these graphs, we can conclude the behaviour of the aethalometers does not really consist in compensating the highest concentration values by very low values, that is why processing outliers was important. All the values that exceeded the threshold were moved off, the initial values as well as the ones that were obtained by the seasonal correction. (Some graphs of the appendix

17.8 take thus into account the raw concentrations, and the others show corrected data.) Using this threshold, *34* data points were moved off from the whole data set, including essentially measures that were recorded in the Brussels area.

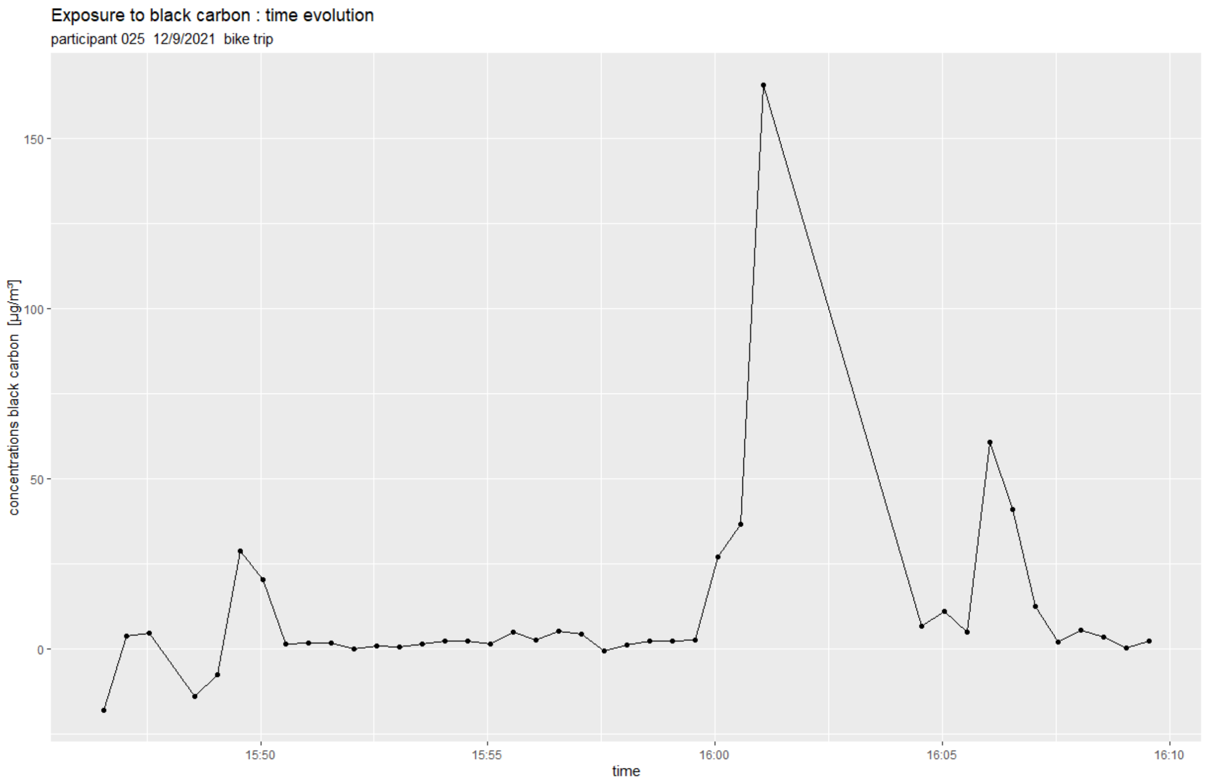

Figure 13 : Example of a time series of the black carbon concentrations that shows a positive outlier during a trip recording. The threshold equals *45 µg/m³*. The other times series are presented at the appendix 17.8.

As for the negative outliers, it appears that many researchers remove the data merely in the framework of their scientific papers. Nevertheless, engineers from AethLabs (manufacturer) explain that these negative values have to be taken into account: as each data series is characterized by noise, removing low negative values could create a bias. Indeed, if the aethalometer is active in a very low polluted area where the effective black carbon concentrations are not much higher than *0 µg/m³*, the measured values oscillate then around this value and there exist thus positive as well as negative values.

That is why the negative values were processed on another way. The interquartile range method has already shown valuable results in different domains (Nnamoko and Korkontzelos, 2020 ; Dash *et al.*, 2023). This method consists in extracting outliers by using a threshold that is calculated from the first (and the third) quartile and the interquartile range.

The lower threshold is obtained this way :

$$T_{min} = 1^{st}\ quartile - 1{,}5.iqr$$

where *iqr* is the interquartile range

This interquartile range algorithm was applied to each of the data sets that were created on this way : one per transport mode for the two different geographical contexts, *i. e.* inside and outside the Brussels area. Considering all the data points related to a trip, in and out of the Brussels area, this method has generated the removal of *529* measures. The two following graphs show the boxplots of the black carbon mean concentrations by transport mode based on the data set resulting from the positive and negative outliers removal. The transport modes that do not include more than *120* measurement points were not taken into account.

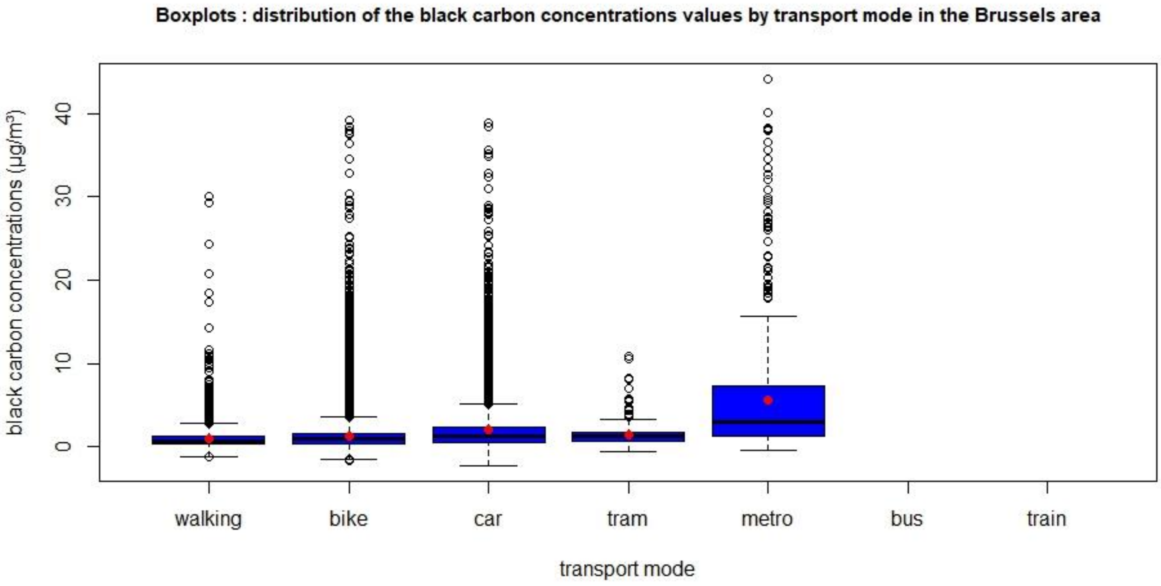

Figure 14 : Boxplots showing the distribution of the black carbon concentration values by transport mode in the Brussels area. The red points correspond to the mean concentrations.

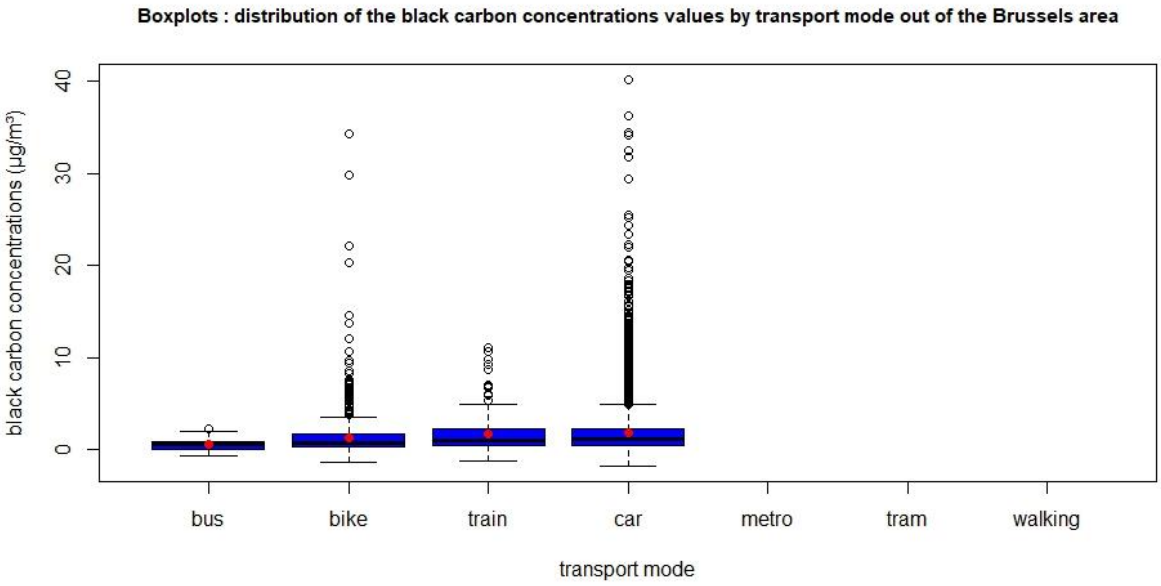

Figure 15 : Boxplots showing the distribution of the black carbon concentration values by transport mode out of the Brussels area. The red points correspond to the mean concentrations.

8.6. Data processing : summary

Here are summed up the different steps of the data processings that were applied on the original black carbon concentrations. They were carried out on the following order.

- removal of the data that were related to an error code
- application of a corrective factor for all data from the AE51 aethalometers (one factor per aethalometer) to take into account the offsets that appeared from the intercomparison sessions
- data smoothing with the “ONA” algorithm for the data that were registered with a *30 seconds* timebase

- multiplication of all the concentrations data by a daily corrective factor related to the seasonal variation
- removal of the positive (higher than *45 µg/m³)* and negative outliers (by using the threshold obtained with the first quartile and the interquartile range)

9. Measurement campaign and correspondence of the different data between each other

Given the citizens had to fill in many information that were used by the VUB in order to carry out its socio-economic studies, the collaboration with this university was important. The paper and online logbooks in the appendix 17.9 were proposed to the aethalometer users. The online logbook was prepared thanks to the Qualtrics website. These documents consisted in filling in the information related to all of their trips and the fact the participants spent time indoor or outdoor, they could indeed get data about the black carbon concentrations they inhaled in interior spaces in their individual reports. Several versions were elaborated before these final ones.

In addition to the mention of the travel mode they used, the participants had to make appear the following data :
- departure and arrival hours and addresses (even if these information were available on the data files from the aethalometer, as the VUB decided not to use them),
- the mean of transport they would have used if they had not lent any cargo bike,
- an assessment of the traffic intensity,
- the purpose of the trip,
- the fact this activity occurred indoor or outdoor.

Regarding the professionals, getting all the needed information was much easier since less information were required for the VUB studies and they only used vans and bikes. The simplest way of working was the following : one biker used an aethalometer and one of his of her colleagues employed another one during his of her van trips.

As for the data treatment, the mention of the transport mode had to be added manually on the data files that came from the aethalometers. The information about the fact the participant spent time indoor (only for individuals and not applied for professionals) was mentioned as well. The figure 16 shows an example of an AE51 data file that was completed by two additional columns corresponding to these information (transport mode and indoor air).

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Application version = 2.2.4.0
Flow = 99 ml/min
Timebase = 30 s
Start date = 2021/06/12
Start time = 08:11:00
Original date format = yyyy/MM/dd
Original time format = hh:mm:ss
Flow units = ml/min
PCB temp units = deg C
Battery units = %
BC units = ng/m^3

Date	Time	Ref	Sen	ATN	Flow	PCB temp	Status	Battery	BC	BC post	Ona_number_pts_avg	transport mode	indoor air
12/06/2021	08:11:00	864072	924122	-6,719	719	99	25	0					
12/06/2021	08:13:00	864043	923798	-6,687	99	25	0	100	97	301	5		indoor
12/06/2021	08:13:30	864012	923738	-6,684	99	25	0	100	292	301	5		indoor
12/06/2021	08:14:00	864090	923805	-6,682	99	25	0	100	179	301	5		indoor
12/06/2021	08:14:30	864017	923696	-6,679	99	25	0	100	337	301	5		indoor
12/06/2021	08:15:00	864017	923641	-6,673	99	25	0	100	598	301	5		indoor
12/06/2021	08:16:30	864176	923477	-6,637	99	25	0	100	221	221	1		indoor
12/06/2021	08:17:00	864240	923511	-6,633	99	25	0	100	374	398	3		indoor
12/06/2021	08:17:30	864219	923448	-6,629	98	25	0	100	446	398	3		indoor
12/06/2021	08:18:00	864231	923426	-6,625	100	25	0	100	375	398	3		indoor
12/06/2021	08:18:30	864249	923388	-6,619	99	25	0	100	623	701	2		indoor
12/06/2021	08:19:00	864260	923329	-6,611	98	25	0	100	778	701	2		indoor
12/06/2021	08:19:30	864150	923203	-6,61	98	25	0	100	93	469	8		indoor
12/06/2021	08:20:00	864119	923143	-6,607	99	25	0	100	292	469	8		indoor
12/06/2021	08:20:30	864211	923203	-6,603	99	25	0	100	417	469	8		indoor
12/06/2021	08:21:00	864031	923092	-6,612	99	25	0	100	-885	469	8		indoor
12/06/2021	08:21:30	864078	923112	-6,609	99	25	0	100	329	469	8		indoor
12/06/2021	08:22:00	863920	923006	-6,616	99	25	0	100	-684	469	8		
12/06/2021	08:22:30	864047	923030	-6,603	98	25	0	100	1228	469	8	bike	
12/06/2021	08:23:00	864232	922953	-6,574	100	25	0	100	2960	469	8	bike	
12/06/2021	08:23:30	864234	922901	-6,568	99	25	0	100	589	767	2	bike	
12/06/2021	08:24:00	864230	922810	-6,558	99	25	0	100	944	767	2	bike	
12/06/2021	08:24:30	864223	922753	-6,553	99	25	0	100	539	839	2	bike	
12/06/2021	08:25:00	864203	922627	-6,542	99	25	0	100	1139	839	2	bike	
12/06/2021	08:25:30	864203	922600	-6,539	99	25	0	100	294	1163	2	bike	
12/06/2021	08:26:00	864196	922406	-6,519	99	25	0	100	2031	1163	2	bike	
12/06/2021	08:26:30	864222	922373	-6,512	98	25	0	100	668	787	2	bike	
12/06/2021	08:27:00	864120	922181	-6,503	99	25	0	100	905	787	2	bike	
12/06/2021	08:27:30	864260	922053	-6,473	99	25	0	100	3023	3023	1	bike	
12/06/2021	08:28:00	864088	922002	-6,487	99	25	0	100	-1444	1031	2	bike	
12/06/2021	08:28:30	864289	921898	-6,453	98	25	0	100	3506	1031	2	bike	

Figure 16 : Example of final data from an AE51 user : the last columns “transport.mode” and “indoor.air” were added to the initial data file. The columns “BC post” and “Ona_number_pts_avg” were created by the data smoothing based on the attenuation values (see above) : the first one corresponds to the concentrations data that were taken into account after this correction and the second one refers to the number of data points which were used for the smoothing. The concentration unit in the initial AE51 and MA200 data files is the *ng/m³* but the general code script turns it to the *µg/m³*, which is the unit that always appears on the graphs.

As for the MA200, given these devices record geolocalised data, the evolution of the geographic coordinates was used to detect the start and the end of each trip. This method implies a calculus that combines the change of the longitude and latitude values between two successive data points. The appendix 17.10 shows the part of the code scripts that implements this calculation.

10. Preparation of the individual reports

The individual reports the participants received constituted the main purpose of the measurement campaign, as the advantage of cycling compared to the car driving in terms of exposure to particulate matter is not always known and brings an additional argument to citizens and professionals who are hesitating to realize the shift towards the cargo bike use. These reports consisted of a written document with explanations and graphics and a video showing the mapping of the different trips and the evolution of the measured concentrations for the citizens while they only included the written part in the case of the professionals.

An example of map appears in the appendix 17.11. For each citizen who recorded valuable data, a sequence of such maps was assembled to create a video document. In these shown examples, the start and end of each trip were removed to protect the personal data.

The written reports include the following sections :

- Measurement period

- Studied pollutant
- Variation of the exposure to black carbon as a function of transport modes : overall remarks
- Variation of the exposure to black carbon as a function of transport modes : data measured in the Brussels area
- Variation of the exposure to black carbon as a function of transport modes : data measured out of the Brussels area
- Indoor air concentrations (if applicable)

10.1. Measurement period

This first section enables to remind the participant the period during which he / she used the aethalometer and mentions the one of the total measurement campaign as well. The meteorology-related normalization based on the telemetric measuring network is explained here, as it is applied on all the following graphics comparing individual and general data.

10.2. Studied pollutant

This part of the written report describes what black carbon consists of, the healthy risk it involves and provides a few data about the emissions of the main pollutants related to the traffic road in the Brussels area.

10.3. Variation of the exposure to black carbon as a function of transport modes : overall remarks

This section consists of a table showing the outcomes from similar studies in different regions.

10.4. Variation of the exposure to black carbon as a function of transport modes : data measured in the Brussels area

At first, the selection of the peak hours is presented here : they are actually defined by Brussels Mobility and are based on the type of roadway.

On all of tables and the general graphs (figure 17), the mean concentration does not appear if less than *60* and *120* measurements were collected, for the individual and the overall data respectively, as the uncertainty is then judged too high. Two graphs are systematically proposed, that show the peak and the off-peak hours data.

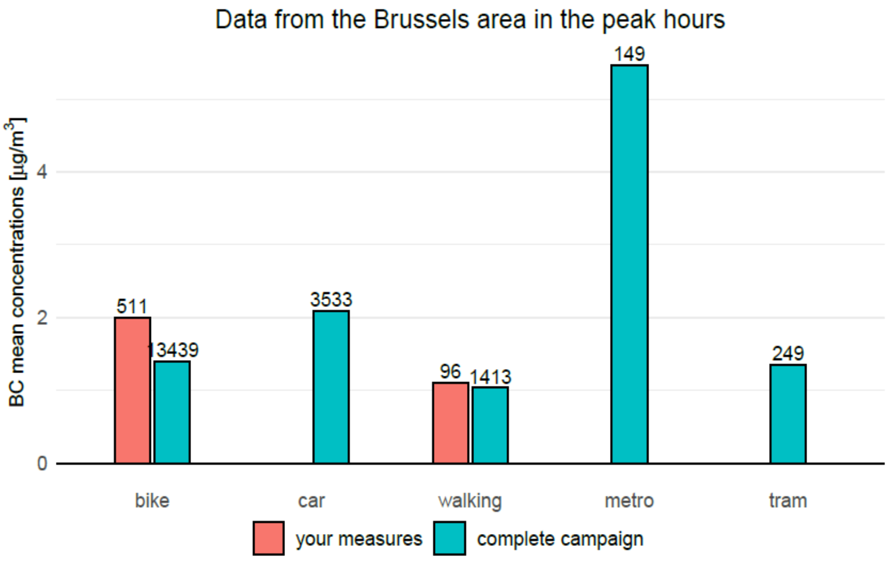

Figure 17 : General graph from an individual report comparing the instantaneous black carbon mean concentrations of the participant with the ones of the whole data set. The numbers above the columns refer to the data that were taken into account.

Other graphs (figure 18) show the participants' individual daily data. As less conclusions could be drawn from daily data, the risk of generalization and hurried interpretation is less high and no limit of the numbers of data was applied.

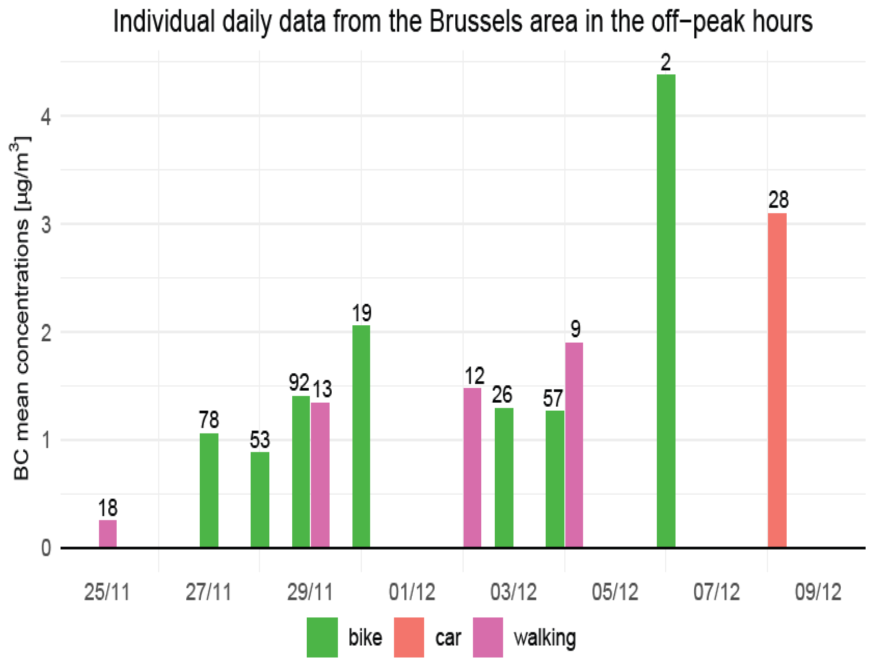

Figure 18 : Graph from an individual report showing the individual daily data for each used transport mode

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10.5. Variation of the exposure to black carbon as a function of transport modes : data measured out of the Brussels area

Some participants did trips out of the Brussels area and this section takes back these travels data. In the individual reports, all the trips at least one segment of which did not occur in the Brussels territory were analysed in this section, as it made the treatment easier. The created graphics are utterly similar to the ones of the previous section.

10.6. Indoor air concentrations

Brussels Environment let the individual participants collect concentrations when they spent time indoor, in the case they were interested in knowing the quality of the air they inhaled in different spaces in terms of black carbon. A daily mean concentration was calculated and the different concerned addresses were not told apart. Given an another measurement campaign conducted by the same institute showed the mean concentration in homes was about *1 µg/m³* (Bogaert and Heene, 2016), this boundary was used to distinguish data that were seen as good (green) and bad (red) concentrations, and these colours appear on the figure 19 that is included in this section.

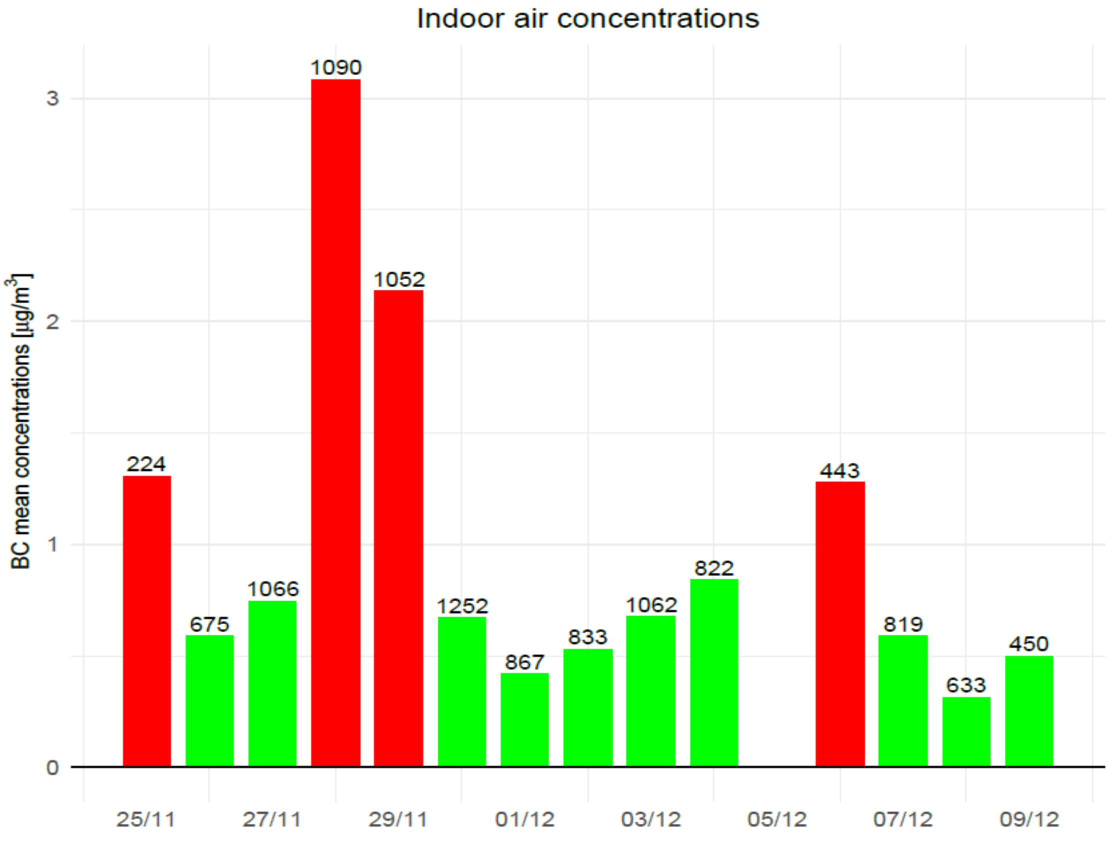

Figure 19 : Graphic from an individual report showing the daily mean indoor concentrations

Considering outliers were also moved off from the data set, the general mean concentration of black carbon in indoor air contexts equals *0,61 µg/m³* and this value was obtained from *91.843* measurements. Bogaert and Heene (2016) obtained *1,2 µg/m³* from another experiment involving Brussels citizens, *i. e.* a mean concentration that was twice as high as the Cairgo Bike mean, which testifies the fact the concentrations of this pollutant get lower, as the indoor air concentrations are also influenced by outdoor phenomena. This value can also be compared with the exposures by bike and by car in the Brussels area (see further), the mean concentrations of which are respectively *1,4* and *2,09 µg/m³* at the peak-hours and *1,27* and *1,94 µg/m³* at the off-peak hours.

11. Black carbon particulates : overall comments

Black carbon consists of fine particulate matter (PM2.5), the diameter of which ranges from *0,01* to *0,5 µm*. Some of these aerosols are thus ultrafine particles (< *0,1 µm*) and this short-lived air pollutants are emitted by the incomplete combustion of fossil fuels, biofuels and biomass. That is why it is a particularly relevant traffic road pollution tracer. As their size is very small, black carbon particulates easily penetrate lungs as well as blood vessels and can then create a high cardiovascular complication risk. Furthermore, they recombine easily with polycyclic aromatic hydrocarbons which can cause increased risks of developing a cancer. The following picture presents the position of black carbon in the distribution of the particulate matter size.

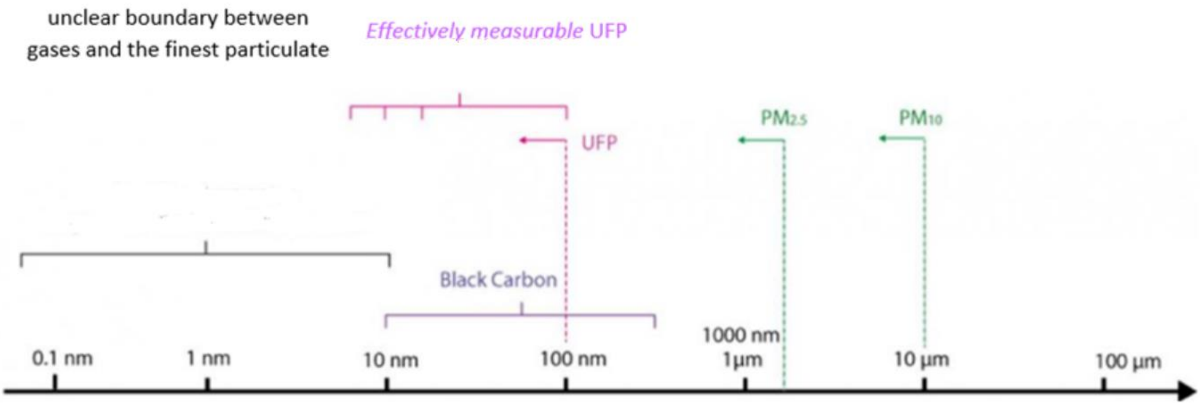

Figure 20 : Distribution of the particulate matter sizes (Brussels Environment, 2020).

Contrary to many other anthropogenic pollutants (sulphur dioxide SO_2, ammonia NH_3, organic carbon C), black carbon particulates are characterized by a positive radiative forcing. The black carbon contribution to 2010-19 warming relative to 1850-1900 would be higher than the one of nitrous oxide N_2O, which is one of the main greenhouse gases (IPCC, 2021), as it can be seen on the figure 21.

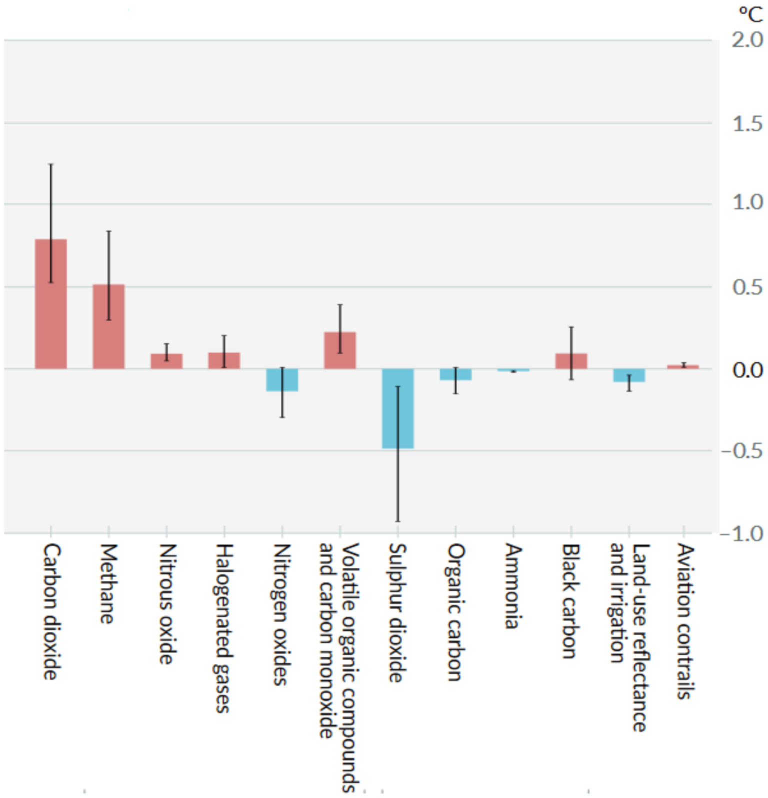

Figure 21 : Contributions of gases and aerosols to 2010-2019 warming (in degrees Celsius) relative to 1850-1900, assessed from radiative forcing studies (IPCC, 2021).

Contrary to nitrogen oxides, that are even more representative of the traffic road related pollution, the mobile measuring of black carbon is easy and implies an optical method (see above) that enables to use a portable device. The contribution of the urban traffic accounted for *48 %* (*57 %*) of the total black carbon production in the Brussels area in 2020 (2019) and therefore these particulate matters are a good indicator of the traffic road pollution. Furthermore, as gases are easily influenced by the atmospheric chemistry, studying black carbon concentrations in the framework of mobility is particularly relevant. Nitrogen oxides as well as black carbon particles are essentially produced by the diesel combustion and to a fewer extend by the gasoline combustion.

Given the current mobility policies that are carried out by the Brussels-Capital Region government (many diesel engines are not allowed to enter in the territory any more) and the technology breakthroughs, measured black carbon concentrations become less and less high. The following graph shows the boxplots of the black carbon mean concentrations that were calculated from the data measured by the four stations of the Brussels telemetric measuring network that concern black carbon. In 2019, too few data had been validated. The blue points correspond to the mean concentrations. The mean values, the median, and the minima highlight an obvious trend towards a decline. The subsequent difference between 2018 and 2020 can be explained by the restraining measures related to the COVID-19 pandemic.

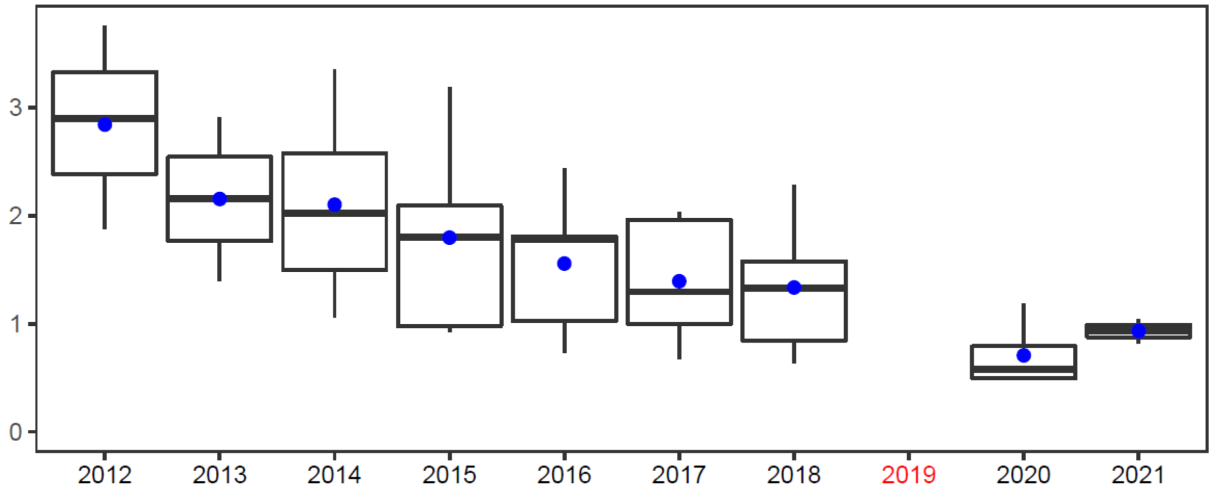

Figure 22 : Evolution of the yearly boxplots of the black carbon concentrations in *µg/m³* from the Brussels telemetric network (Brussels Environment, 2022). The blue points correspond to the mean concentrations.

12. Difference between exposure to atmospheric pollution and inhaled dose of pollutants

This section aims to avoid any misinterpretation about the general differences that appear between bikes and cars in terms of exposure to air pollution.

Indeed, as everyone knows, bikers inhale air volumes that are generally higher than the one that concern car drivers, as they ride outside and are making physical effort, provoking a more intense breathing. A pollutant concentration refers to the amount of this component in a given volume (for example *1 m³*) while the inhaled dose corresponds to the total amount of pollutants that are inhaled, anywhere the volume. Reviewing a large number of studies and taking into account general mean values about the following pollutants : black carbon, nitrogen dioxide, carbon monoxide, fine (PM2.5) and coarse (PM10) particles, Cepeda et al. (2017) found out car commuters were characterized by higher exposure (thus concentrations) to all pollutants than did active commuters (*i. e.* cyclists and pedestrians), followed by the bus commuters, the motorcycle users and car drivers whose vehicle included a ventilation setting, who all showed higher concentration levels than bikers and pedestrians as well. On the contrary, active commuters had higher inhalation doses than commuters using motorised vehicles. Considering the higher breathing intensity and longer trip time of an active commute, inhaled pollutants doses reveal to be more elevated among cyclists and pedestrians than for motorised transport users.

Another systematic review was carried out by Mueller *et al.* (2015), who focused on health impact assessment and they concluded there existed a consensus : despite the higher inhaled dose of pollutants among active commuters, the benefits of physical activity from active commuting remain larger. As for the differences in terms of concentration levels, Cepeda *et al.* (2017) explained the proximity to traffic increased the exposure to air pollution of commuters of motorized transport. As a conclusion of their review, they calculated motorized transport users lost up to *1 year* of life expectancy more than did cyclists.

13. Variation of the exposure to black carbon pollution according to the travel mode

13.1 General outcome from the data collection

Regarding mobility and the exposure to this atmospheric pollutant according to mode of transport, several research studies have already outlined positive results for bikers in comparison with automobilists in terms of concentrations levels in cities and the link with the development of the cycling infrastructure (De Nazelle *et al.*, 2012, Dons *et al.*, 2012, Li *et al.*, 2015, Bogaert and Heene, 2016, Cepeda *et al.*, 2017, Ham *et al.*, 2017). That is why this study was particularly relevant and important in the framework of a broad project that aims to promote the cargo bike use and make it wider.

The two following graphs present the general data, that correspond to the mean concentrations from the whole data set relative to the data points that were measured in the territory of the Brussels area, their error bars and the number of data points that were taken into account, at the peak and the off-peak hours. Considering the error bars, the mean black carbon concentrations by bike are 28 to 37 % lower than for motorised vehicles at peak hours and 30 to 39 % at off-peak hours. Therese results confirm the exposure to atmospheric pollution in terms of concentrations is generally weaker for bikers than for car drivers.

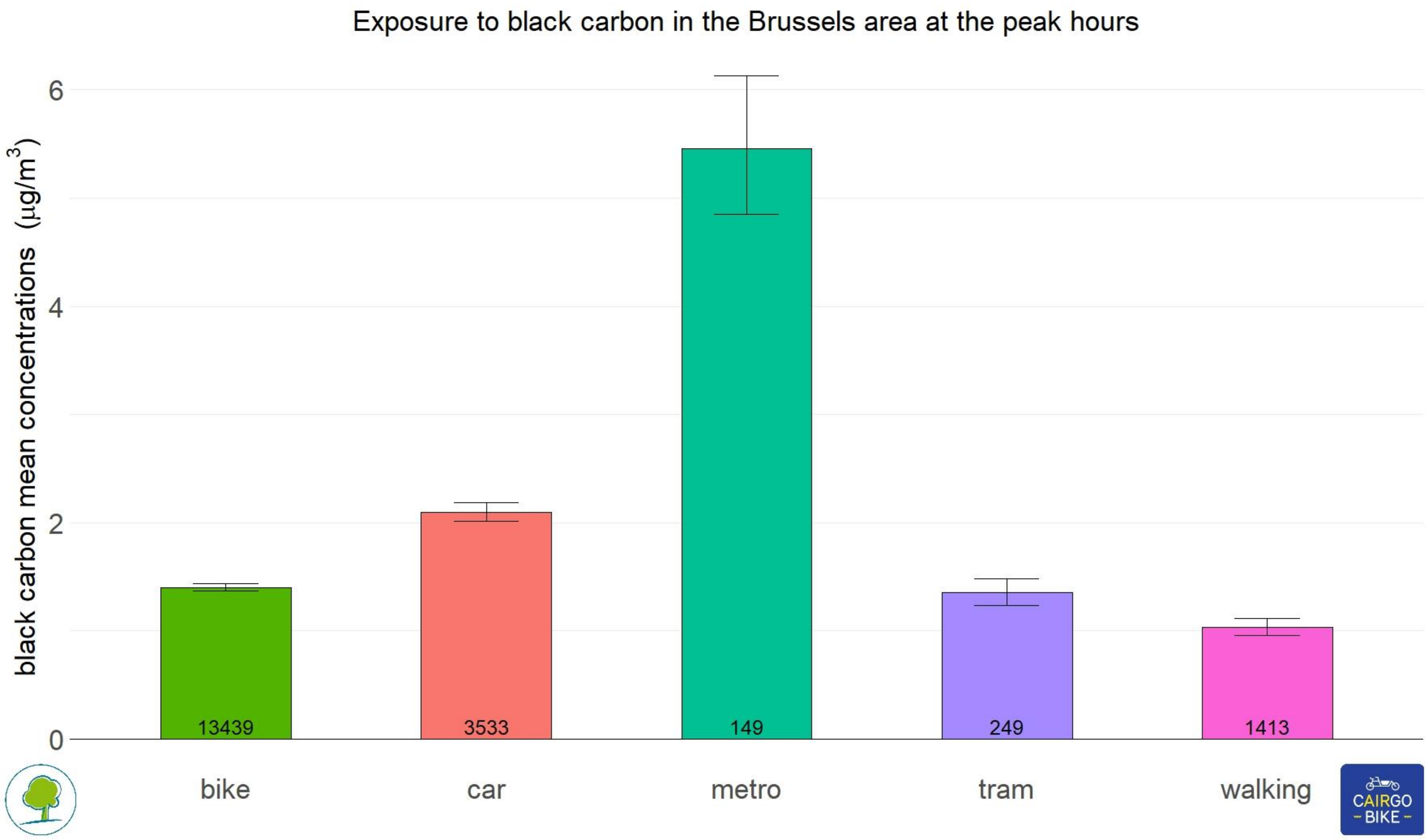

Figure 23 : Mean concentrations by transport mode from the whole data set of the participants' trips corresponding to all the measurement points that were collected in the territory of the Brussels area in the peak hours. The number which appears on each column is related to the measurement points that were taken into account to obtain the values.

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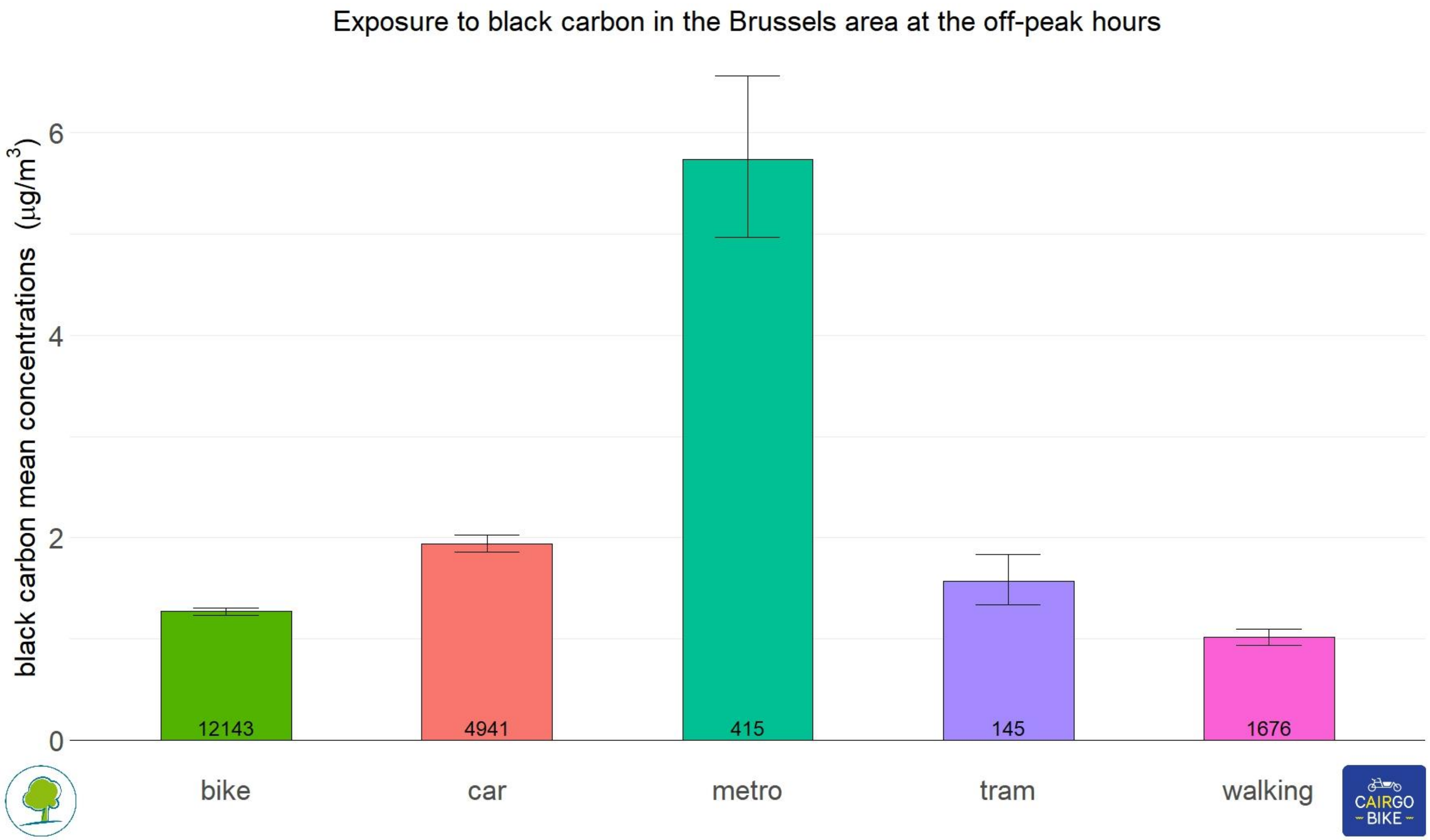

Figure 24 : Mean concentrations by transport mode from the whole data set of the participants' trips corresponding to all the measurement points that were collected in the territory of the Brussels area in the off-peak hours. The number which appears on each column is related to the measurement points that were taken into account to obtain the values.

These two figures illustrate the general trends that were highlighted in most of the research studies that focused on this subject : the atmospheric pollutants concentrations are generally higher for car drivers, lower for pedestrians and intermediate by bikers and tram users. One can note the error bars of the bike and car data do not cross over each other, which is reassuring with a view to drawing conclusion form the Cairgo Bike data set, as well regarding the peak as the off-peak hours. The concentrations that were measured in subways will be discussed further. The figures 17.12.1 and 17.12.2 in the appendixes illustrate the data that were measured out of the Brussels area. As for the comparison between the bike and the car data, one can note the trend is similar to the one of the Brussels area.

The table 2 include all the mean concentrations and the error bars that appear on the previous graphics of the figures 23 and 24. The table 17.12.1 in the appendixes shows the data that were measured out of the Brussels area.

	Complete data		Data from the peak hours		Data from the off-peak hours	
Transport mode	**BC [µg/m³]**	**n**	**BC [µg/m³]**	**n**	**BC [µg/m³]**	**n**
bike	1.34 [1.31 – 1.37]	25582	1.4 [1.37 – 1.44]	13439	1.27 [1.23 – 1.31]	12143
car	2 [1.94 – 2.07]	8474	2.09 [2.01 – 2.18]	3533	1.94 [1.86 – 2.03]	4941
metro	5.67 [5.06 – 6.3]	564	5.46 [4.85 – 6.13]	149	5.74 [4.97 – 6.57]	415
tram	1.44 [1.32 – 1.56]	394	1.36 [1.23 – 1.48]	249	1.57 [1.33 – 1.84]	145
walking	1.02 [0.96 – 1.08]	3089	1.03 [0.96 – 1.12]	1413	1.01 [0.94 – 1.09]	1676

Table 2 : Black carbon mean concentrations by transport mode, at the peak and the off-peak-hours and inside the Brussels area that were obtained after the whole data collection. The number "n" corresponds to the number of data points that were collected to get these values.

As for the error bars, they systematically were obtained from the bootstrap method, which consists of resampling a data set by choosing the number of replications. In the code script, the number of *1.000* replications was selected for all the graphs and all the tables where an error interval appears.

Contrary to the data that appear on the individual reports (see above), the peak hours that were defined for this general study were obtained from the counting of vehicles that were carried out in 2018 on the Brussels Pentagone (geographic zone of about $5\ km^2$ delimited by a small ring road that is located inside the conurbation of the capital Region). The data from *347* counting points in this area were used. For each hour between midnight and 11:59 pm, the mean of the number of vehicle were calculated on each data point and. For each day (week days, Saturday and Sunday), the daily mean was then calculated. Then, an index was obtained for each hour and on each day by the following reasoning :

$$index = \frac{hourly\ mean}{\frac{5 * week\ day\ mean + Saturday\ mean + Sunday\ mean}{7}}$$

The figure 25 results from these calculations and enabled to isolate the following slots as peak hours :
- between 6 a.m. and 10 a.m. and between 3 p.m. and 6 p.m. on each week day
- between 12 p.m. and 6 p.m. on Saturday.

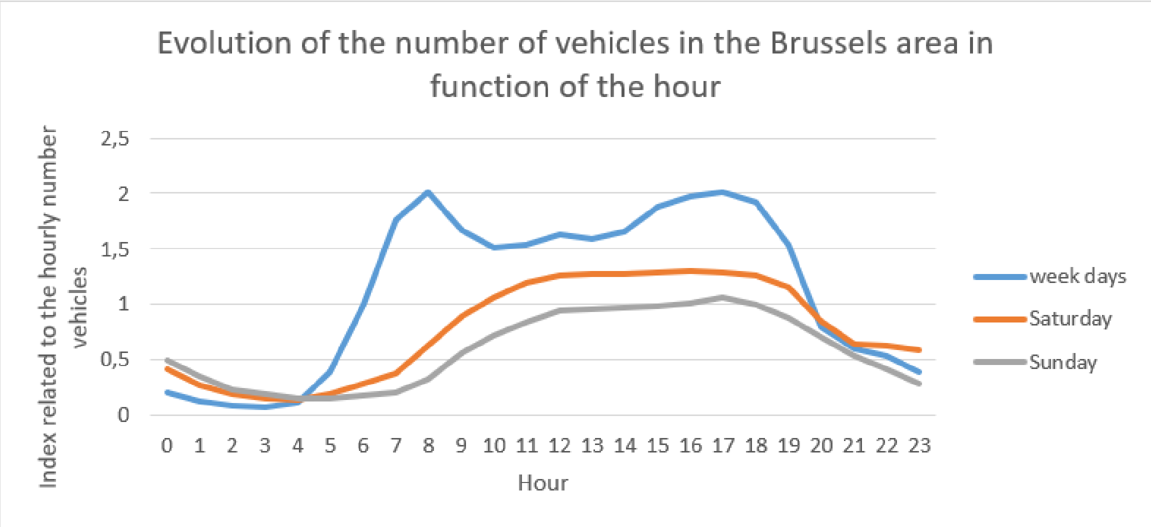

Figure 25 : Determination of the peak hours based on the counting data from 2018 on the Brussels Pentagone. For each hour and on each day (week day, Saturday and Sunday), an index was defined based on these data.

13.2 Variation of the exposure to black carbon with the streets geometry

In the domain of urban atmospheric pollution, the geometry of the streets has widely been studied and its importance is well known. In particular, the aspect ratio describes the confined character of a street. The aspect ratio is defined as the ratio between the mean height of the buildings and the width of the street. Many streets present an aspect ratio H/W the value of which is about *1* while some others are characterized by ratio that is twice as high or even higher. When this ratio is higher than *0,5*, the avenue or street can be seen as a deep canyon and that is why the expression street canyon is used.

The figure 26 shows a colour scale that is applied on street sections from a geographic information system (GIS) layer that resulted from the ExP'air project Environment Brussels carried out in the years 2010. The different parameters of this layer were obtained in 2015. It can be noted that the comparison of two other GIS layers from the Environment Brussels data did not show any difference between the streets geometries in 2016 and 2018. As these layers did not include the heights and widths of the streets, using them could not have been possible in the framework of this analyse but the absence of difference between these two years is positive and lets us believe taking parameters from 2015 into account is reasonably relevant.

We can notice an obvious and general trend : the aspect ratio gets more and more low as the streets are located far from the center. The districts that are located out of the center of the Brussels-Capital Region can be considered as suburban areas and are logically characterized by buildings that are less high.

Comparing the three following figures 26, 27 and 28 can enable to figure out a slight trend appears : the highest concentrations values are essentially located on the streets where the aspect ratios are bigger, as well for the peak hours as for the off-peak hours. As the GIS layer that includes the geometry of the street is not utterly complete, associating an aspect ratio value to each data measurement point was not possible. *14405* out of *25582* measurement data points were available to carry out this cartographic analyse. The boundaries of the concentration classes of the figures 27 and 28 were determined by the quantiles : *20 %* out of the *14405* values are lower than *0,2 µg/m³* and *80 %* out these values are weaker than *1,9 µg/m³* for example.

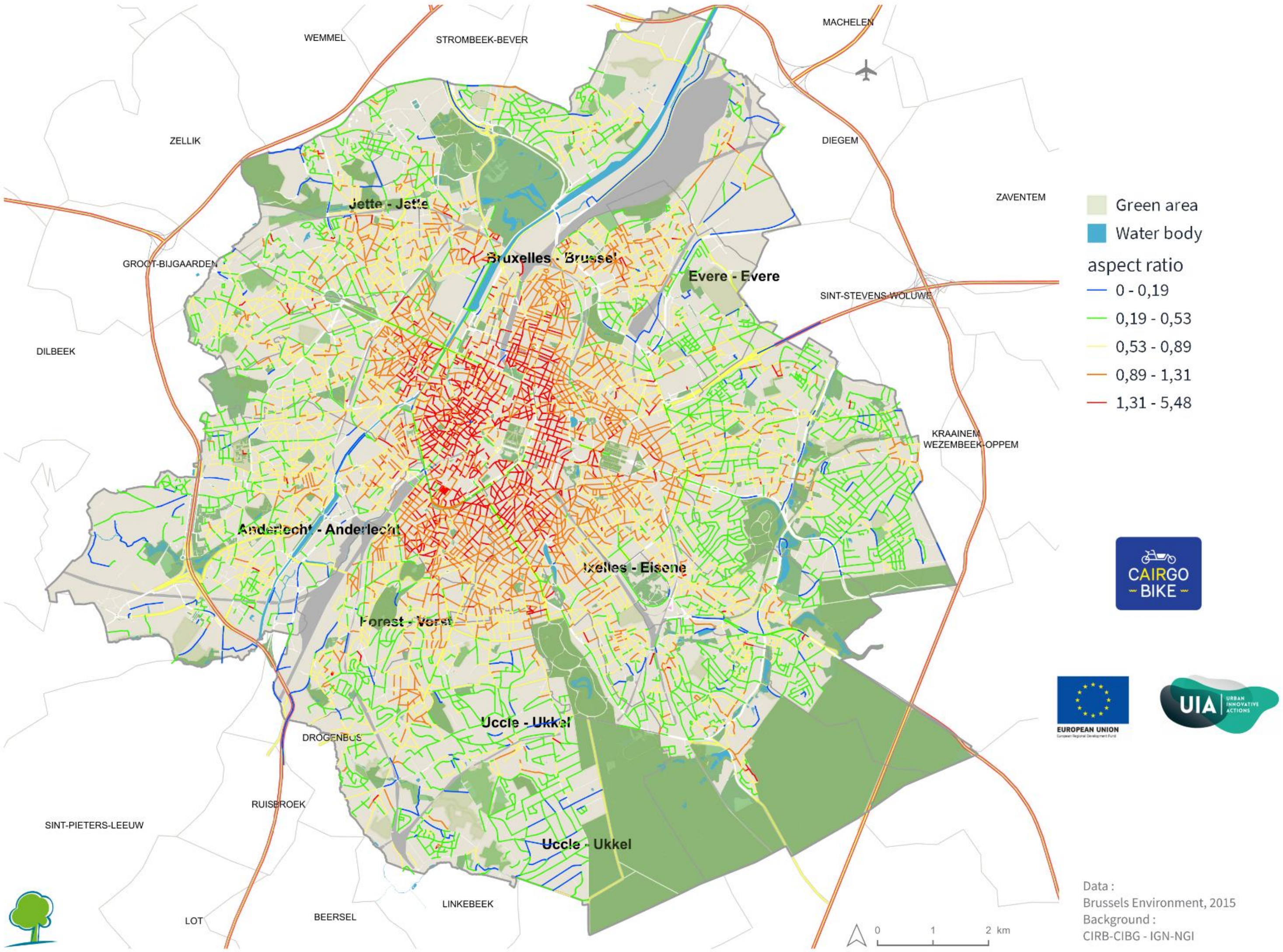

Figure 26 : Mapping of the aspect ratio corresponding to the different street sections of the Brussels area. Five classes of aspect ratio values were defined and their respective colours are given in the legend.

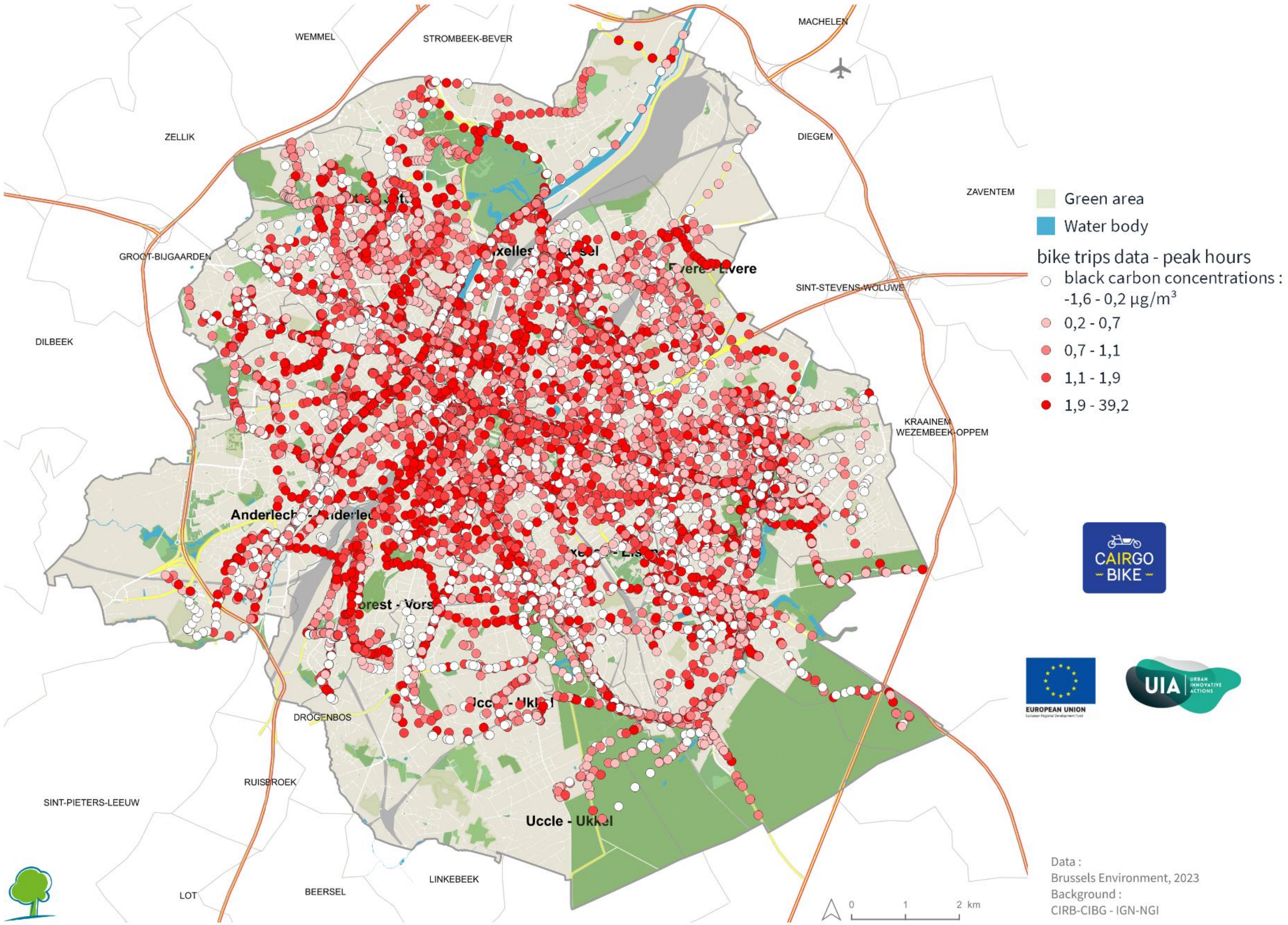

Figure 27 : Mapping of the black carbon concentrations that were measured during the trips by bike and at the peak hours. All the concentration values were corrected by the daily seasonal factors. The negative values can be explained by the weak oscillations in a context of low exposure, as explained in a previous section.

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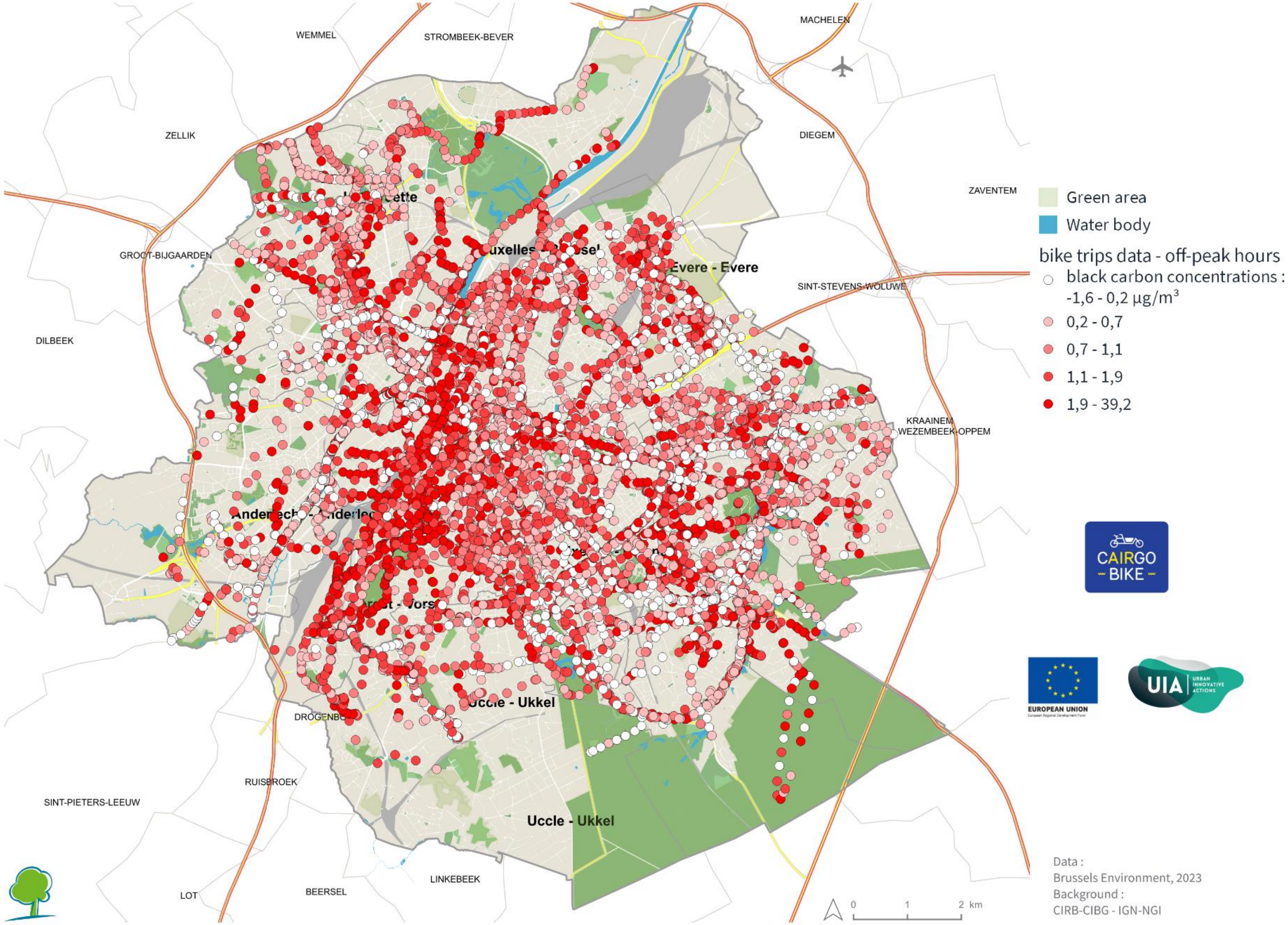

Figure 28 : Mapping of the black carbon concentrations that were measured during the trips by bike and at the off-peak hours. All the concentration values were corrected by the daily seasonal factors. The negative values can be explained by the weak oscillations in a context of low exposure, as explained in a previous section.

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Since evidence of higher concentrations of atmospheric pollutants in the street canyons in regard with the open avenues have already been highlighted (Bogaert and Heene, 2016, Zhang *et al.*, 2019), different categories of aspect ratios values were established (map of the figure 26) in order to wonder whether a relationship existed between the street geometry and the general concentration values in the data set that is available after the geographic analyse detailed previously. The graphs on the figures 29 and 30 enables to understand a slight trend seems to appear : as the aspect ratio gets higher, the mean of the concentrations measured by bike generally rises, as well at peak hours as during off-peak hours. As this phenomenon concerns particularly the lateral extremities of the streets (along the buildings where the streams carry the pollutants), the same analyses were applied on the pedestrians' data. Given the participants recorded much less measurement by foot than by bike during their cargo trials, there does not exist enough data (at least *120* measurement points) for each aspect ratio category but a light trend can be observed anyway on the figures 31 and 32. The drawing on the figure 33 illustrates the aspect ratio and the fact a street canyon mitigates the advantage of bikers compared to motorised vehicles drivers in terms of exposure to atmospheric pollutants : the concentrations are proportionnaly higher along the building fronts than in the case of open streets.

It has to be noted that the data set is quite weak and the trends are slight enough to be careful about any general interpretation. The general conclusions correspond to the results of research studies that were carried out in this branch but a wider data set and modelling taking into account the different geometric parameters of the streets and the meteorological conditions could confirm the trends and make the conclusions stronger. The wide error bars around the means seem to confirm the fragility of the data sets that are implied in the different categories of all the graphs. This issue concerns the following analyses as well.

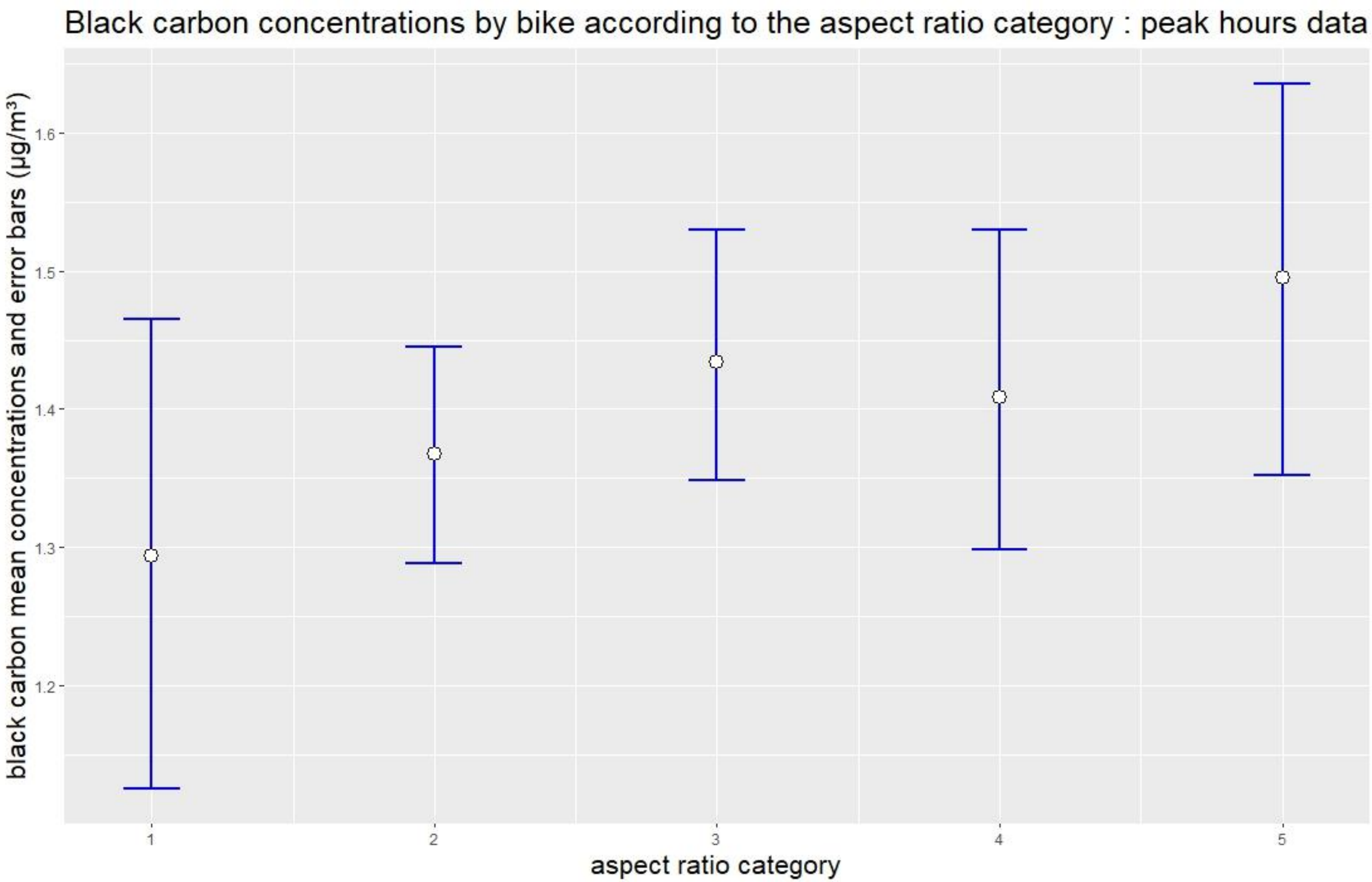

Figure 29 : Means and error bars of the black carbon concentrations that were measured during the trips by bike and at the peak hours, classified by aspect ratio category. All the concentration values taken into account were corrected by the daily seasonal factors. The aspect ratio categories correspond to the ones that are defined on the map of the figure 26.

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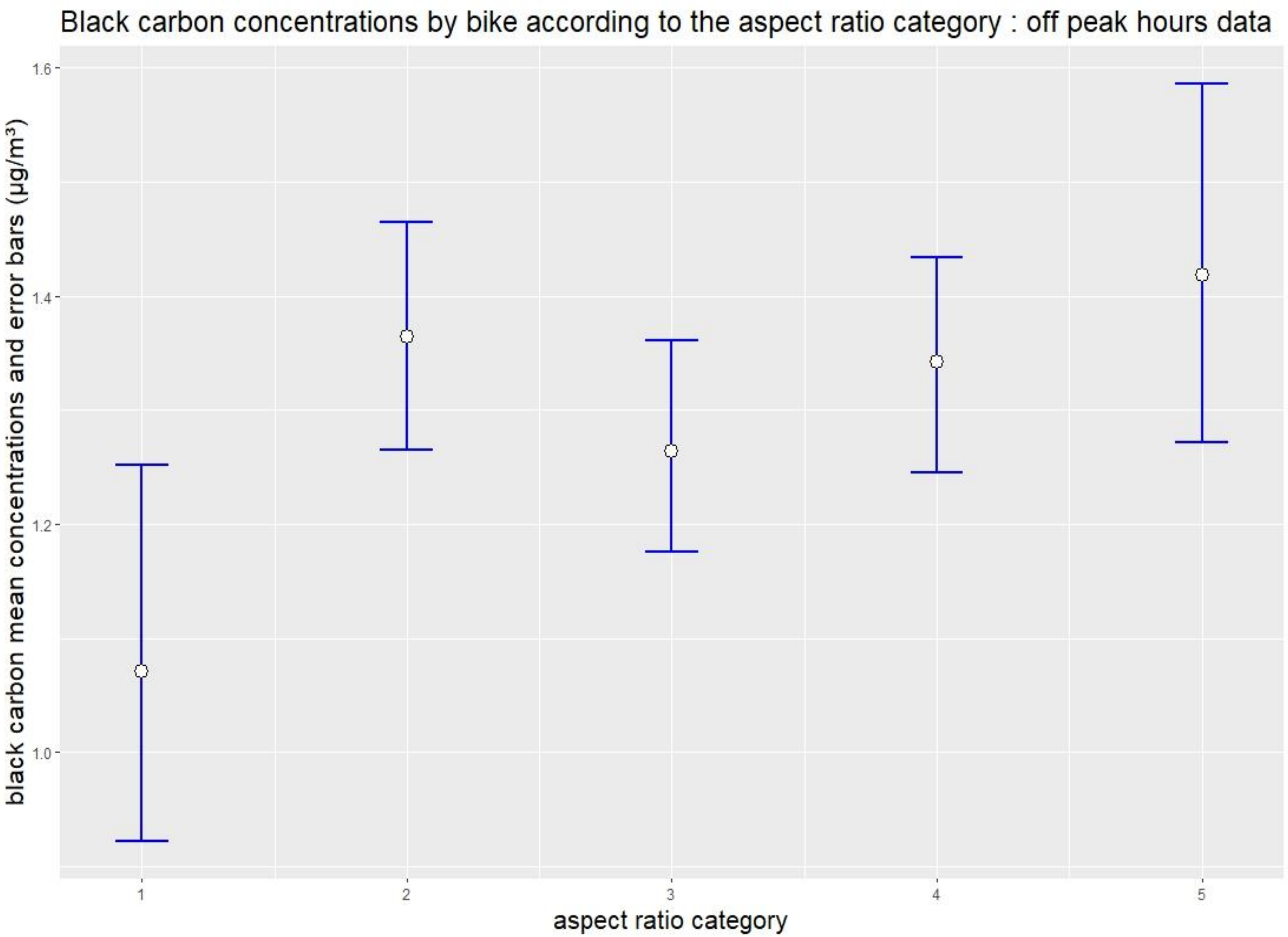

Figure 30 : Means and error bars of the black carbon concentrations that were measured during the trips by bike and at the off-peak hours, classified by aspect ratio category. All the concentration values taken into account were corrected by the daily seasonal factors. The aspect ratio categories correspond to the ones that are defined on the map of the figure 26.

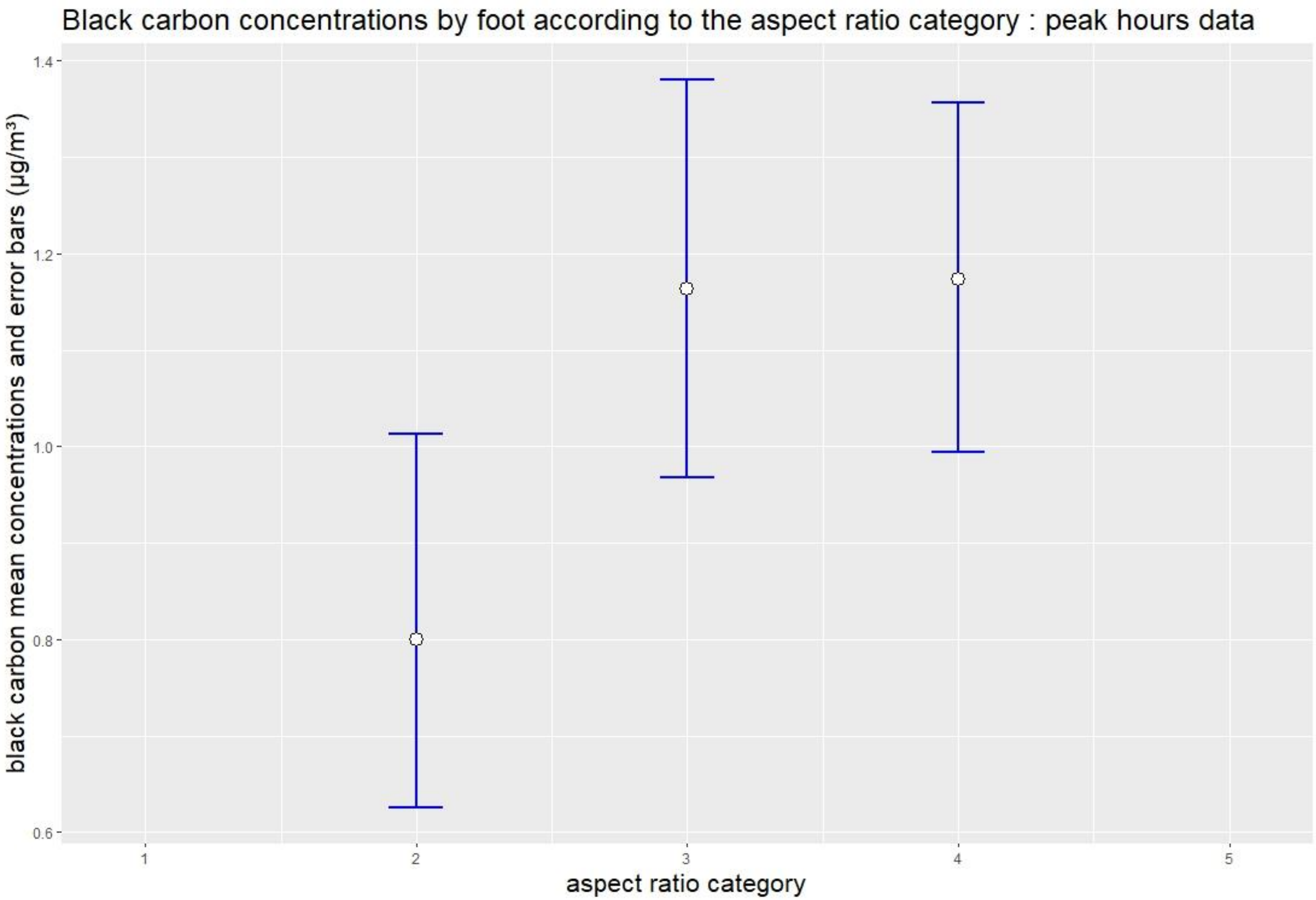

Figure 31 : Mean and error bars of the black carbon concentrations that were measured during the trips by foot and at the peak hours, classified by aspect ratio category. All the concentration values taken into account were corrected by the daily seasonal factors. The aspect ratio categories correspond to the ones that are defined on the map of the figure 26. Given there are not enough data for all categories (> *120* data points), only some of them make a mean value and an error bar appear.

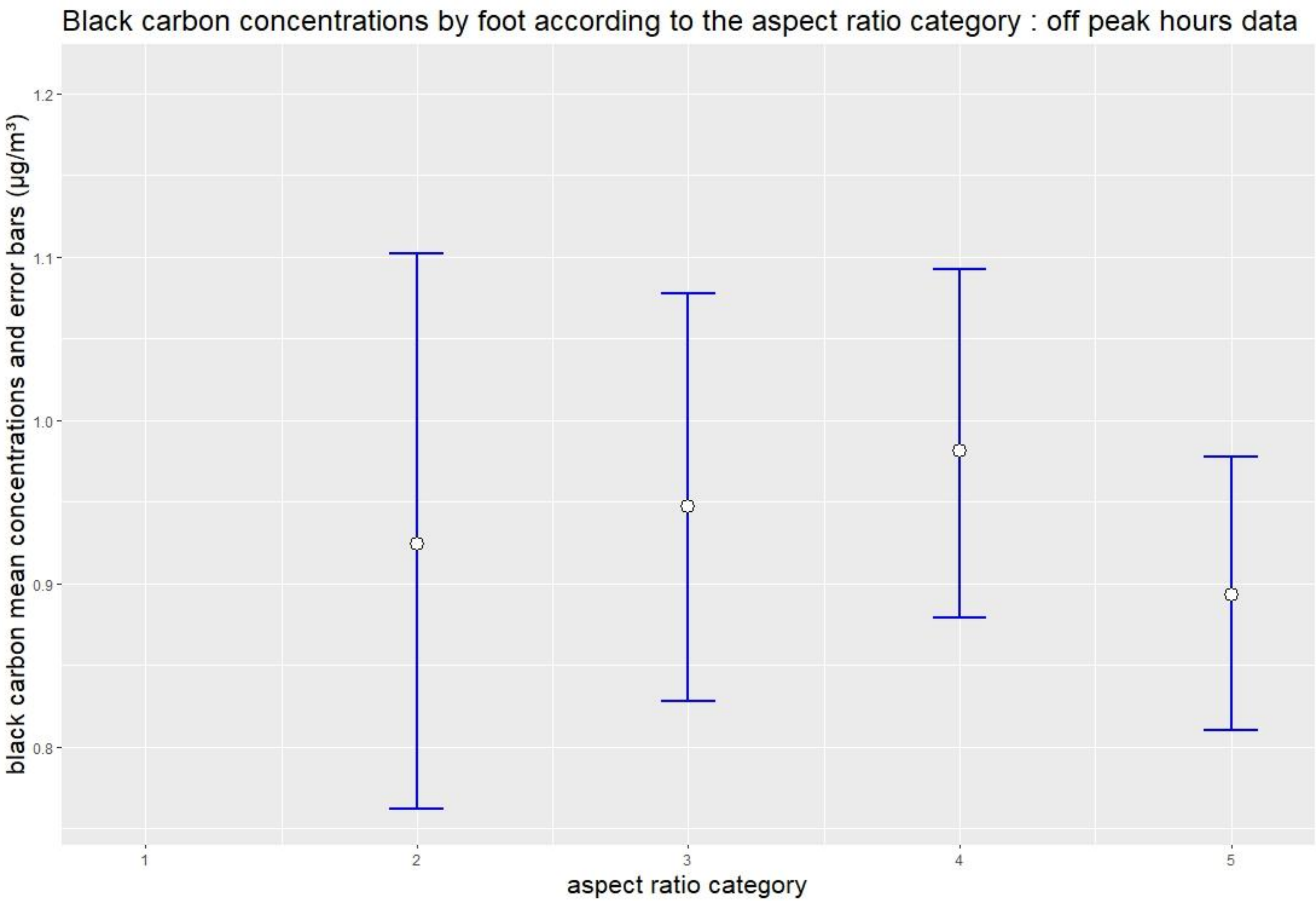

Figure 32 : Mean and error bars of the black carbon concentrations that were measured during the trips by foot and at the off-peak hours, classified by aspect ratio category. All the concentration values taken into account were corrected by the daily seasonal factors. The aspect ratio categories correspond to the ones that are defined on the map of the figure 26. Given there are not enough data for all categories (> *120* data points), only some of them make a mean value and an error bar appear.

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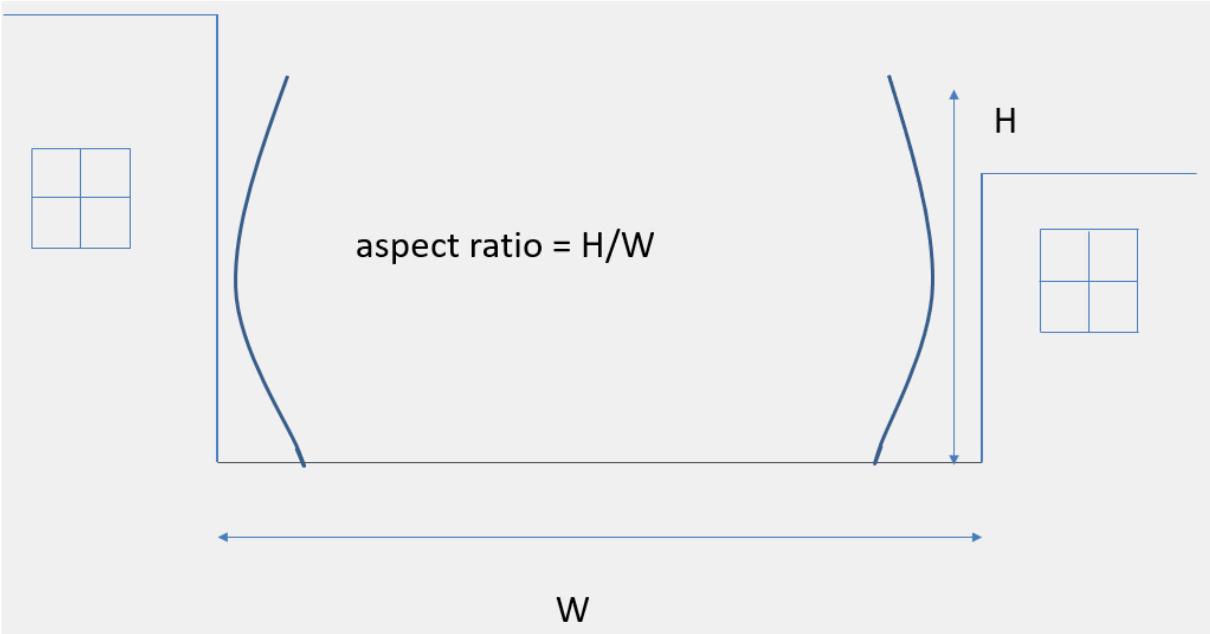

Figure 33 : Illustration of the aspect ratio. The curves are related to the pollutant concentrations that are proportionally higher along the building fronts in comparison with the situation of open streets.

13.3 Variation of the exposure to black carbon with the type of roadway

13.3.1 Analyse based on IRIS 2 mobility plan

As Brussels Mobility defined categories of roadways depending on their width, the intensity of the traffic and the allowed speed, wondering how the exposure to atmospheric pollutants with travel modes vary on these different road types is a relevenant issue. Here is the established hierarchy :

- highways A0,
- metropolitan roads A1,
- main roads A2,
- inter-neighborhood roads A3,
- neighborhood collectors A4,
- neighborhood roadways A5.

This hierarchy was planned in order to cut the browsed distances by car by 20 % between 2001 and 2018 in the framework of the mobility plan IRIS2. The cartography of this road hierarchy ranking appears with a colour code on the figure 17.13.1 in the appendixes.

The two following graphs on the figures 34 and 35 show the black carbon mean concentrations and the error bars by bike and by car that were obtained from the whole Cairgo Bike data set, respectively at peak and off-peak hours. Since the A0 type is related to the highway, this category does not appear as it is not relevant in the case of trips by bike. One can note there exists a clear and logical trend : the concentrations get generally lower as the roadways become more local between the first and the fourth categories. That could be explained by the fact the mobility plan aimed to avoid the transit itineraries in the local streets. It also appears that the difference of exposure between these two travel modes follows the same trend : it gets lower for the roadways that are more local and that is true for the four first categories, even if this observation is much less obvious at the off-peak hours. The reduction of the advantage of bikes compared to motorised vehicles in terms of exposure to particulate matter could be explained by the proportion of isolated cycle paths that gets higher with the road width, so that the mean distance between the bikers and the engine exhaust pollutants rises as well.

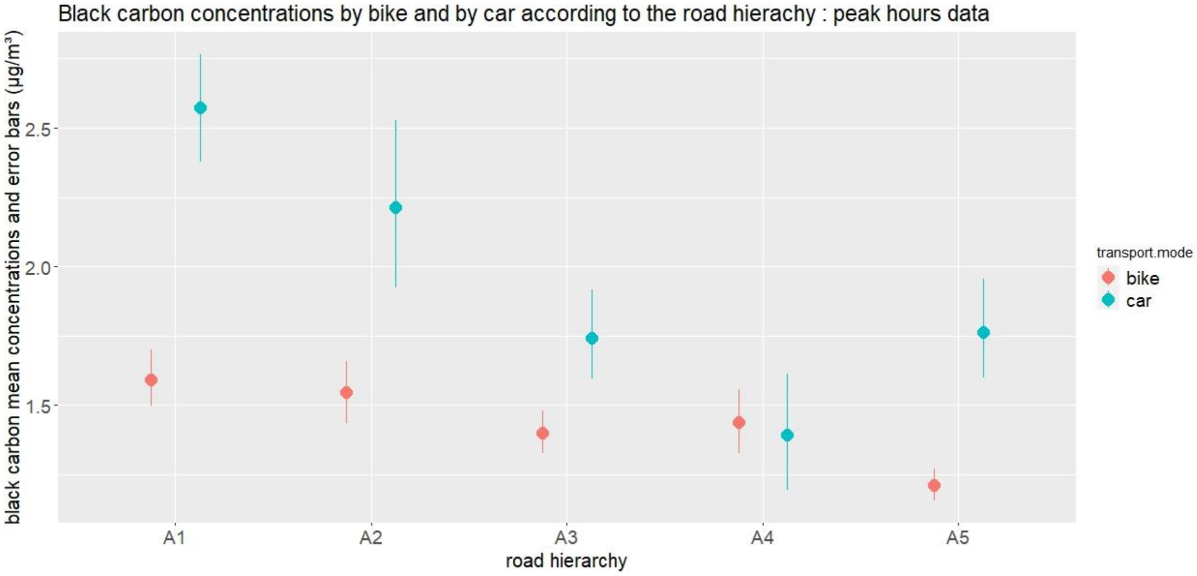

Figure 34 : Distribution of the black carbon mean concentrations and error bars by bike and by car at the peak hours according to the road hierarchy ranking that was proposed by the mobility plan Iris 2. These classes are the following : A1 metropolitan roads, A2 main roads, A3 inter-neighborhood roads, A4 neighborhood collectors, A5 neighborhood roadways.

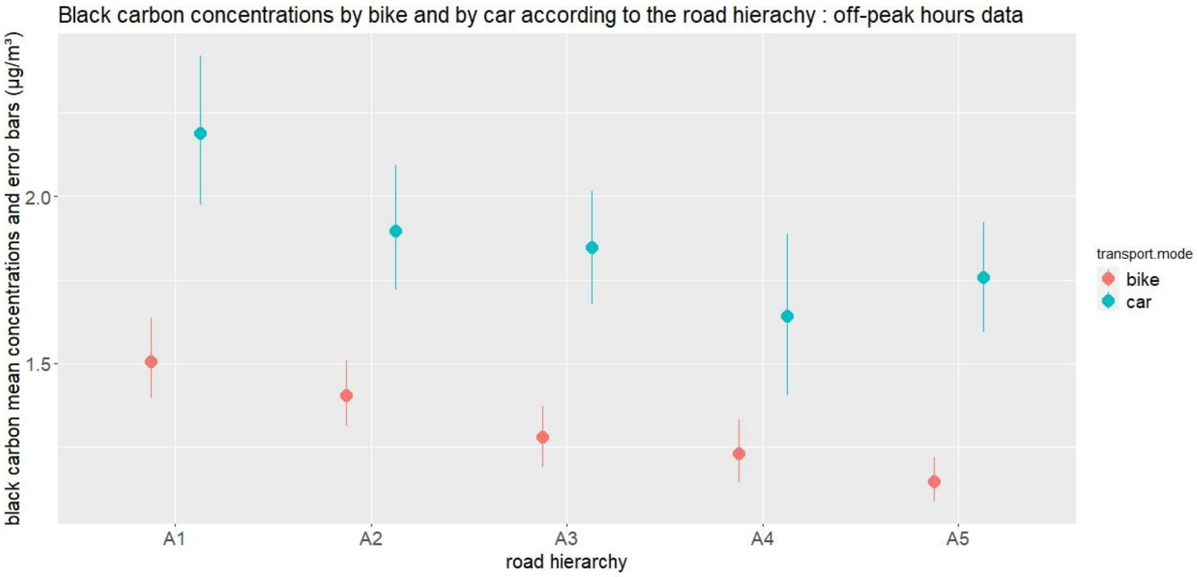

Figure 35 : Distribution of the black carbon mean concentrations and error bars by bike and by car at the off-peak hours according to the road hierarchy ranking that was proposed by the mobility plan Iris 2.

The mapping of the cycling infrastructure of the Brussels area is presented on the figure 17.13.2 in the appendixes, that actually shows the available GIS layer which is produced by Brussels Mobility. As there exists a wide variety of infrastructures that include road items which do not really enable the bikers to ride on an isolated path from the motorised vehicles, another GIS layer was created from the first one, that only contains the paths that do not concern any car. The following items were selected : unidirectional cyclopedestrian furnishing, bidirectional cyclopedestrian furnishing, unidirectional bicycle track, bidirectional bicycle track, and marked bicycle track. The figure 17.13.3 resulted from this handling. The following table refers to the number of segments of bicycle paths (from the GIS layer of the figure 17.13.3) on each hierarchy level of road. The third column inludes the proportion between the number of segments of isolated bicycle tracks on a given type of road and the number of segments of road from this hierarchy ranking. The figure 36 consists of a graph showing the evolution of this proportion according to the roadway type. It appears the trend is obvious and this outcome seems to be logical : the proportion of isolated bicycle paths in relation to the total road segments is higher on the regional roadways than on the little local roads. This larger proportion can be the explanation of the slight trend noted on the basis of the two previous graphs : as bikers are better isolated from motorised vehicles, the difference in terms of exposure to air pollution between these travel modes appear even more beneficial to bikers.

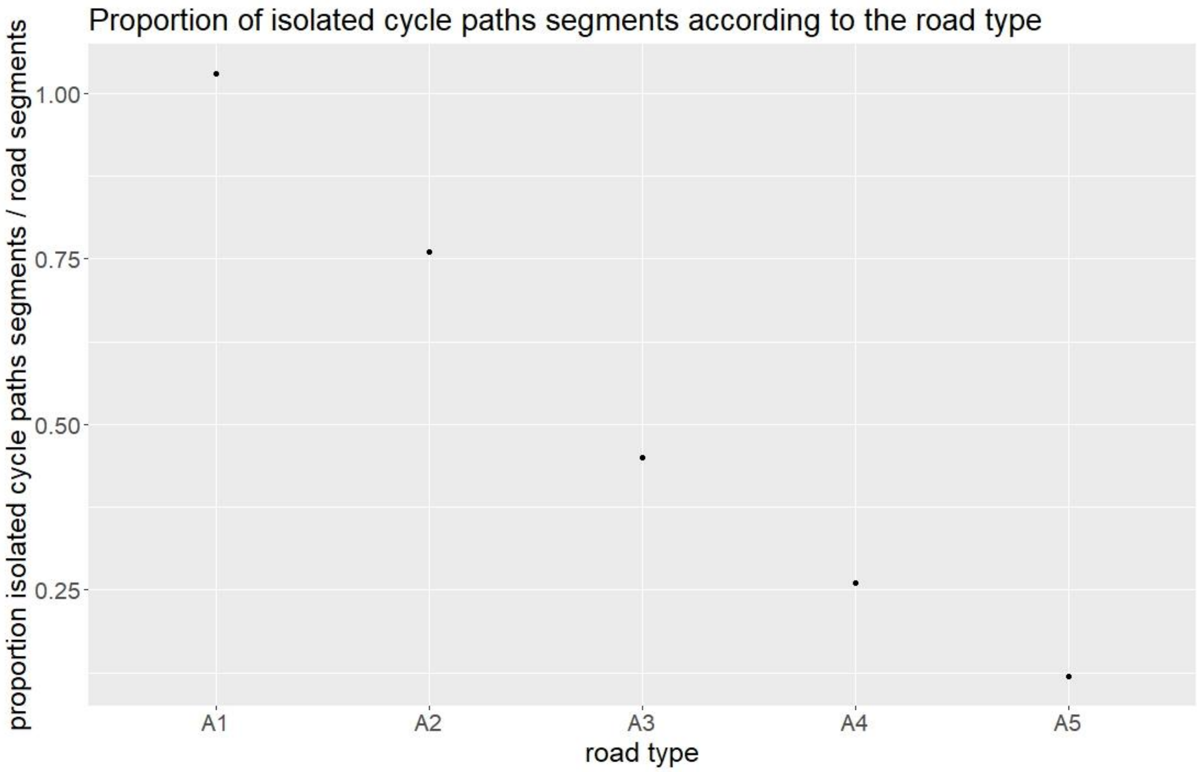

Figure 36 : Proportion of isolated cycle paths segments related to road segments of each hierarchy ranking in function with the road hierarchy ranking. These classes are the following : A1 metropolitan roads, A2 main roads, A3 inter-neighborhood roads, A4 neighborhood collectors, A5 neighborhood roadways.

The figure 17.13.4 in the appendixes corresponds to the data of the previous graphic and of the table 3 and enables the reader to see the proportion of isolated bicycle track for different levels of roadway hierarchy based on the colour code.

road hierarchy ranking and roadway type	number of segments of isolated bicylce tracks	proportion
A1 metropolitan road	*1569*	*1,03*
A2 main road	*1704*	*0,76*
A3 inter-neighborhood road	*2304*	*0,45*
A4 neighborhood collector	*870*	*0,26*
A5 neighborhood roadway	*1908*	*0,12*

Table 3 : Data related to the relationship between the really isolated bicycle tracks and the types of roadway that were defined by the mobility plan IRIS2. The last column is related to the proportion between the number of segments of isolated bicycle paths and the number of segments of road with a given hierarchy ranking.

As the figure 34 shows that the difference in exposure to black carbon pollution on the streets from the hierarchy type A5 is highly benficial to bikers, which counters the general trend of the graph between the hierarchy tpes A1 and A4, the following paragraph describes the analyse that was carried out in order to explain this observation.

As one might assume the street canyons could imply the fact the difference between bikers and car drivers is less high given that the increase of concentrations especially concerns the lateral areas of the

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roadway (along the buildings where a recirculation phenomenon occurs), the following analyse aims to figure out whether the streets geometry on the roads from the hierarchy ranking A5 is particularly different from the other ones. As the street canyons (thus the ones the aspect ratio of which is higher) tend to mitigate the difference between the rates of exposure between bikes and cars, the proportion of open streets (with a weak aspect ratio) related the number of segments from a type of road is here studied. For this purpose, the streets from the two first aspect ratio categories were taken into account, *i. e.* the ones that are characteized by an aspect ratio that is lower than *0,53* given that *0,5* is often considered as a boundary to tell open streets and street canyons apart according to Bogaert and Heene (2016). The result appears obvious on the figure 27, that illustrates the data from the table 4 : the proportion of open streets in relation to the number of segments on the road hierarchy A5 is much higher than in the case of the other road types. That could explain why the advantage of bikes concerning the black carbon concentrations is higher for this road hierarchy ranking than for the previous classes.

road hierarchy ranking and roadway type	number of street segments with an aspect ratio category = 1 or 2	proportion
A1 metropolitan road	*1309*	*0,86*
A2 main road	*1096*	*0,49*
A3 inter-neighborhood road	*3824*	*0,74*
A4 neighborhood collector	*2315*	*0,68*
A5 neighborhood roadway	*16737*	*1,1*

Table 4 : Data related to the relationship between the aspect ratio and the types of roadway that were defined by the mobility plan IRIS2. The last column is related to the proportion between the number of street segments from the aspect ratio category 1 or 2 and the number of segments of road with a given hierarchy ranking.

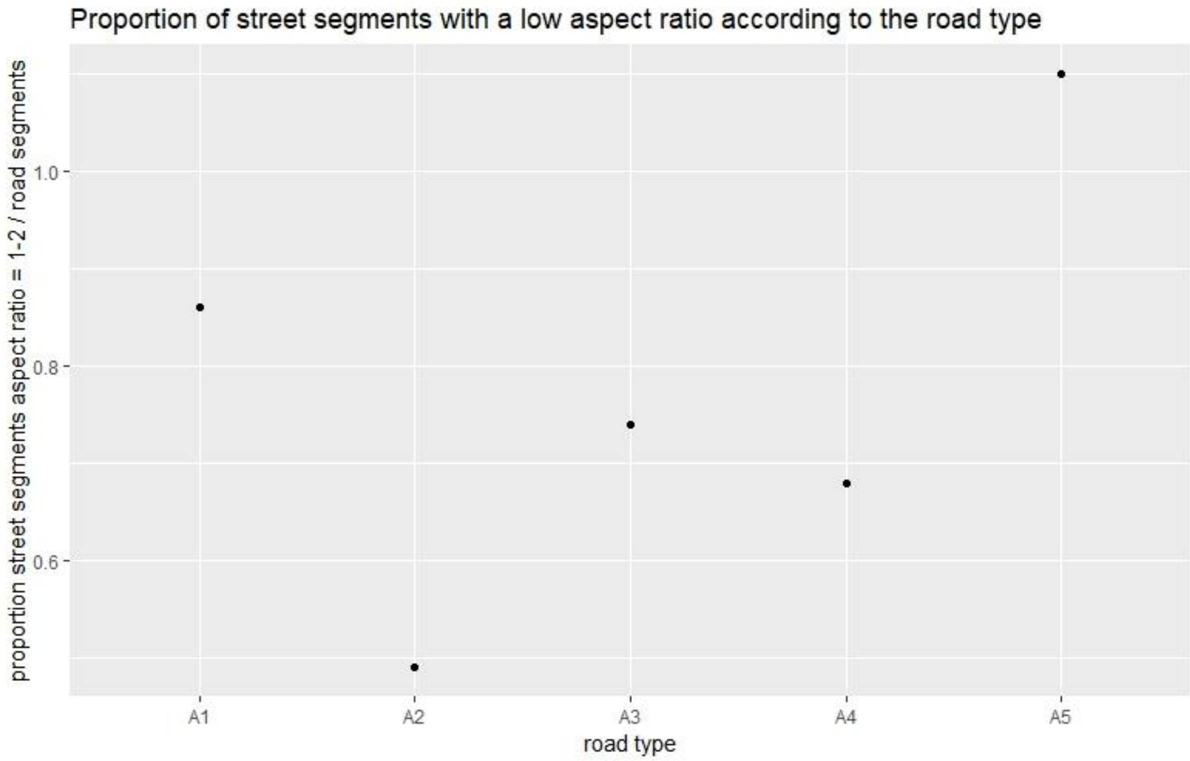

Figure 37 : Proportion of the street segments from the aspect ratio category 1 or 2 related to the segments of road from a given hierarchy class.

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13.3.2 Analyse based on the Good Move mobility plan

As a new mobility plan was implemented by the Brussels-Capital Region, that recovers the period 2020-2030, wondering how the exposure to air pollution and its differences between the transport modes vary in function with its networks makes sense. Citizens, administrations, associations and elected officials were involved to build the Good Move mobility plan, which defined five networks depending on the travel mode with a view to establishing an order of priority for each of them. In particular, the situation of the cycle and automobile networks are taken into account here. For each mode of transport (thus each network), the following levels were proposed :

- "plus" level : for the main travel routes on a metropolitan scale,
- "comfort" level : completes the networking and ensures service to the various polarities of the capital,
- "neighborhood" level : ensures fine service to districts and urban functions allowing both the performance of each network, as well as their proper integration into the public space.

The figure 17.13.5 in the appendixes illustrates the bike network while the following shows the one that is related to motorized vehicles.

The four following graphs on the figures 38 - 41 show the black carbon mean concentrations and the error bars by bike and by car that were obtained from the whole Cairgo Bike data set, at peak and at off-peak hours. The two first figures illustrate the results from the analyse that was carried out taking account of the cycle network while the following are relative to the automobile network. The data points are classified by road specialisation. At first, we can note the concentrations are generally slightly higher on the automobile network than on the cycle one, as well during the peak as the off-peak hours and this observation stands for the two modes of transport. This outcome appears logical since the cycle network is supposed to be more suitable for bikers (the networks do not exactly include the same data in the GIS layer because 222 items from the road and street segments only belong to the automobile network and correspond to highways, and 135 segments present the opposite situation). The same trend as in the case of the road hierarchy analyse appears here, which is obvious during the peak hours once again and very light on the graph relative to the cycle network at off-peak hours (drawing any conclusion from the figure 41 seems not to be possible) : the difference between the exposure rates gets first lower as the streets become more local and then increases between the two last levels. On the same way, we could explain these results by the wider proportion of isolated cycle paths on the main roadways ("plus" level 1) that enable the bikers to ride in low concentration zones of the pollution gradient and the effect of open streets with very small buildings in comparison with the others on the neighborhood level (thus on local streets). Focusing only on these large groups of roads, some might say this classification enables to highlight even more obviously the fact the exposure to black carbon pollution in terms of mean concentrations is in favour of bikes compared to cars, as this observation systematically appears, anyway the level or the network in the framework of this experiment, which was not true with the hierarchy road analyse. The figure 40 shows the only graph where two error bars lightly cross each other ("comfort" level 2).

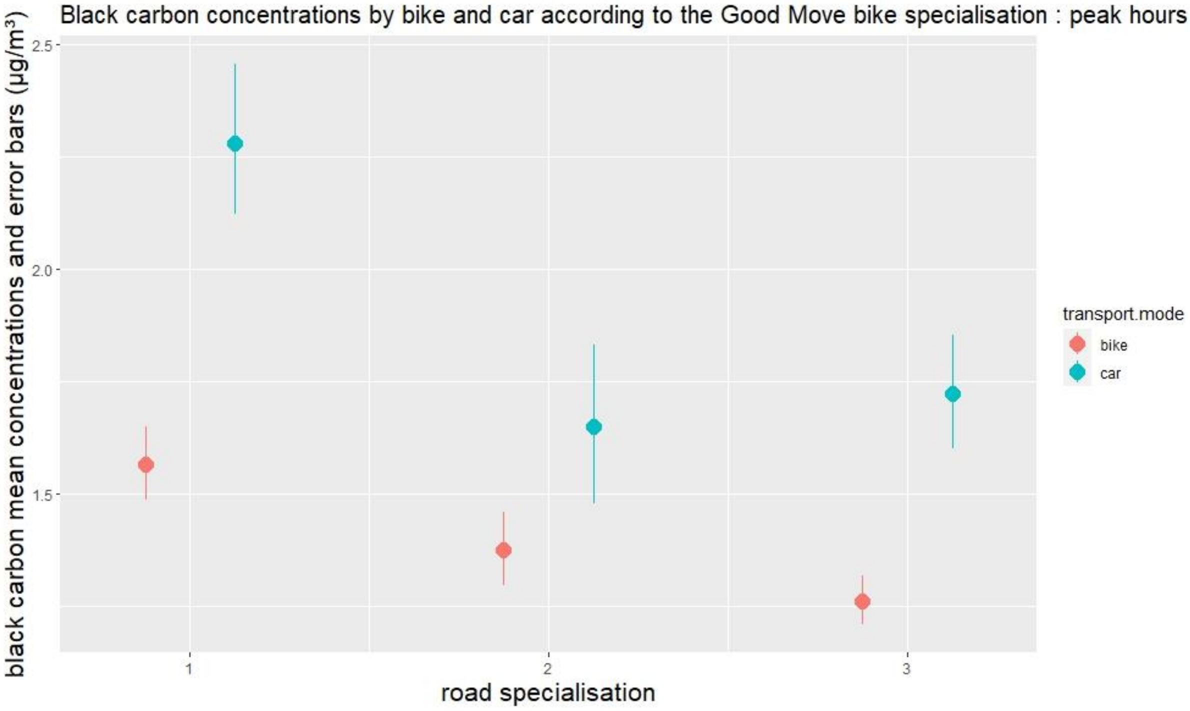

Figure 38 : Distribution of the black carbon mean concentrations and error bars by bike and by car at the peak hours according to the cycle road specialisation that is proposed by the Good Move plan. These classes are the following : 1 “plus” level, 2 “comfort” level, 3 “neighborhood” level.

Figure 39 : Distribution of the black carbon mean concentrations and error bars by bike and by car at the off-peak hours according to the cycle road specialisation that is proposed by the Good Move mobility plan.

Figure 40 : Distribution of the black carbon mean concentrations and error bars by bike and by car at the peak hours according to the automobile road specialisation that is proposed by the Good Move mobility plan. These classes are the following : 1 “plus” level, 2 “comfort” level, 3 “neighborhood” level.

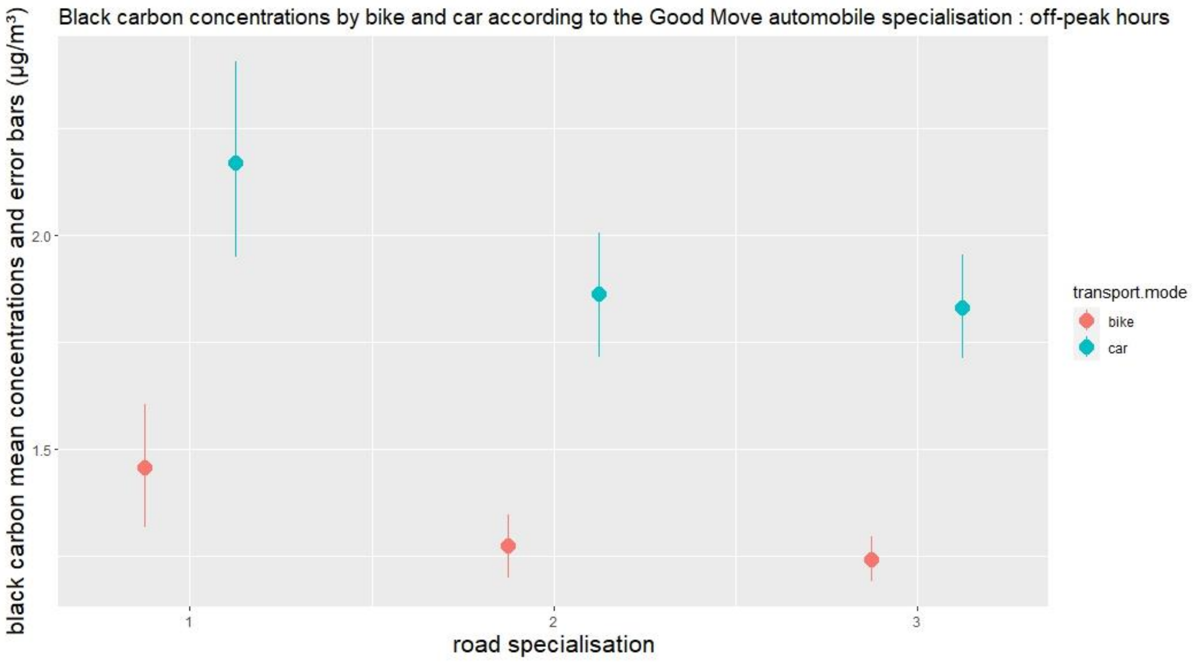

Figure 41 : Distribution of the black carbon mean concentrations and error bars by bike and by car at the off-peak hours according to the automobile road specialisation that is proposed by the Good Move plan.

14. The metro case

Analysing the general figures of the measured mean concentrations by transport mode (figures 23 and 24) makes the situation of the exposure to black carbon in the subway areas interesting. Some might think these very high concentration levels are illogical as subway commuters are not supposed to face exhausts from thermal engines that burn petrol or diesel. Nevertheless, it is well known that particulate matter is characterized by a wide variety of composition and metals could form little particles that are as small as the ones of black carbon. In this section focuses on explanation elements about how concentrations can reach so high values of black carbon concentration in this underground transport mode.

The following figure was extracted from a participant's data who did a metro trip during which this person made the aethalometer active. Many metro trips from the Cairgo Bike data set show concentration times series with levels that are similar to these of this trip.

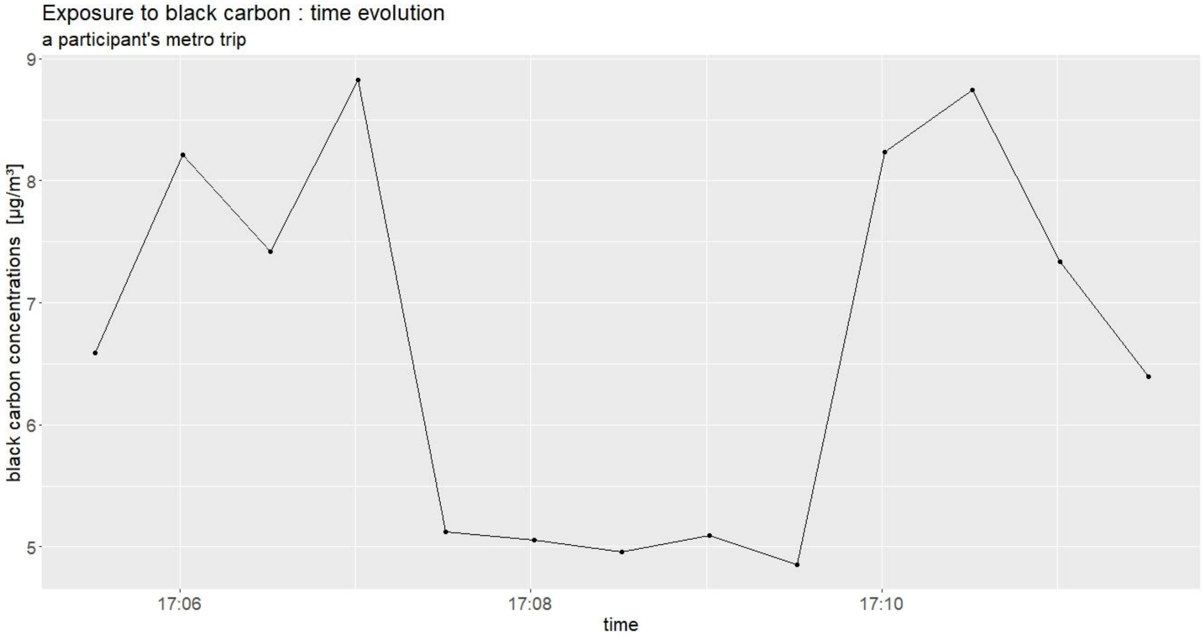

Figure 43 : Concentration time series from a Cairgo Bike participant during a metro journey.

Tan *et al.* (2022) emphasizes that subway stations in Singapore were characterized by particulate matter levels that exceeded the new World Health Organization 24-hour mean exposure and that was especially true for fine particulate matter (PM2.5), of which black carbon particles are part. In Shanghai, Qiao *et al.* (2015a) observed the mean level of PM1 (particulate matter that is smaller than *1 µm*) reached *231 µg/m³* +- *152* (error bar) in metro system. Chemical composition and mineralogy of subway system have already been assessed and iron (Fe) can be observed as the most abundant metal element, followed by calcium (Ca), aluminium (Al), magnesium (Mg) and manganese (Mn) and their concentrations were significantly higher than those in the urban ambient air, which could imply these metals may be associated with the metro use and the rail-wheel-brake interface (Quiao *et al.*, 2015b.) Xu and Hao (2017) had already showed particulate matter in the subway stations were characterized by different compositions from those of the street-level ambient air. They also figured out that the concentration rates were influenced by the airflow rate (thus the ventilation system), the architecture of the station, the depth of the platform, the frequency of metros and the presence of platform screen doors.

As metals often produce black dusts, noting that they absorb visible light and infra-red beams would not be surprising and wondering how high are the coefficient absorption values of metals depending on the wavelength is relevant.

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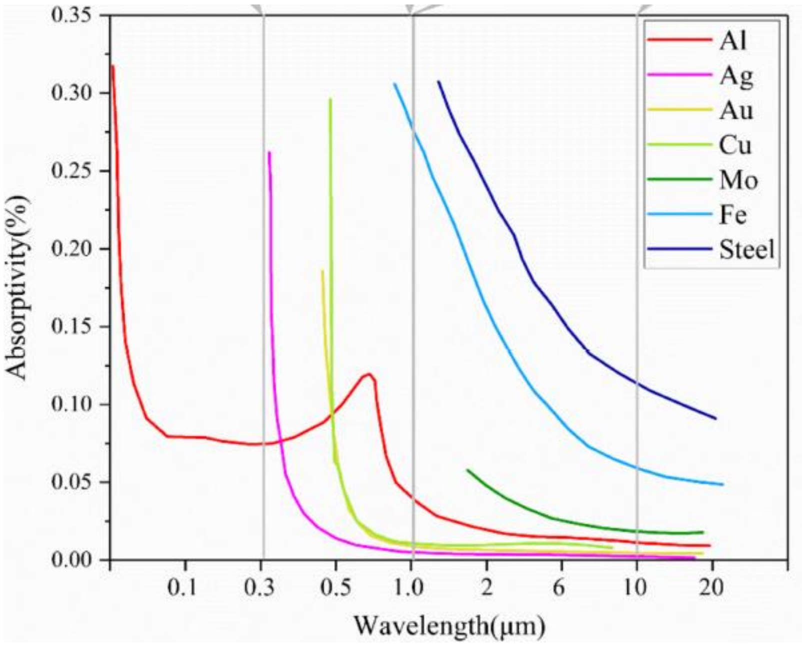

Absorption rates of different metals, expressed in absorptivity (%) for different wavelengths (*µm*) (modified from Zhu *et al.*, 2019).

Looking for the metals properties in the framework of testings about the quality of the weld, Zhu *et al.* (2019) obtained this graph using lasers. The absorptivity is the fraction of the radiation energy incident on a surface that is absorbed by it. This parameter refers thus to the absorption coefficient. It appears from this figure that the absorptivity (thus the absorption coefficients) is particularly high for iron (Fe) and not negligible at all for aluminium (Al) at *0,8 micrometers* (thus *880 nm*), that is the wavelength which is used by the aethalometers and is relative to infra-red beams that are absorbed by black carbon particles. That seems to explain why the black carbon aethalometers detected high concentrations in subway areas. The fact that the contact between the metro and its rail produces iron is not really surprising but proving a black carbon measuring device could detect its concentration level and knowing this metal (and other ones) absorb widely in the same wavelengths domain as black carbon particles was not necessary obvious. Even if these materials are not really black carbon, their physical properties enabled the participants to measure them.

The following list corresponds to the metro stations the participants mentioned in their loogbooks. The municipalities where they are located appear as well. It can be noted that the concentrations were high as well in the stations as during the trips between two of them.
- Etangs noirs (1080 Molenbeek-Saint-Jean)
- Comte de Flandre (1080 Molenbeek-Saint-Jean)
- De Brouckère (1000 Brussels)
- Maelbeek (1000 Brussels)
- Schuman (1000 Brussels)
- Porte de Namur (1050 Ixelles)
- Bizet (1070 Anderlecht)
- Erasme (1070 Anderlecht)
- Tomberg (1200 Woluwe-Saint)

As there exists an abundant literature on this subject (see above), the air quality in subway areas begins to become a real concern and further research deserves to be carried out with a view to better understanding this issue in the metro network of the Brussels region.

15. Conclusions

The Cairgo Bike programme aimed to promote the cargo bike and to make it a common mode of transport in the Brussels area. As lots of research studies in many regions around the world have already shown the advantage of bikes in comparison to motorised vehicles in terms of concentrations of atmospheric pollutants, this fact formed of an important argument to give citizens and professionals another incentive to realize a modal shift from vans or cars to bikes and change their travel habits. For this purpose, this experiment gathered data from more than a hundred participants who wore a portable black carbon aethalometer during a couple of weeks. Given that two different generations of these devices were used due to a delivery delay, making the data correspond in a sole set was not an easy step. As the older aethalometers were not designed with the same performant system of measurement correction as the newest, they implied processings that are widely discussed. Since the data were collected during a large period of time, another processing consisted of the application of a seasonal correction, that took into account the concentrations from the telemetric measuring network, and that concerned all the data points from all the aethalometers.

As a controversy exists between the total inhaled dose of atmospheric pollutants and the exposure in terms of concentrations and since it constitutes a real concern in the framework of the general understanding when speaking about the air quality in traffic, a pure theorical section was drawn up about this subject. Another section focuses on the particular case of the subway, given the high concentration levels that were measured in this travel mode during the project.

The general results enable to highlight the fact the exposure to these particulate matter is well lower for bikers than car drivers and the outcomes appear obvious as well at peak as during off-peak hours. The collected concentrations were used on a geographic information system and implemented with data sets relative the mobility parameters which are managed by the regional government department that is responsible for infrastructure and transport. As the Brussels-Capital Region has implemented several mobility plans in its highly urbanized territory to make it more pleasant for the inhabitants, the classification of roadways they established was used with a view to figuring out on what way the different defined road classes could provoke trends in the comparison between the exposure to pollution of these two travel modes. Given the quite large cycle paths network of the Brussels built-up area, the obtained results were compared to the geographical data on these bicycle tracks and logical relationships seem to appear, as the distance between the motorised vehicles and the bikes (and thus the proportion of isolated cycle tracks) seems to be an essential parameter impacting the exposure levels. The pollution exposure rates were also analysed on the basis of the streets geometry and that enabled to emphasize a likely link between it and the road classifications. The overall trends that were highlighted could clearly encourage to support the existing cycling infrastructure and address regulations with the aim of developing it and in particular creating more isolated cycle paths.

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17. Appendixes

17.1. Cargo bike trial sessions for citizens who used a black carbon aethalometer

Cargo bike trial session	Date	Number of participants	Number of participants whose the collected data were useable
Woluwe-Saint-Pierre 2	from 20th May to 3rd June 2021	6	5
Jette 1	from 3rd June to 17th June 2021	2	1
Jette 2	from 10th June to 24th June 2021	3	3
Koekelberg 1	from 24th June to 7th July 2021	2	2
Koekelberg 2	from 1st July to 15th July 2021	4	4
Ixelles 1	from 19th August to 2nd September 2021	4	4
Ixelles 2	from 26th August to 9th September 2021	3	2
Brussels 1	from 9th September to 23rd September 2021	3	3
Brussels 2	from 16th September to 30th September 2021	3	3
Forest 1	from 30th September to 14th October 2021	3	3
Forest 2	from 7th October to 21st October 2021	2	2
Saint-Gilles 1	from 21th October to 4th November 2021	4	3
Saint-Gilles 2	from 28th October to 10th November 2021	4	4
Circularium 1	from 25th November to 9th December 2021	5	4
Circularium 2	from 3rd February to 17th February 2022	3	2
Circularium 3	from 24th February to 10th March 2022	5	3
Watermael-Boitsfort 1	from 17th March to 31st March 2022	1	1
Watermael-Boitsfort 2	from 24th March to 7th April 2022	5	4
Schaerbeek 1	from 21st April to 5th May 2022	4	4
Schaerbeek 2	from 28th April to 12th May 2022	2	1
Auderghem 1	from 9th June to 23rd June 2022	7	6
Circularium 4	from 10th August to 23rd August 2022	6	6
Circularium 5	from 25th August to 6th September 2022	5	4
Evere 1	from 8th September to 22nd September 2022	3	3
Evere 2	from 15th September to 29th September 2022	2	2
Woluwe-Saint-Lambert 1	from 29th September to 13th October 2022	7	7
Woluwe-Saint-Lambert 2	from 6th October to 19th Obtober 2022	3	3
Auderghem 2	from 19th October to 3rd November 2022	3	2
Circularium 8	from 2nd February to 16th February 2023	3	3
Berchem-Sainte-Agathe 2	from 16th March to 30th March 2023	2	2
Ganshoren 1	from 30th March to 13th April 2023	2	2

Table 17.1.1 : List of cargo bike trial sessions that were organized by Pro Velo for citizens and numbers of participants who contributed to the black carbon measurement campaign. Some participants eventually decided not to use the aethalometer during the bike test period, other ones did not use it on the right way as it was not active during the trips they recorded in their logbook or they did not mention any journey whereas the device was measuring. Technical issues sometimes occurred as well. Some initial users could not provide valid data for all of these reasons.

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17.2. Handbook for the use of the MA200 aethalometer

MODE D'EMPLOI DE L'AETHALOMÈTRE PORTABLE

1. INTRODUCTION

L'æthalomètre portable (photographie 1) est destiné à mesurer les concentrations de Black Carbon (BC). Il contient de plus un GPS intégré permettant de le géolocaliser.

Les particules de BC constituent une sous-catégorie des particules fines PM2.5. Ces particules sont issues de la combustion incomplète des combustibles fossiles et présentent des diamètres généralement compris entre 10 et 500 nm. Dans les zones urbaines, ces particules constituent un bon traceur des polluants émis par le transport routier. Par ailleurs, d'après plusieurs études récentes, cette sous-catégorie de particules fines serait aussi considérée comme étant une des plus toxiques en raison de leur petite taille.

Photo. 1

L'æthalomètre qui vous est remis est directement prêt à l'utilisation, c'est-à-dire avec batterie chargée. Il n'est pas nécessaire de le mettre en marche, cela a déjà été effectué au moment où il vous a été remis.

2. MANIÈRE DE PORTER L'AETHALOMÈTRE

L'æthalomètre est fourni avec une pochette de transport.

- L'æthalomètre **doit donc rester allumé.** Portez en permanence l'æthalomètre en bandoulière (photo. 2).

Photo. 2

- Pour le bon déroulement des mesures, il est <u>indispensable</u> que la prise d'air (photo. 3) ne soit jamais obstruée. Cela signifie notamment que l'æthalomètre doit toujours être disposé au-dessus des vêtements. Le tube de prélèvement d'air est présenté sur la photographie 3.

Photo. 3

Système de prise d'air

<u>Conseils importants</u> :

1. Pensez à porter en permanence l'appareil en toutes circonstances (en voiture, lorsque vous cuisinez, etc).
2. Évitez de donner des chocs.
3. Évitez les projections d'eau sur l'æthalomètre ; utilisez un parapluie pour éviter que les précipitations ne s'introduisent dans le système de prise d'air.

3. Utilisation de l'appareil durant la journée

L'appareil restera **allumé toute la durée de son utilisation**. La prise de mesures a été activée lorsqu'il vous a été remis et il vous est donc possible de le laisser fonctionner toute la journée. Si vous ne souhaitez pas obtenir de données de concentrations d'air intérieur, vous pouvez, dès que vous venez de terminer un trajet, désactiver les mesures, mais l'æthalomètre doit toujours resté allumé. Dans le cadre du projet, il est par contre **essentiel que l'appareil soit actif** (bruit de la pompe) **lors de chacun de vos déplacements**.

- Si vous souhaitez **désactiver** la prise de mesures (**sans éteindre l'appareil**), il vous suffit d'**appuyer brièvement sur le bouton du milieu** (les messages « Start Measurement » et « STOPPED » apparaissent alors sur l'écran et restent visibles jusqu'à la réactivation du prélèvement d'air). Les photographies 4 et 5 mettent cela en évidence. Nous vous invitons à faire cela au moment où vous recharger l'appareil en fin de soirée.

=>

Photo. 4 **Photo. 5**

- Pour **réactiver** le prélèvement d'air, il suffit d'appuyer **longuement** sur le même bouton du milieu jusqu'à ce que le message « Skipped Tape Advance » apparaisse au milieu de l'écran. Il disparait ensuite et vous pouvez alors lire « Press Center to Stop » et « SAMPLING ». La manipulation et son résultat sont visibles sur les photographies 6 et 7.

=> Skipped Tape Advance =>

Photo. 6 **Photo. 7**

- Il est important d'**appuyer durant plusieurs secondes lors de la réactivation**, jusqu'à ce que le message « Skipped Tape Advance » s'affiche. Avec une simple pression brève, la cassette qui permet de récolter les particules sera beaucoup plus vite épuisée.
- Les deux **boutons latéraux** n'ont aucune utilité durant le test et **ne doivent pas être utilisés**.

4. RECHARGE DE LA BATTERIE

- Branchez le câble d'alimentation à la prise située sur la face arrière de l'æthalomètre, celle qui est accessible au moyen de la tirette de l'étui (photo. 8).

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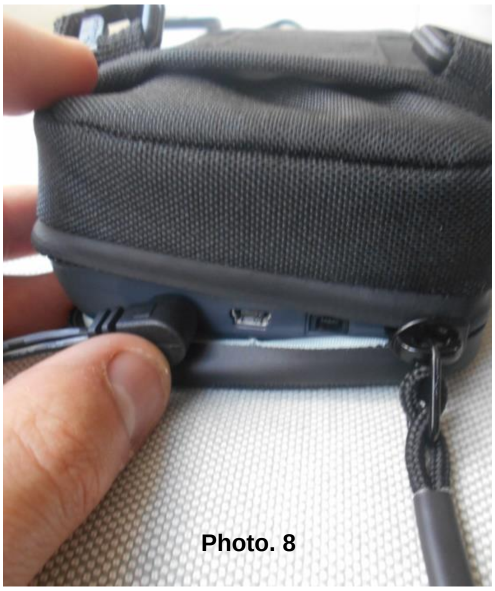

Photo. 8

- Branchez l'adaptateur sur le secteur, pendant au moins 3 heures consécutives.

- Il est également possible de recharger la batterie de l'æthalomètre en le connectant à un ordinateur. Utilisez pour cela le câble mini-USB, à brancher à l'arrière de l'appareil également, comme montré sur la photographie 9. Dans ce cas, 6,5 heures sont nécessaires pour une recharge complète.

Photo. 9

- Pour une bonne utilisation de l'appareil, veuillez le **recharger au moins tous les soirs**.
- Le coin supérieur droit de l'écran fait apparaître le pourcentage du niveau de charge, comme repris sur la photo. 10 : « B : X% ».   Tant que possible, il s'agit de **recharger la batterie dès que ce niveau est faible**.

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niveau de charge de la batterie

Photo. 10

<u>Conseil important</u> : le soir, déposez l'æthalomètre à recharger à un endroit qui permettra de ne pas oublier d'emporter l'appareil le matin (par ex. à proximité des clés, vêtements, objets à emporter, etc).

Parallèlement à l'utilisation de l'æthalomètre, **veuillez bien décrire dans le carnet de bord les différents trajets que vous réalisez tout au long des journées de mesure.** Ainsi, votre exposition au BC pourra être évaluée.

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17.3. General Data Protection Regulation documents

Projet Cairgo Bike : valorisation des vélos cargos avec périodes de test par les citoyens, utilisation de moniteurs portables de qualité de l'air et enquête d'adhésion à ce mode de transport

Entre les soussignés :

Bruxelles Environnement, dont le siège social est situé avenue du Port 86C/3000, 1000 Bruxelles ; enregistré à la Banque-Carrefour des entreprises sous le numéro 0236.916.956 ; représenté par Frédéric FONTAINE, Directeur général, et Barbara DEWULF, Directrice générale adjointe;

Ci-après dénommé « **BE** »,

Et

Pro Velo dont le siège social est établi à Rue de Londres 15, 1050 Ixelles ; enregistré à la Banque-Carrefour des entreprises sous le numéro 0449.049.820 ; représenté par Christophe WINKEL, Directeur;

Ci-après dénommé « **PV**»,

Et

la VUB / de Vrije Universiteit Brussel est établie au Boulevard de la Plaine 2, 1050 Ixelles ; enregistré à la Banque-Carrefour des entreprises sous le numéro 0677.439.981 ; représentée par Caroline PAUWELS, Rectrice.

Ci-après dénommée « **VUB** »,

Les PARTIES à la présente CONVENTION étant ci-après désignées, ensemble ou séparément par les «PARTIES» ou la «PARTIE».

SOMMAIRE

Il est convenu ce qui suit :

1 Description sommaire du Projet

Les partenaires s'engagent à collaborer dans le cadre d'un projet de promotion du vélo cargo et de sensibilisation auprès des citoyens et entreprises de la Région Bruxelles-Capitale faisant notamment intervenir une mise à disposition de vélos cargos auprès de particuliers et d'entreprises ainsi qu'une collecte de concentrations de polluants et des données relatives à l'utilisation de différents moyens de transport et aux trajets parcourus. Ainsi, concernant les mesures de concentrations, un GPS intégré dans un moniteur de qualité de l'air sera employé et les différents mouvements des participants seront géolocalisés et pris en considération. Parmi les participants, les particuliers auront répondu à un appel de Pro Velo relayé par les communes et auront fait l'objet d'une sélection par cette Partie, les choix étant notamment effectués sur base des lieux approximatifs d'habitat ainsi que des modes de transport fréquemment utilisés. Dans le cas où de nombreuses candidatures seraient effectuées lors des derniers jours possibles, la priorité serait donnée aux autres de façon à fluidifier le déroulement du Projet. Hormis l'obligation d'être non-fumeur, qui concerne uniquement les personnes souhaitant participer à la collecte de mesures de concentrations (afin de ne pas biaiser les concentrations mesurées), aucun critère ne sera restrictif : il s'agit de représenter au mieux la diversité de la population bruxelloise.

La participation des citoyens doit permettre d'atteindre différents objectifs, auxquels aspirent les trois Parties. Il s'agit pour Bruxelles Environnement d'affiner la connaissance de la variation au taux d'exposition à ce polluant avec les différents modes de transport et de mettre en évidence la variation spatiale des concentrations sur base des quartiers et donc de l'intensité du trafic routier. De plus, une modélisation de la diminution des productions de polluants atmosphériques et de gaz à effet de serre sur base d'une utilisation plus abondante des vélos cargos sera également réalisée par l'institut. Concernant la VUB, l'objectif sera d'une part d'analyser la façon dont la population et les entreprises adhèrent à l'utilisation du vélo cargo et d'autre part, de modéliser l'impact du vélo cargo sur les externalités du transport à travers les différents pilotes réalisés dans Cairgo Bike. Enfin, ce Projet correspond parfaitement à l'essence même des activités de Pro Velo, dont le but est de promouvoir la mobilité douce, ainsi que former et soutenir en particulier les cyclistes. De façon générale, Cairgo Bike, projet approuvé et financé par la Commission Européenne rentre dans le cadre de la transition de la mobilité en Région bruxelloise et d'un accès aisé à l'information concernant la qualité de l'air pour les citoyens, enjeu majeur dans une agglomération aussi dense, et constitue un outil de sensibilisation permettant aux citoyens eux-mêmes de contribuer grandement au changement.

Les mesures de concentrations et les enregistrements des coordonnées géolocalisées sont réalisées durant trois périodes, l'une de quatre mois, les autres de trois mois. Les moniteurs portables de qualité de l'air seront distribués lors de deux semaines sur trois durant ces périodes. L'utilisation des vélos cargos et le suivi par PV s'étaleront sur une période plus longue, de 26 mois, en différentes périodes.

2 Les Partenaires et leur rôle respectif

Les partenaires sont co-responsables du traitement des données faisant l'objet de la présente Convention.

Les partenaires sont :

- **Pro Velo** est une association sans but lucratif qui accompagne citoyens et entreprises vers une mobilité active et facilite la transition vers le vélo. Depuis 1992, l'équipe de Pro Velo offre un soutien professionnel aux particuliers, aux pouvoirs publics et aux entreprises sous forme de services et de solutions « sur mesure ». Le but principal de Pro Velo est de répondre aux besoins. La ligne de conduite : soutenir les cyclistes actuels et potentiels, enseigner la conduite à vélo, diffuser une image positive et accompagner la politique cycliste. Pro Velo contribue ainsi à une meilleure qualité de vie !

- **Bruxelles Environnement** est l'administration de l'environnement et de l'énergie en Région de Bruxelles-Capitale. Ses domaines d'activité recouvrent l'environnement au sens large, ce qui comprend entre autres la mesure de la qualité de l'air et la mise en œuvre de plusieurs politiques en lien avec la mobilité durable, comme la Low Emission Zone, la sortie des moteurs thermiques, les plans de déplacement des entreprises, ou encore le verdissement de la flotte de véhicules des autorités publiques. Bruxelles Environnement est également en charge du réseau de mesure de qualité de l'air et des inventaires d'émissions de polluants atmosphériques, qui sont rapportés chaque année auprès de la Commission européenne.

- **La VUB (Vrije Universiteit Brussel)** est une université à vocation internationale située à Bruxelles, au cœur de l'Europe. Grâce à une recherche et une éducation de haute qualité, la VUB souhaite contribuer de manière active et engagée à une société meilleure pour demain. Le groupe de recherche MOBI de la VUB contribuera à Cairgo Bike compte tenu de sa longue expérience dans l'évaluation de la mobilité / logistique urbaine. MOBI intègre les sciences environnementales et sociales, les questions économiques et politiques et développe des outils pour les décideurs privés et publics. Le groupe analyse l'impact environnemental, économique et social des nouveaux concepts impliquant les Parties prenantes dans le processus de décision.

Les rôles des partenaires sont définis comme suit :

- **Pro Velo** effectue la sélection des candidats sur base de leurs réponses à l'appel, gère la disponibilité des vélos et les contacts avec les participants durant le Projet et leur fournit un guide d'utilisation alimenté par l'expérience en la matière acquise par l'ASBL. De plus, Pro Velo proposera des formations afin de familiariser à la conduite des vélos cargos, de façon à ce que les participants se sentent en sécurité lors de la pratique.

- **Bruxelles Environnement** distribue les moniteurs de qualité de l'air employés durant la campagne de mesures, collecte de l'information liée aux déplacements des participants et leur exposition aux polluants, prépare des rapports propres à chaque participant reprenant leurs mesures et déplacements et rédige un rapport d'étude statistique. Les données liées aux déplacements des participants sont partagées avec la VUB afin qu'une étude socio-économique soit établie par cette autre Partie. Cette étude s'appuie sur les formulaires remplis par les participants et les données de géolocalisation collectées par le moniteur. BE assure la gestion des moniteurs de qualité de l'air et réalise des campagnes de comparaison des mesures issues des moniteurs distribués avec celles de son réseau télémétrique. Sur base de l'enquête réalisée par la VUB, BE modélisera la diminution de production de polluants atmosphériques et de gaz à effet de serre que pourraient engendrer les changements dans les moyens de transport employés qui seraient mentionnés par les participants. Par ailleurs, BE accueille les participants lors de la distribution des vélos afin de leur transmettre les moniteurs de qualité de l'air en expliquant leur utilisation, répond aux questions durant les mesures et se charge des éventuels contacts avec le fournisseur en cas de problème rencontré lié à l'appareil. Enfin, BE proposera des recommandations visant à réduire l'exposition aux polluants sur base des résultats obtenus et œuvrera avec une ou plusieurs association(s) de citoyens à la sensibilisation en s'appuyant sur cette campagne de mesures.

- **La VUB** a un double objectif dans l'évaluation du Projet. D'une part, l'université explorera l'adhésion de la population aux vélos cargos. D'autre part, l'impact de l'utilisation du vélo cargo sera évalué à l'aide d'une analyse de coûts externes. Pour ce faire, la VUB collecte les données de géolocalisation issues des moniteurs de qualité de l'air transmises par BE, des carnets de bord reprenant l'utilisation des vélos cargos et les trajets effectués ainsi que des enquêtes distribuées aux participants à différents moments du pilote.

3 Comité de pilotage

Les partenaires mettent en place un Comité de Pilotage, plus large car prenant en charge d'autres tâches liées à Cairgo Bike, qui a pour but de suivre la mise en œuvre et le bon déroulement du Projet.

Le Comité de Pilotage est composé de représentants de chacune des structures participant au Projet. Ainsi, les différents partenaires y sont représentés :
- Bruxelles Mobilité ;
- Bruxelles Environnement (départements Laboratoire et qualité de l'air, Mobilité durable, Evaluation air climat énergie, Economie en transition) ;
- Parking.Brussels;
- BePark;
- Cambio;
- Pro Velo (départements EDUC et COM);
- Remorquable;
- Urbike;
- VUB (Mobility Logistics and Automotive Technology Research Centre).

Les décisions du Comité de Pilotage sont prises par consensus. Dans le cas où une objection est émise, tous les membres essaient de trouver une solution et en dernier recours, le Comité de Gestion est habilité à prendre la décision. Il est constitué de Simon Dehouck (Bruxelles Environnement), Anne Larroque (Bruxelles Mobilité) et Charlotte De Broux (Bruxelles Mobilité).

4 Autres partenaires associés au projet

Les communes de la Région bruxelloise, qui sont responsables d'une partie de la diffusion de l'information concernant l'existence du Projet et la possibilité pour les citoyens d'y participer, constituent des partenaires du Projet. Elles vont également œuvrer de façon à rendre des lieux disponibles afin que les participants puissent venir y chercher les vélos et les moniteurs d'air, ainsi que les ramener. Les éventuels autres partenaires interviennent de façon ponctuelle et à la demande des membres du Comité de Pilotage, les contacts seront donc établis progressivement en fonction des besoins et de l'évolution du Projet.

La liste de Parties prenantes peut être complétée à tout moment en fonction des besoins et opportunités identifiés par le Comité de Pilotage.

5 Durée

Le Projet en tant que tel s'étale entre juillet 2020 et juin 2023. Par la suite, certaines Parties œuvreront à la diffusion des résultats et la collaboration avec d'autres partenaires européens, et ce jusqu'en juin 2024 mais cela n'est pas à considérer dans le cadre de la présente Convention.

Les stipulations relatives à la confidentialité resteront applicables même après la résiliation ou l'expiration de la Convention pour quelque raison que ce soit (cf. Article 7).

6 Conditions financières

Ayant été sélectionné dans le cadre du programme Actions Innovatrices Urbaines de la Commission Européenne, le Projet Cairgo Bike bénéficie d'un financement couvrant la majeure partie des frais. Ainsi, les vélos à disposition, le personnel engagé par certaines Parties ou encore le matériel de mesure de la qualité de l'air rentrent dans le cadre des subsides. La région bruxelloise, à laquelle appartiennent plusieurs institutions publiques faisant partie du Comité de Pilotage, finance également le Projet, à hauteur de 20 %.

7 Cession

Les Parties ont expressément conclu la présente Convention de partenariat intuitu personae, c'est-à-dire en considération de la qualité respective de chacune des Parties.

Une Partie ne pourra en aucun cas céder ou transférer le présent document à un tiers sans avoir obtenu au préalable l'accord de l'ensemble des Parties.

8 Confidentialité

Les Parties considèrent comme confidentielles toutes les informations auxquelles elles ont accès dans le cadre du Projet.

Toute information confidentielle, quel qu'en soit le support, communiquée par l'une des Parties aux autres, à l'occasion du Projet, ou à laquelle les Parties pourraient avoir accès à l'occasion du Projet ne peut être utilisée que dans le cadre du Projet et ne peut être communiquée à un tiers.

Sont notamment déclarées confidentielles les informations de nature financière, technique et commerciale de chaque Partie, les informations relatives aux projets de développement de produits et de services des Parties, les données à caractère personnel qui seront manipulées. Ces dernières données constituent les informations suivantes : les données de géolocalisation des trajets par participant, les données personnelles des participants, à savoir leur nom, leur adresse mail, leur adresse de résidence, leur sexe, leur année de naissance, leur numéro de téléphone, leur langue maternelle, le fait qu'ils soient touchés ou pas par la Low Emission Zone, leurs modes de transport, leur diplôme, et le type d'emploi (ouvrier / employé). Les documents utilisés lors de la phase de négociation de la Convention de partenariat ou lors de la réalisation du Projet sont également considérés comme confidentiels.

Les Parties prendront vis-à-vis de leur personnel impliqué dans le Projet toutes les mesures nécessaires pour assurer, sous leur responsabilité, le secret et la confidentialité de toutes les informations et documents visés aux alinéas ci-dessus.

Les Parties s'engagent à faire respecter ces engagements auprès de leurs partenaires et/ou sous-traitants dont l'implication est requise pour exécuter l'une ou l'autre des prestations prévues.

Les Parties prennent l'engagement de respecter les obligations résultant du présent article pendant toute la durée de la Convention ainsi qu'après son expiration, ou la résiliation de la Convention de partenariat pour quelque motif que ce soit.

Les obligations de confidentialité ne s'appliquent pas si le destinataire de l'information apporte la preuve que cette information :

- Est entrée dans le domaine public préalablement à sa divulgation, ou après celle-ci, mais dans ce cas en l'absence de toute faute;
- Etait déjà connue des Parties avant le début des négociations menant à la conclusion de la présente Convention;
- A été reçue d'un tiers d'une manière licite, sans restriction, ni violation de la présente Convention ou quelque autre obligation contractuelle ou légale;
- Résulte de travaux indépendants entrepris de bonne foi.

9 Dispositions particulières liées à la protection des données à caractère personnel

9.1 Cadre général

La réalisation des buts poursuivis par les Parties nécessite le traitement de données à caractère personnel.

Les Parties s'engagent à respecter la réglementation en vigueur applicable au traitement de données à caractère personnel et, en particulier, le règlement (UE) 2016/679 du Parlement européen et du Conseil du 27 avril 2016, ci-après désigné « le règlement européen sur la protection des données ».

Les opérations de traitement des données se font dans l'ordre suivant.

1) Les administrations communales informent les citoyens par une publication qui inclut un lien vers le site de Pro Velo, permettant aux intéressés d'obtenir plus d'informations et de manifester leur intérêt afin de s'inscrire au Projet.
2) Ainsi, les candidats au Projet contactent Pro Velo pour soumettre leur candidature (le site web de Pro Velo fait apparaître les conditions dans lesquelles leurs données sont traitées et la charte de vie privée permettant aux candidats de comprendre comment sont traitées leurs données dans le cadre du recrutement).
3) Les candidats sont sélectionnés par Pro Velo sur base des moyens de transport qu'ils comptent employer durant le Projet et du respect de certains critères (lieu de résidence dans la commune concernée et fait d'être non-fumeur) qui seront mentionnés dans la communication de départ. PV recrute les candidats qui s'annoncent via leur site web selon les conditions de la charte vie privée figurant sur ce dernier.
4) PV partage les formulaires remplis par les participants sélectionnés avec la VUB, afin que celle-ci puisse réaliser son étude socio-économique, et avec BE, qui pourra ainsi vérifier que tous les utilisateurs du moniteur sont bien non-fumeurs et disposera ainsi des informations concernant les moyens de transport habituellement utilisés par les participants.
5) Ensuite, Pro Velo met à disposition des vélos pour les citoyens concernés par la participation (différentes dates en fonction des communes) et BE leur transmet les moniteurs nécessaires à la collecte des mesures.
6) Régulièrement, en plus des données enregistrées par le moniteur et récoltées par BE, différents questionnaires remplis par les participants seront récupérés : un document reprenant l'ensemble de l'organisation horaire de la journée sera remis à BE et la VUB, comprenant les heures de début des déplacements effectués, celles des activités réalisées (la raison des déplacements sera précisée, comme le fait de se rendre au travail, à une activité de loisir comme le sport, faire les courses, mais pas les détails exacts), le fait que ces dernières ont lieu en intérieur ou en extérieur, et le moyen de transport employé. Les géolocalisations

des participants seront étudiées par BE pour évaluer les différences de taux d'exposition entre les axes routiers, les moments de la journée et les moyens de transport. Les coordonnées géolocalisées impliquent, pour être traitées, d'employer un programme établi par le fournisseur des capteurs, auquel les participants n'auront pas accès. Ce programme n'est pas lié à une quelconque interface web qui permettrait au fournisseur de disposer de ces données.

7) Lors de chaque récolte de données enregistrées par les moniteurs que portent les participants, BE transmet à la VUB les données de déplacement géolocalisées.
8) Après chaque récolte de données, BE effectue un rapport par participant reprenant les concentrations mesurées durant les différents déplacements effectués ainsi que lors des activités (mesures continues durant la journée).
9) A fréquence régulière, les moniteurs sont transmis à de nouveaux participants (en même temps que les vélos) mais les données, conservées dans la mémoire interne de l'appareil, ne leur seront pas accessibles, comme expliqué au point 6.
10) Lorsque toutes les données ont été rassemblées, BE effectue une analyse statistique reprenant les concentrations mesurées et faisant intervenir une cartographie de la pollution. L'institut modélise également les changements en termes d'émissions de polluants par la combustion de carburants sur base d'une utilisation abondante de vélos cargos qui pourrait être supposée au moyen des questionnaires remplis par les participants.
11) Parallèlement, la VUB modélise l'impact sur les coûts externes obtenus grâce aux déplacements effectués à vélo au moyen des données de géolocalisation d'une part et des carnets de bord d'autre part.
12) La VUB évalue également l'adhésion à l'utilisation des vélos cargos en exploitant un questionnaire distribué aux participants avant le pilote, à la fin du pilote et après 6 mois. Dans le cadre de ce questionnaire, les informations relatives aux données à caractère personnel suivantes seront enregistrées : leur diplôme, leur sexe, leur âge, leur lieu de résidence, leur situation professionnelle, la taille de leur ménage, leurs habitudes de transport, le type de voiture qu'ils possèdent.
13) Toutes les données à caractère personnel collectées par les différentes Parties sont supprimées des bases de données. Elles ne seront conservées qu'un an après la fin du Projet, en cas de rapport à effectuer.

9.2 Obligations de PV

En tant que coresponsable de la gestion des données, PV s'engage à :

- Traiter les données à caractère personnel nécessaires à la campagne de sélection des candidats, en respectant les critères de sélection définis par BE et la VUB, dans le respect du règlement 2016/679 du Parlement européen;
- Ne pas partager les données concernant les candidats non retenus avec BE et donc seulement avec la VUB;
- Agir comme Partie responsable des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés à leurs données de contact, collectées via le formulaire d'inscription;
- Collaborer avec BE selon les procédures mises en place pour la gestion des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés à leurs données collectées via le moniteur portable;
- Collaborer avec la VUB selon les procédures mises en place pour la gestion des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de

leurs droits liés à leurs informations aux sujets de leurs habitudes de déplacement et de leurs véhicules personnels.

En tant que Partie responsable des données de contact, collectées via le formulaire d'inscription :

- Mettre en place des procédures, permettant aux personnes concernées, en l'occurrence les citoyens participant au Projet Cairgo Bike, d'exercer leurs droits relatifs au Règlement Général de Protection des Données en concertation avec la VUB et BE;
- Mettre en place des procédures, pour la gestion des incidents de sécurité et de la violation des droits des participants liés à leurs données de contact;
- Collaborer avec l'Autorité de Protection des Données (APD) en cas d'incidents de sécurité ou de violation des droits des participants liés à leurs données de contact.

9.3 Obligations de la VUB

En tant que coresponsable de la gestion des données, la VUB s'engage à :

- Traiter les données à caractère personnel nécessaires pour ses recherches dans le respect du règlement 2016/679 du Parlement européen et le respect des exigences imposées par la loi vie privée du 30 juillet 2018 de la Belgique en la matière pour le traitement des données personnelles à des fins de recherche scientifique ou historique ou à des fins statistiques (section 3). Dans ce cadre, BE partagera les données de géolocalisation des trajets effectués par les participants ainsi que les carnets de bord remplis par ces derniers avec la VUB;
- Agir comme Partie responsable des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés aux informations transmises aux sujets de leurs habitudes de déplacement et de leurs véhicules personnels;
- Collaborer avec BE selon les procédures mises en place pour la gestion des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés à leurs données collectées via le moniteur portable;
- Collaborer avec PV selon les procédures mises en place pour la gestion des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés à leurs données collectées récoltées par l'intermédiaire des formulaires de candidature.

En tant que Partie responsable des données relatives aux habitudes de déplacements et aux véhicules personnels des participants :

- Mettre en place des procédures permettant aux personnes concernées, en l'occurrence les citoyens participant au Projet Cairgo Bike, d'exercer leurs droits relatifs au Règlement Général de Protection des Données en concertation avec PV et BE;
- Mettre en place des procédures pour la gestion des incidents de sécurité et de la violation des droits des participants liés à leurs informations aux sujets de leurs habitudes de déplacements et de leurs véhicules personnels;
- Collaborer avec l'Autorité de Protection des Données (APD) en cas d'incidents de sécurité ou de violation des droits des participants liés à leurs informations aux sujets de leurs habitudes de déplacements et de leurs véhicules personnels.

9.4 Obligations de BE

En tant que coresponsable de la gestion des données, BE s'engage à :

- Traiter les données à caractère personnel nécessaires pour ses recherches dans le respect du règlement 2016/679 du Parlement européen et le respect des exigences imposées par la loi vie privée du 30 juillet 2018 de la Belgique en la matière pour le traitement des données personnelles à des fins de recherche scientifique ou historique ou à des fins statistiques (section 3). Dans ce cadre, BE partagera les données de géolocalisation des trajets effectués par les participants ainsi que les carnets de bord remplis par ces derniers avec la VUB;
- Dans le cadre des courts rapports remis à chaque participant, BE s'engage à ne divulguer le traitement des données géolocalisées, dont celles de déplacement, qu'individuellement. Seules les données de géolocalisation, les moyens de transport utilisés et les préférences des participants en la matière seront transmises par BE à la VUB;
- Agir comme Partie responsable des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés à leurs données collectées via les moniteurs portables, à savoir les coordonnées géographiques et les concentrations de polluants mesurées;
- Collaborer avec PV selon les procédures mises en place pour la gestion des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés à leurs données de contact;
- Collaborer avec la VUB selon les procédures mises en place pour la gestion des éventuelles questions et plaintes des participants relatives aux incidents de sécurité et à la violation de leurs droits liés à leurs informations aux sujets de leurs habitudes de déplacement et de leurs véhicules personnels.

En tant que Partie responsable des données collectées par l'intermédiaire des moniteurs portables :

- Mettre en place des procédures, permettant aux personnes concernées, en l'occurrence les citoyens participant au Projet Cairgo Bike, d'exercer leurs droits relatifs au Règlement Général de Protection des Données en concertation avec PV et la VUB;
- Mettre en place des procédures, pour la gestion des incidents de sécurité et de la violation des droits des participants liés à leurs données collectées par l'intermédiaire des moniteurs portables, à savoir les coordonnées géographiques et les concentrations de polluants mesurées;
- Collaborer avec l'Autorité de Protection des Données (APD) en cas d'incidents de sécurité ou de violation des droits des participants liés à leurs données collectées par l'intermédiaire des moniteurs portables.

9.5 Obligations communes à toutes les Parties prenantes

Concernant la notification des violations de données à caractère personnel

Chacune des Parties redirige la personne plaignante vers le contact de référence pour par la demande.

Chacune des Parties notifie auprès de la Partie responsable toute violation de données à caractère personnel dans un délai de maximum 12 heures après en avoir pris connaissance.

Cette notification est accompagnée de toute documentation utile afin de permettre à la Partie concernée, si nécessaire, de notifier cette violation à l'autorité de contrôle compétente :

- La description de la nature de la violation de données à caractère personnel et, si possible, les catégories et le nombre approximatif de personnes concernées par la violation;
- Les coordonnées d'un contact auprès duquel des informations supplémentaires peuvent être obtenues;
- La description des conséquences probables de la violation de données à caractère personnel;
- La description des mesures prises ou proposées pour remédier à la violation de données à caractère personnel, y compris, le cas échéant, les mesures pour en atténuer les éventuelles conséquences négatives.

Mesures de sécurité

Les trois Parties mettent en œuvre des mesures de sécurité techniques et organisationnelles pour protéger les données à l'égard des risques auxquels elles sont exposées, dans une approche dynamique et conforme aux dernières techniques en matière de sécurité raisonnablement applicables.

BE, PV et la VUB s'engagent au minimum à mettre en œuvre les mesures décrites ci-dessous :

- Protéger les données contre l'accès non-autorisé (gestion des accès aux données);
- Protéger les données contre la divulgation non autorisée (déclaration de vie privée, clause de confidentialité);
- Protéger les données contre la perte et la destruction (backups);
- Chiffrer mes données lors de leur transfert (les fichiers envoyés par mail sont protégés par un mot de passe);
- Supprimer les données lorsqu'elles ne seront plus nécessaires (au plus tard 12 mois après la fin du Projet);
- Ne pas inclure de données à caractère personnel dans le rapport d'étude ni dans des publications relatives au Projet.

Délai de rétention des données

Des rapports pouvant être effectués jusqu'à un an après la durée du Projet, toutes les données à caractère personnel des participants seront conservées dans ce laps de temps. BE et la VUB s'engagent à détruire ces données dès cette échéance passée.

Partage de données avec des tiers

Chaque Partie s'engage à ne partager les données avec aucun tiers.

10 Responsabilité et assurance

Chaque Partie pourra évaluer la pertinence de contracter une assurance pour les risques encourus. Il s'agit de couvrir les éventuels dommages liés aux violations des droits des personnes quant à leurs données.

11 Communication

Toute publication ou communication, et ce quel qu'en soit le support, relative à la présente Convention et au Projet, y compris concernant les actions et travaux y afférent, est réalisée avec l'accord unanime du Comité de Pilotage.

12 Litiges et droit applicable

Les Parties s'efforceront de résoudre à l'amiable les litiges qui pourraient survenir entre elles.

Tout litige relatif à la conclusion, l'exécution, l'interprétation et la dissolution de la présente Convention relève de la compétence exclusive des juridictions de l'arrondissement judiciaire de Bruxelles.

La présente Convention est soumise et interprétée conformément au droit belge.

13 Divisibilité

Si une quelconque stipulation ou condition de la présente Convention est interdite ou rendue invalide ou inapplicable, intégralement ou partiellement, cette interdiction, invalidité ou inapplicabilité pour quelque raison que ce soit ne saurait affecter la validité ou le caractère exécutoire des autres clauses et conditions du présent document.

Si une clause est annulée ou déclarée non valable, le reste de la Convention est maintenu et la clause en question est remplacée par une clause reflétant le mieux possible l'intention initiale des Parties.

14 Résiliation

La Convention pourra être résiliée de plein droit, le cas échéant par lettre recommandée avec accusé de réception, avec effet 1 (un) mois après la réception, sur décision de l'une des Parties.

15 Complétude et Avenants

Les stipulations de la Convention prévalent sur toutes les dispositions verbales ou écrites contraires résultant d'accords antérieurs éventuels entre les Parties au titre du Partenariat.

Toute modification ou prorogation de la Convention ne pourra intervenir valablement qu'après signature d'un avenant écrit, dûment signé et paraphé par les représentants des Parties.

La Convention et ses Annexes forment un ensemble contractuel indivisible. En cas de contradiction entre leurs stipulations, il est entendu que les stipulations de la Convention, y compris son Préambule, prévaudraient sur celles des Annexes.

En cas d'entrée de partenaire(s) supplémentaire(s), de retrait de partenaire(s) pour quelque raison que ce soit dans le Projet et /ou en cas d'obtention de financement public, un accord de partenariat sera conclu entre les partenaires du Projet. Il définira notamment la gouvernance commune qui s'appliquera au dit Projet et remplacera la Convention après accord exprès des Parties aux présentes.

Fait à Bruxelles, le 14 avril 2021, en autant d'exemplaires originaux que de Parties, chaque Partie accusant réception d'un exemplaire original.

Pour BE,

Barbara DEWULF
Directrice générale adjointe

Frédéric FONTAINE
Directeur général

Pour la VUB,

Caroline PAUWELS
Rectrice

Pour Pro Velo,

Christophe WINKEL
Directeur

ANNEXE 1

Note technique sur le Projet Cairgo Bike

1 Objet du document

Ce document récapitule les aspects techniques essentiels du Projet Cairgo Bike, à savoir le dispositif de collecte et de traitement des données relatives aux participants au Projet.

2 La sélection des candidats : formulaire à remplir

Le formulaire de candidature est un document diffusé par les communes, l'une après l'autre, et s'adressant systématiquement aux habitants de celles-ci. Au-delà des informations relatives au but et au contenu du Projet, il reprend certaines parties à remplir par les candidats, concernant leurs modes de transport, mais également des données à caractère personnel, à savoir le nom, l'adresse de résidence, le numéro de téléphone, l'âge, le fait d'être professionnellement actif ou pas, le statut de travailleur (avec possibilité de ne pas répondre dans ce dernier cas), et l'âge et le poids des enfants qui profiteraient du vélo cargo.

Ces questions ont pour but de nous permettre de collaborer avec des citoyens représentatifs, tant que possible, de la diversité propre à la région bruxelloise, et ce dans différents domaines.

3 L'instrument de mesure : l'aethalomètre MA200 de la société Aethlabs

3.1 Les différents composants de l'appareil

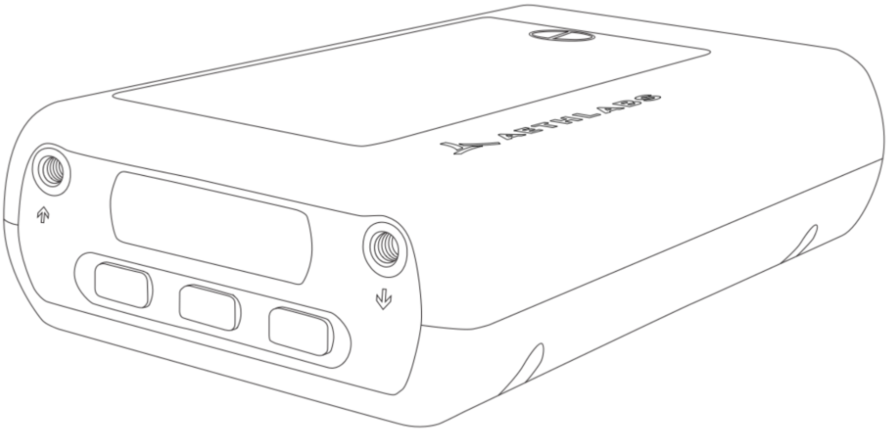
L'æthalomètre MA200 est un moniteur portable permettant la mesure de concentrations dans l'air de black carbon, particules fines riches en carbone issues de la combustion, comprises dans la gamme des PM2.5 (particules fines dont le diamètre est inférieur à 2,5 micromètres). Les mesures se font par un procédé optique de comptages de taches déposées sur des filtres par les particules et faisant intervenir la variation d'absorption de lumière transmise du fait de leur présence. Il est composé des éléments suivants :

- Un système d'analyse par absorption à 5 longueurs d'onde (880 nm, 625 nm, 528 nm, 470 nm, 375 nm) en mesurant la vitesse de changement de la lumière transmise due au dépôt continu de particules sur le filtre. La mesure à 880 nm est interprétée comme la concentration de carbone noir ('BC'). La mesure à 375 nm est interprétée comme la concentration de particules ultraviolettes ('UVPM') indiquant la combustion de fumée de bois, de tabac et de biomasse;
- Un système de compensation de la charge du filtre appelé « DualSpot », grâce à la collecte simultanée sur deux spots en parallèle à des débits différents;
- Un tube de prélèvement, qui sera en contact avec l'air et permet de le capter, en étant fixé au reste de l'appareil;
- Une pompe intégrée faisant circuler l'air;
- Un contrôleur de débit de l'air à calibrer;
- Une batterie rechargeable par l'intermédiaire d'un adaptateur ou d'une fiche USB;
- Des cartouches de ruban filtrant utilisables entre deux et trois semaines;

This project is co-financed by the European Regional Development Fund
through the Urban Innovative Actions initiative

- Un GPS embarqué pour l'enregistrement des coordonnées géographiques ainsi que de l'heure par synchronisation;
- Un système de stockage de données permettant de conserver les concentrations mesurées ainsi que les coordonnées géolocalisées et l'heure;
- Un accéléromètre mesurant, sur base des coordonnées géographiques ainsi que de l'heure, la variation de vitesse par unité de seconde;
- Un altimètre mettant en évidence l'altitude et un baromètre mesurant la pression atmosphérique subie ;
- Des capteurs d'humidité relative et de température.

3.2 **Représentation visuelle de l'Aethalomètre MA200** (document issu du site du concepteur Aethlabs)



4 Les données recueillies et leur traitement

4.1 Les données recueillies

Les données enregistrées par le moniteur de qualité de l'air sont les suivantes :
- les concentrations en black carbon dans 5 longueurs d'onde (880 nm, 625 nm, 528 nm, 470 nm, 375 nm), à la résolution temporelle d'une concentration par 1, 5, 10, 30, 60, ou 300 secondes (à fixer en fonction des objectifs de mesure),
- les coordonnées géographiques en continu,
- l'heure en synchronisation avec les coordonnées géographiques,
- l'accélération linéaire,
- la pression atmosphérique,
- la température,
- l'humidité relative.

ANNEXE 2

Contenu des rapports de BE et de la VUB

1 Les rapports effectués par BE

Bruxelles Environnement réalisera des rapports scientifiques pour lesquels l'attention sera portée sur les concentrations mesurées et leur distribution.

De façon systématique, après chaque série de tests (chaque série de deux semaines au cours desquelles des particuliers auront utilisé les vélos et le moniteur de qualité de l'air), BE réalisera un rapport personnalisé pour chacun des citoyens ayant participé. Ce rapport sera bien individuel et divulgué uniquement à la personne concernée. Il comprendra les informations suivantes :

- Des graphiques mentionnant l'heure en abscisse et les concentrations en black carbon mesurées en ordonnée;
- En vis-à-vis de ces figures, un tableau représentera le déroulement de la journée avec l'exposition au black carbon suivant les déplacements effectués (ne mentionnant que leurs raisons comme le départ au travail, aux courses ou au sport, sans préciser les adresses) et en fonction des modes de transport employés. Ce tableau comprendra aussi le fait que les activités effectuées en dehors des déplacements ont été réalisées en intérieur ou en extérieur. Ce tableau découlera du carnet de bord rempli par les participants;
- Une ou des cartes montrant les trajets réalisés et associant un code couleur à chaque tronçon du trajet pour indiquer les niveaux mesurés en black carbon;
- Une appréciation du taux d'exposition moyen pour chaque journée sera également fournie, sur base de points ou d'un code couleur.

Pour l'ensemble de la campagne de mesures, un rapport global sera rédigé et consacré à l'analyse et l'interprétation scientifique des données collectées. Il évaluera notamment la distribution dans le temps et l'espace des concentrations mesurées et fera intervenir une étude statistique. Ce rapport portera sur la comparaison des résultats obtenus à vélo et en voiture. Les données seront dans ce cas anonymisées et aucun nom, ni aucune adresse n'apparaîtront. D'éventuels axes routiers correspondant à des concentrations particulièrement faibles ou élevées subies par les cyclistes seront mises en évidence sur une carte mais correspondront au recoupement des données issues de plusieurs participants et non des itinéraires propres à certains d'entre eux.

2 Les rapports effectués par la VUB

La VUB réalisera une étude socio-économique du Projet Cairgo Bike. D'une part, la VUB explorera l'adhésion de la population aux vélos cargos. D'autre part, l'impact de l'utilisation du vélo cargo sera évalué à l'aide d'une analyse de coûts externes.

L'objectif de l'analyse de l'adhésion de la population au vélo cargo est de comprendre les éléments qui favorisent et bloquent son utilisation. Au moyen du modèle UTAUT (Unified Theory of Acceptance and Use of Technology), nous analyserons l'influence d'éléments comme l'utilité, le prix, la facilité d'utilisation du vélo cargo sur l'adhésion de ce nouveau mode de transport. Sur cette base, nous pourrons identifier les points forts à valoriser pour développer ce mode. Nous pourrons également identifier les points à améliorer. Ces résultats pourront alimenter des recommandations de politiques publiques dans des publications scientifiques.

L’analyse de coûts externes veillera à évaluer l’impact d’une utilisation accrue du vélo cargo sur les externalités du transport. Nous prendrons ainsi en compte les impacts sur la qualité de l’air, le changement climatique, les nuisances sonores, le cycle de vie, la congestion et les accidents. En comparant la manière dont les kilomètres ont été parcourus lorsqu’un vélo cargo était à disposition pendant le pilote ou lorsqu’un vélo cargo n’était pas à disposition (avant le pilote), les résultats montreront dans quelle mesure le vélo cargo impacte les différentes externalités du transport. Ces résultats peuvent ensuite alimenter une discussion sur le potentiel de cette solution pour contribuer aux objectifs de développement durable.

Appendix 17.3.1 : French version of the three-party agreement between Brussels Environment, Pro Velo and the VUB that was drawn up in order to explain what data would be collected and exchanged between these structures and expose the processings that would be applied.

1. Wij zijn verantwoordelijk voor de verwerking van uw persoonlijke gegevens (hierna "persoonsgegevens" genoemd) en dit in het kader van onze activiteiten met betrekking tot het leefmilieu in de ruimste zin van het woord.

Leefmilieu Brussel voert de volgende activiteiten uit op het gebied van het leefmilieu in de brede zin van het woord:

- luchtkwaliteit;
- energie;
- bodem;
- geluidshinder;
- elektromagnetische golven;
- planning van het afvalbeheer;
- duurzame productie, bouw en consumptie;
- natuur en biodiversiteit;
- dierenwelzijn;
- beheer van het Zoniënwoud, groene ruimten en natuurgebieden;
- beheer van niet bevaarbare waterwegen;
- de strijd tegen klimaatverandering.

2. Wij verbinden ons ertoe om in het kader van onze activiteiten en overeenkomstig de op het niveau van de Europese Unie toepasselijke regelgeving, namelijk Verordening (EU) 2016/679 van het Europees Parlement en de Raad van 27 april 2016 betreffende de bescherming van natuurlijke personen in verband met de verwerking van persoonsgegevens en betreffende het vrije verkeer van die gegevens (Algemene verordening gegevensbescherming, hierna " AVG " genoemd), een passende beveiliging en vertrouwelijkheid van uw persoonsgegevens te waarborgen, alsook uw privacy te respecteren.

3. Wij verzamelen uw persoonlijke gegevens in het kader van het project Cairgo Bike, dat de promotie van cargofietsen en de sensibilisering voor "soft mobility" bij burgers en bedrijven in het Brussels Hoofdstedelijk Gewest beoogt. In het kader van dit project worden bakfietsen ter beschikking gesteld van particulieren en bedrijven, waarbij dan ook de concentraties van verontreinigende stoffen en gegevens over het gebruik van de verschillende vervoermiddelen en de afgelegde trajecten worden geregistreerd. In deze context verzamelen wij informatie over u, zoals uw verplaatsingen, en meten wij via monitoren de luchtkwaliteit waaraan u tijdens deze verplaatsingen wordt blootgesteld

3.1. Na afloop van de testperiode verzamelen wij uw persoonlijke gegevens, wanneer de fietsen worden teruggebracht en waarbij de monitor en de formulieren worden ingeleverd.

3.2. De gegevens worden via u ingewonnen en via een derde die gemachtigd is uw gegevens te communiceren. Inderdaad, de non-profit vereniging Pro Velo zal verantwoordelijk zijn voor de selectie van de kandidaat-burgers en dus voor de verdere verwerking van de door de gemeenten ter beschikking gestelde formulieren.

4. De categorieën van persoonsgegevens die wij verwerken zijn de volgende:
- voornaam, achternaam, e-mailadres, verblijfplaats ;
- uw verplaatsingen, met inbegrip van uw verblijplaats, die ook indirect zichtbaar zullen zijn, omdat uw geografische coördinaten permanent door de monitors worden geregistreerd ;

- de gebruiktevervoermiddelen tijdens uw ritten ;
- uw blootstelling aan verontreiniging stoffen tijdens uw verplaatsingen.

5. Uw persoonlijke gegevens worden met uw toestemming verwerkt voor de volgende doeleinden:
- na te gaan welke voordelen het gebruik van bakfietsen kan opleveren in termen van blootstelling aan luchtverontreiniging, vergeleken met dat van gemotoriseerde voertuigen;
- een statistische studie uit te voeren waarbij rekening wordt gehouden met de door de deelnemers gemeten concentraties en de frequentie van deze concentraties in een bepaalde buurt, straat of wijk;
- een wetenschappelijke studie uit te voeren waarin de gemeten concentraties per locatie, straat of buurt, de wijze van vervoer waarmee deze concentraties zijn verkregen en de algemene frequentie van de verschillende in de betrokken straat gebruikte vervoermiddelen worden vermeld;
- de vermindering van de productie van luchtverontreinigende stoffen en broeikasgassen op basis van het toegenomen gebruik van bakfietsen te bestuderen.

5.1. Het juridisch kader bestaat voornamelijk uit de volgende teksten:
- COBRACE in de ordonnantie van 2 mei 2013 (titel 2 "Specifieke bepalingen inzake luchtkwaliteit en emissies van luchtverontreinigende stoffen", hoofdstuk 1 "Opdrachten van het Instituut");
- het lucht-Klimaat-Energieplan, maatregel 52;
- de AVG en de wet van 30 juli 2018 tot bescherming van de persoonlijke levenssfeer ten opzichte van de verwerking van persoonsgegevens.

6. De persoongsebonden gegevens worden slechts bewaard gedurende de periode die nodig is om de doeleinden waarvoor ze worden verwerkt te realiseren, en daarna tot het verstrijken van de wettelijke bewaarplicht die is vastgelegd in de overeenkomst met twee andere partijen (Pro Velo en de VUB). De gegevens betreffende uw verplaatsingen worden in een niet-geanonimiseerde vorm bewaard tot 12 maanden na het einde van het Cairgo Bike project. Daarna worden de gegevens vernietigd.

7. De gegevens zijn, voor zover ze wettelijk zijn toegestaan en enkel voor de hierboven aangegeven doeleinden nodig zijn, bestemd voor :

7.1. verwerking door onze interne diensten, met name alleen het departement Laboratorium en het departement Evaluatie Lucht Klimaat Energie.

7.2. medegedeeld aan de volgende derden:
- de VUB met betrekking tot de geografische coördinaten die permanent worden geregistreerd door de monitors gerdagen door elke deelnemer.

8. Een informatiedocument over ons privacybeleid is op verzoek verkrijgbaar als u meer informatie wenst over onze goede praktijken inzake privacy en uw rechten op grond van de AVG. Dit document is een gedetailleerde versie van deze Privacyverklaring.

9. Door middel van een schriftelijk, gedateerd en ondertekend verzoek en met overlegging van een bewijs van uw identiteit, kunt u van ons kosteloos de schriftelijke mededeling van uw gegevens verkrijgen, alsmede de correctie of schrapping van gegevens die onjuist, onvolledig of niet relevant zijn. In bepaalde omstandigheden kunt u verzoeken om de beperking van de verwerking en hebt u het recht bezwaar aan te tekenen tegen verdere verwerking.

Om uw rechten te laten gelden, kunt u contact met ons opnemen of met onze verantwoordelijke voor gegevensbescherming mits u uw identiteit kan aantonen.

U kunt contact opnemen met onze diensten door een brief te sturen naar het volgende adres : **Leefmilieu Brussel, Cairgo Fietsproject, Waversesteenweg 1850 B (site Jean Massarttuin), 1160 Oudergem**. Wij zijn ook bereikbaar via het volgende e-mailadres: **cairgobike@leefmilieu.brussels**. Het is ook mogelijk om een afspraak te maken met de projectmanager voor een gesprek ter plaatse op een van de opendeurdagen, met uitzondering van woensdagen.

U kunt ook schriftelijk contact opnemen met onze functionaris voor gegevensbescherming op het volgende adres: **privacy@leefmilieu.brussels.**

Overeenkomstig artikel 77 van de AVG kunt u ook contact opnemen of een klacht indienen bij de Algemene verordening gegevensbescherming op het volgende adres: 1000 Brussel, Drukpersstraat 35 (dpo@apd-gba.be) of bij de toezichthoudende autoriteit van het land waar u doorgaans verblijft.

Appendix 17.3.2 : Dutch version of the privacy statement that exposes the rules of Brussels Environment in terms of data management.

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17.4. Outcome dissemination and participation in communication events

Figure 17.4.1 : First slide of the presentation that was proposed during the NEHAP meeting in October 2021

17.5. Comparison of the AE51 data concentrations : general data and data with high attenuation values

Participant	Date	General indoor air concentrations	Indoor air concentrations with ATN > *90th* quantile
001	21/5/2021	0.2263455	0.071
001	23/5/2021	0.1004889	0.1347013
001	24/5/2021	0.2263455	0.1487556
001	25/5/2021	0.001522523	0.122
001	28/5/2021	0.07703358	0.226
001	29/5/2021	0.3773063	0.3261562
001	30/5/2021	0.3477376	0.3122353
001	31/5/2021	0.2160851	0.3086316
001	1/6/2021	0.387593	0.3428772
001	2/6/2021	0.3978634	0.355859
001	3/6/2021	0.3478041	0.4796
002	24/5/2021	0.1666302	0.1671613
002	1/6/2021	0.3620431	0.2921538
003	24/5/2021	0.3546148	0.3795362
003	25/5/2021	0.2863135	0.4495541
003	26/5/2021	0.3593069	0.2091579
004	23/5/2021	0.106875	0.1052
005	24/5/2021	0.1874846	0.2751087
005	26/5/2021	1.106842	0.554875
005	27/5/2021	1.100797	1.466111
005	28/5/2021	1.052211	0.8164118
009	12/6/2021	0.4369312	0.4608174
009	16/6/2021	0.7536233	0.9297207
009	22/6/2021	0.7582896	0.3226226
010	25/6/2021	0.2075749	0.3025
010	26/6/2021	0.5279577	0.8201458
010	27/6/2021	0.5328123	0.5212361
011	30/6/2021	0.3117903	0.4160217
011	7/7/2021	0.2794366	0.5804091

Table 17.5.1 : Comparison of mean indoor air concentrations per day and per participant. The first column takes into account general daily mean concentrations in indoor air conditions and the second column represents the mean concentrations of the part of the same data sets the attenuation of which is higher than its *90th* percentile. The days without any concentration in indoor air conditions at the end of the evening (higher attenuation as the filter was used the whole day) were not taken into account. As no trend appeared from the participant 001, the comparison was not carried out for all days for the other ones. These data concern all the participants who used an AE51 aethalometer and who made the device active in indoor air conditions.

17.6. Aethalometers intercomparison campaigns

General mean concentration	Aethalometer reference	Mean concentration	Corrective factor
0.158122	S4-518 30 s	0.1811221	X 0,8730610
	S5-760 30 s	0.1884559	X 0,8390398
	S5-899 30 s	0.1498759	X 1,0550195
	S6-1198 30 s	0.1362222	X 1,1607653
	S6-1199 30 s	0.1231782	X 1,2836849
	S6-1375 30 s	0.1805886	X 0,8755924
	S6-1377 30 s	0.1376623	X 1,1486224
	S6-1382 30 s	0.1678696	X 0,9419335

Table 17.6.1 : Corrective factors applied to each AE51 aethalometer for a *30 seconds* timebase.

General mean concentration	Référence de l'aethalomètre	Mean concentration	Corrective factor
0.1556033	S4-518 60 s	0.1837331	X 0,8468986
	S5-899 60 s	0.162917	X 0,9551078
	S6-1198 60 s	0.1378736	X 1,1285939
	S6-1199 60 s	0.128069	X 1,2149958
	S6-1375 60 s	0.1755415	X 0,8864189
	S6-1377 60 s	0.1289515	X 1,2066808
	S6-1382 60 s	0.1721373	X 0,9039488
General mean concentration	Aethalometer reference	Mean concentration	Corrective factor
0.4456327	S5-760 60 s	0.4691274	X 0,9499182
	S5-899 60 s	0.422138	X 1,0556564

Table 17.6.2 : Corrective factors applied to each AE51 aethalometer for a *60 seconds* timebase. The intercomparison of the S5-760 and S5-899 models happened in another context.

Figure 17.6.1 : AE51 intercomparison : raw data for a *30 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

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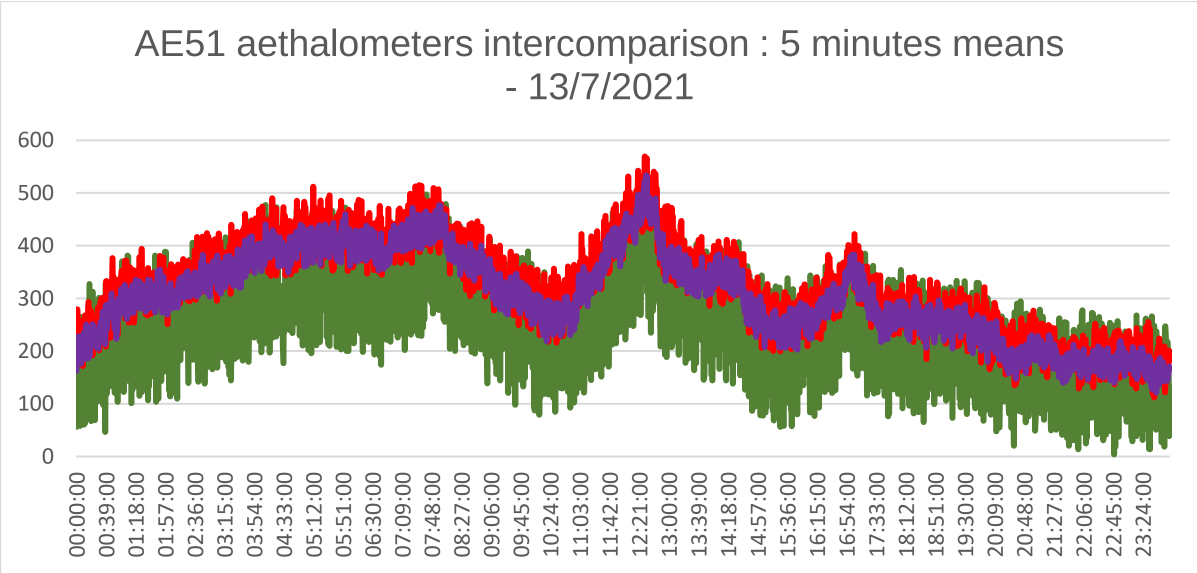

Figure 17.6.2 : AE51 intercomparison : *5* minutes-smoothed data for a *30 seconds* timebase. Each concentration value corresponds to the mean of a five minutes-series raw values. The black carbon concentrations are expressed in *ng/m³*. The colours correspond to the ones of the previous graphic.

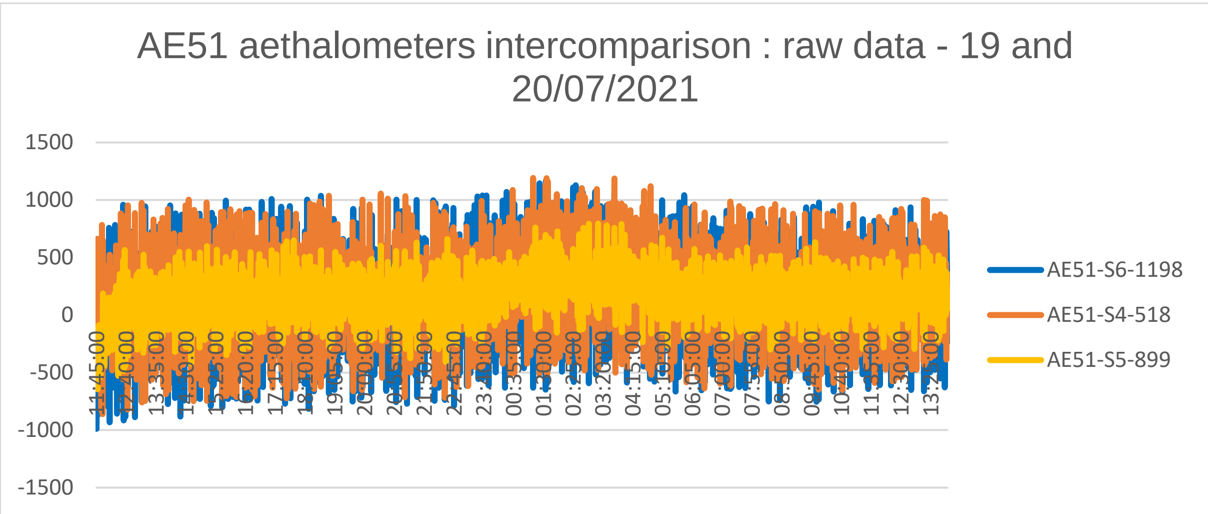

Figure 17.6.3 : AE51 intercomparison : raw data for a *60 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

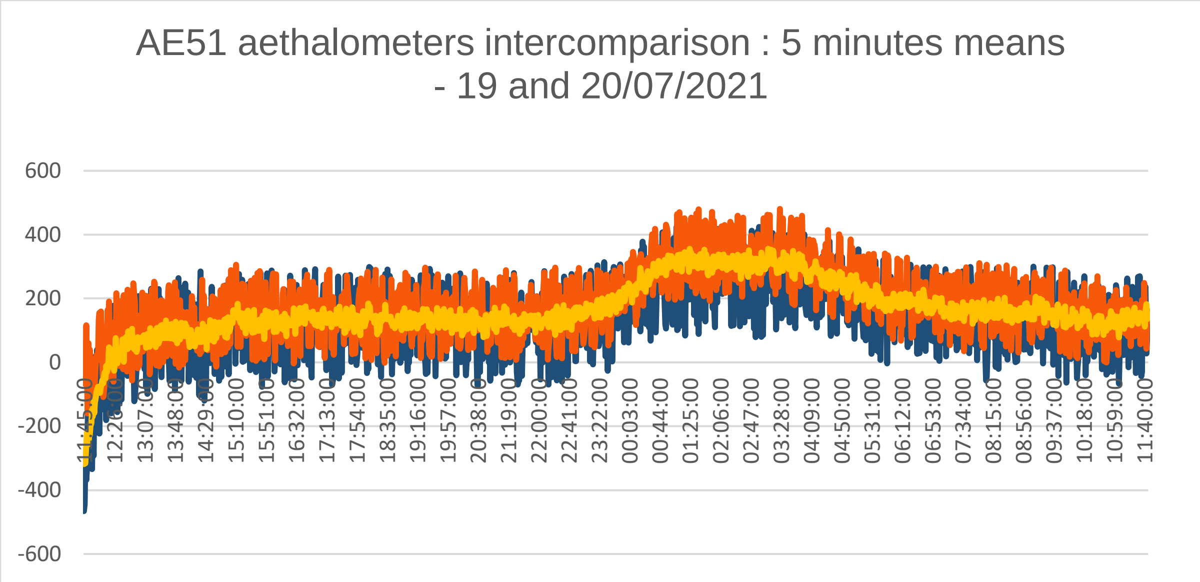

Figure 17.6.4 : AE51 intercomparison : *5 minutes-smoothed* data for a *60 seconds* timebase. Each concentration value corresponds to the mean of a five minutes-series raw values. The black carbon concentrations are expressed in *ng/m³*. The colours correspond to the ones of the previous graphic.

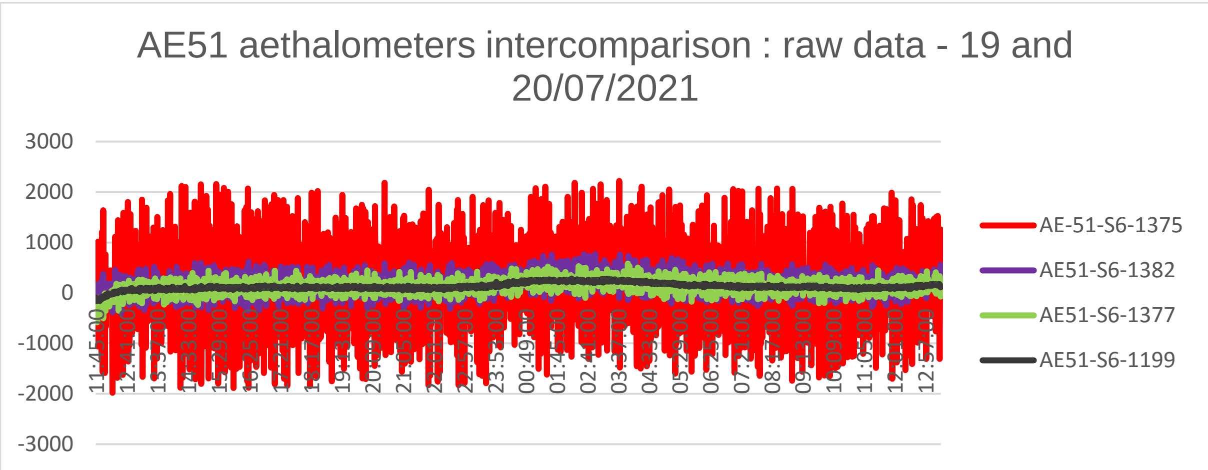

Figure 17.6.5 : AE51 intercomparison : raw data for a *60 seconds* timebase. *The black carbon concentrations are expressed in ng/m³.*

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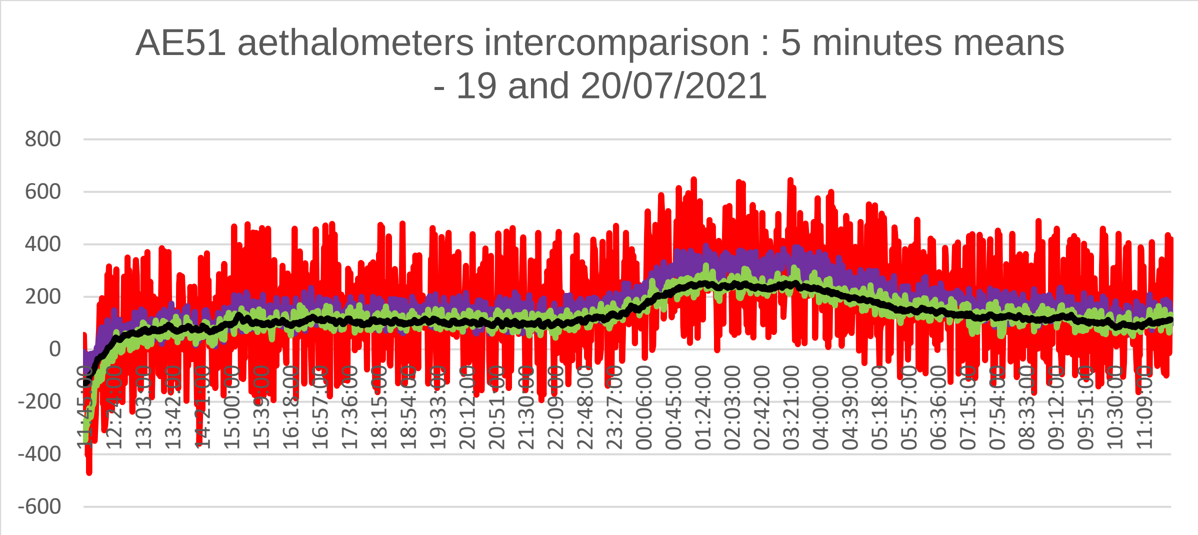

Figure 17.6.5 : AE51 intercomparison : *5 minutes-smoothed* data for a *60 seconds* timebase. Each concentration value corresponds to the mean of a five minutes-series raw values. The black carbon concentrations are expressed in *ng/m³*. The colours correspond to the ones of the previous graphic.

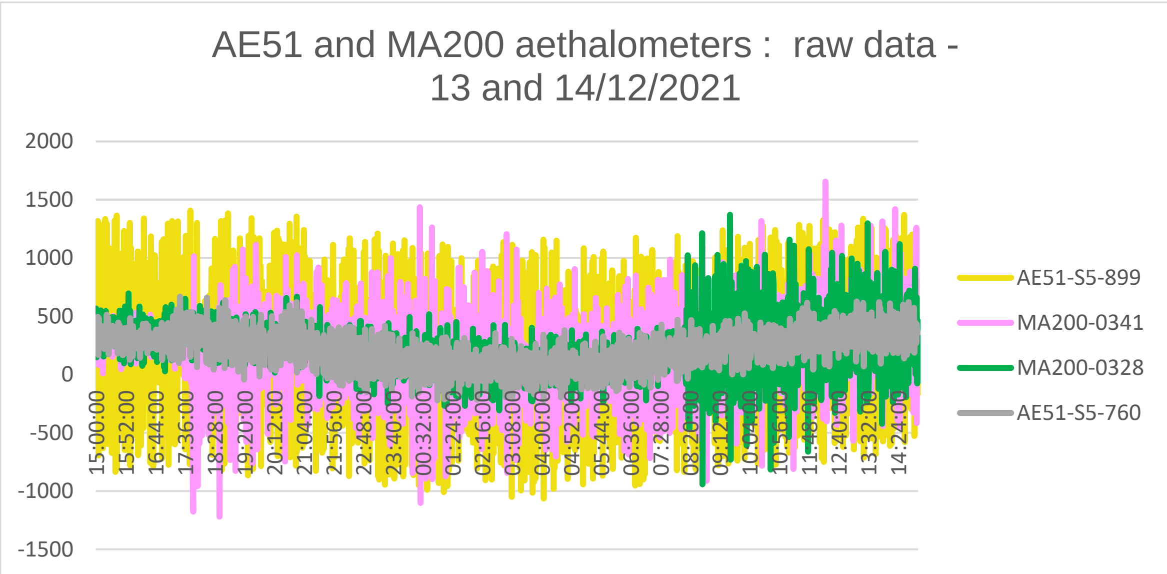

Figure 17.6.6 : AE51 and MA200 intercomparison : raw data for a *60 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

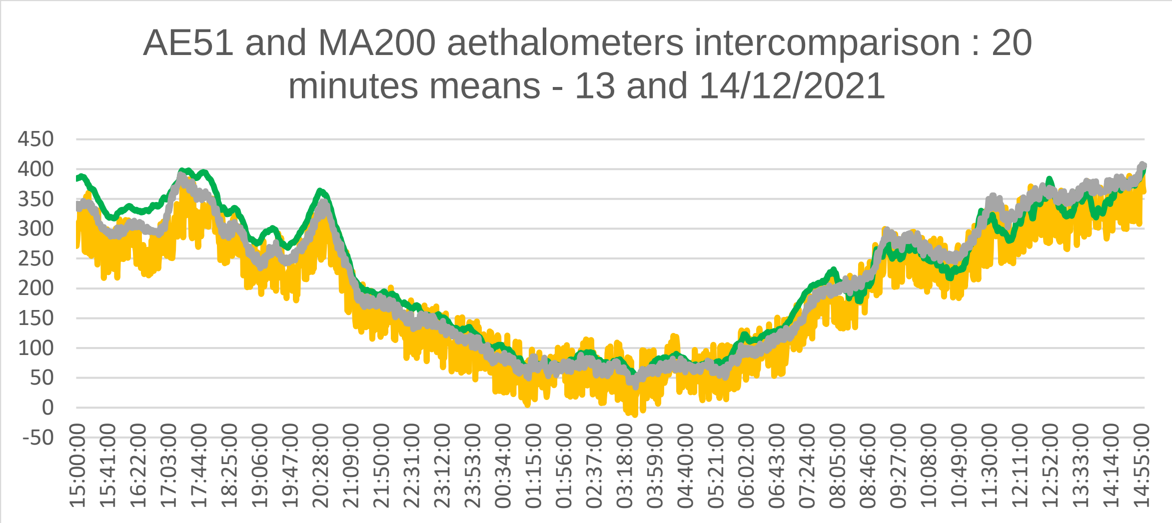

Figure 17.6.7 : AE51 and MA200 intercomparison. *20 minutes-smoothed* data for a *60 seconds* timebase. Each concentration value corresponds to the mean of a five twenty-series raw values. The black carbon concentrations are expressed in *ng/m³*. The colours correspond to the ones of the previous graphic.

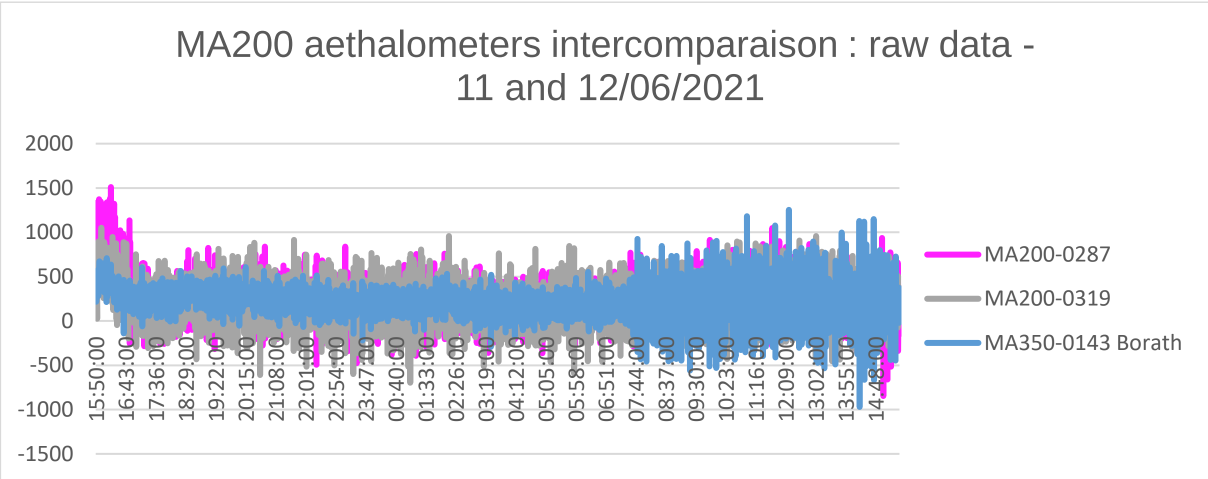

Figure 17.6.8 : MA200 intercomparison : raw data for a *30 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*. MA350 device is another aethalometer that is designed by the same manufacturer and that is not portable. Borath is its internal reference.

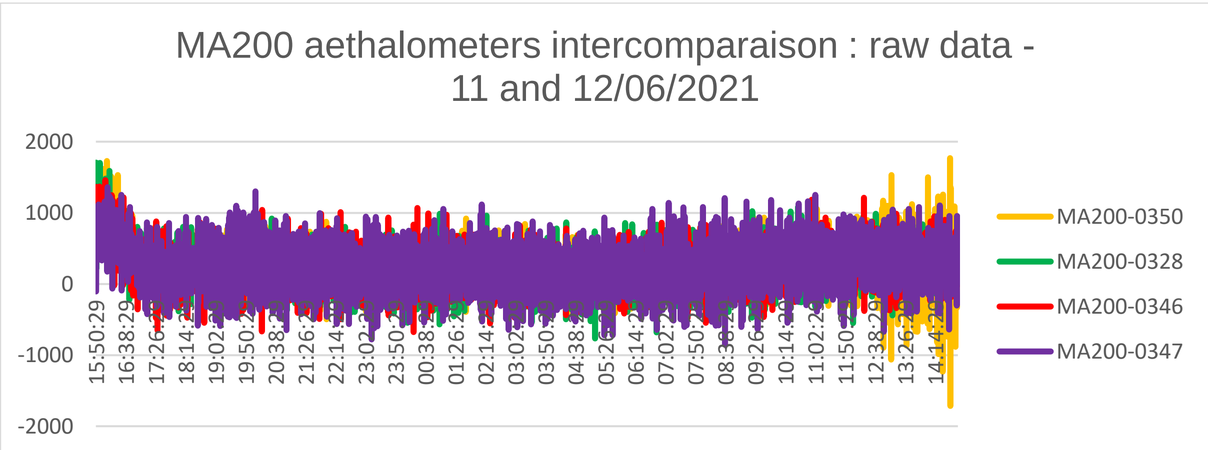

Figure 17.6.9 : MA200 intercomparison : raw data for a *30 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

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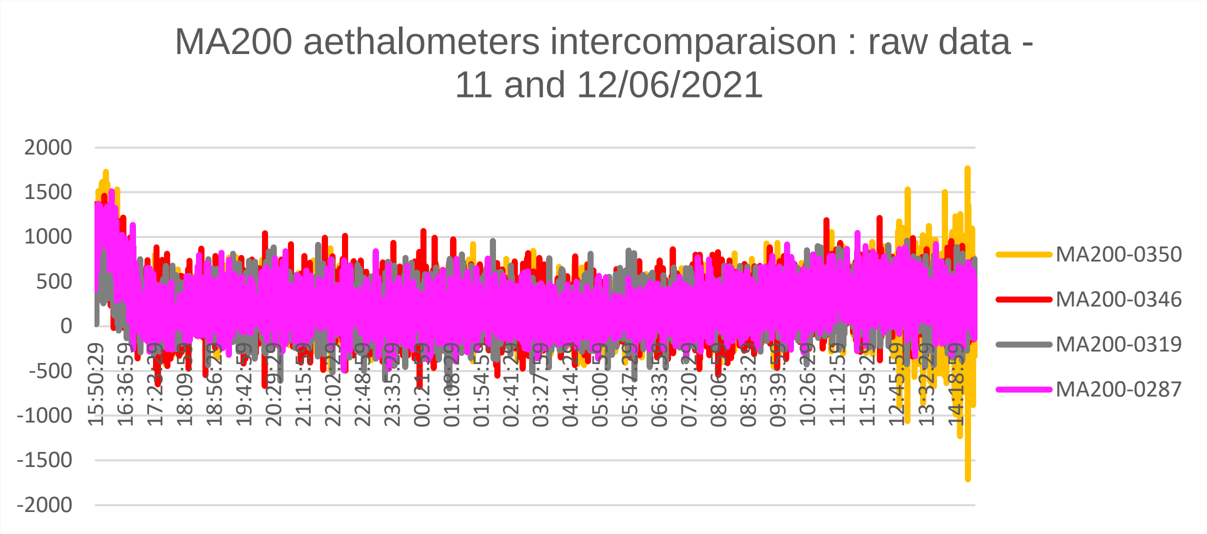

Figure 17.6.10 : MA200 intercomparison : raw data for a *30 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

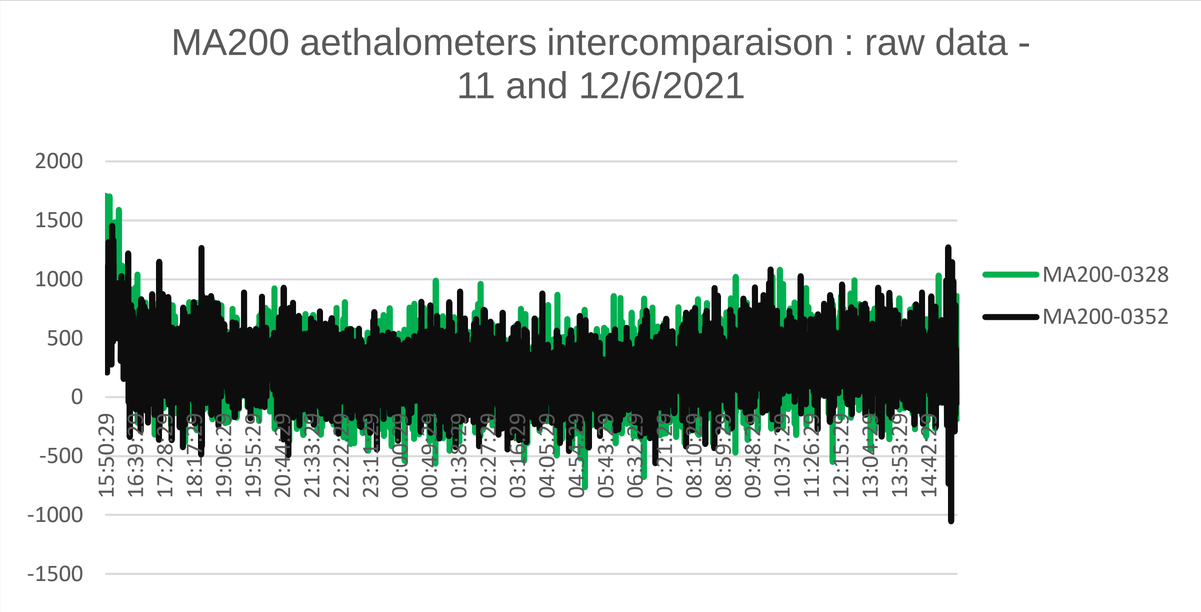

Figure 17.6.11 : MA200 intercomparison : raw data for a *30 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

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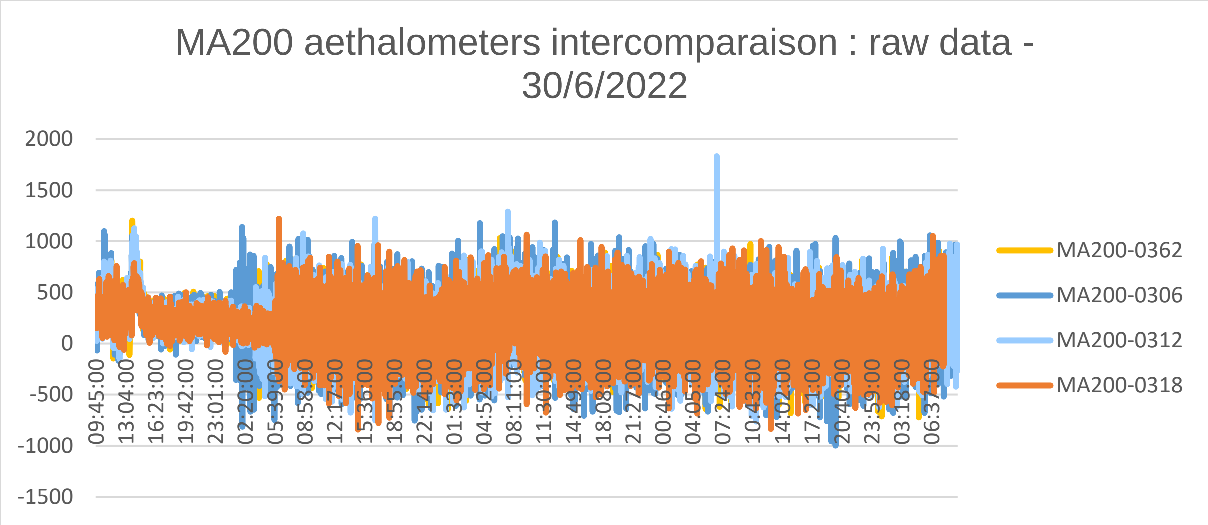

Figure 17.6.12 : MA200 intercomparison : raw data for a *60 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

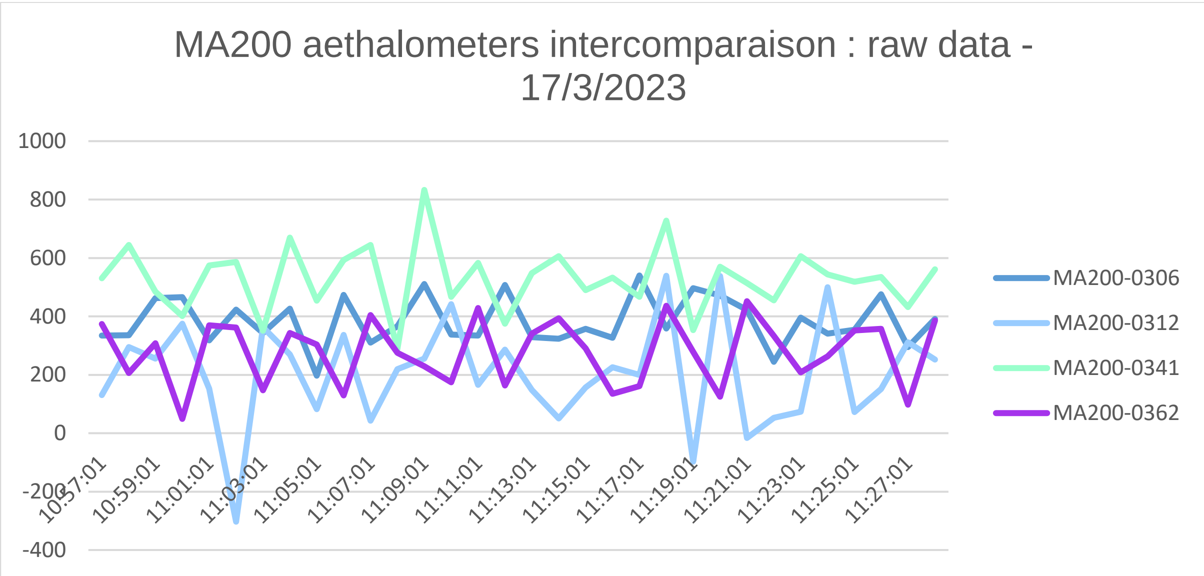

Figure 17.6.13 : MA200 intercomparison : raw data for a *60 seconds* timebase. The black carbon concentrations are expressed in *ng/m³*.

General mean concentration	Aethalometer reference	Mean concentration	Corrective factor
0.158122	S4-518 30 s	0.1811221	X 0,8730610
	S5-760 30 s	0.1884559	X 0,8390398
	S5-899 30 s	0.1498759	X 1,0550195
	S6-1198 30 s	0.1362222	X 1,1607653
	S6-1199 30 s	0.1231782	X 1,2836849
	S6-1375 30 s	0.1805886	X 0,8755924
	S6-1377 30 s	0.1376623	X 1,1486224
	S6-1382 30 s	0.1678696	X 0,9419335

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	S6-1375 60 s	0.1755415	X 0,8864189
	S6-1377 60 s	0.1289515	X 1,2066808
	S6-1382 60 s	0.1721373	X 0,9039488
General mean concentration	Aethalometer reference	Mean concentration	Corrective factor
0.4456327	S5-760 60 s	0.4691274	X 0,9499182
	S5-899 60 s	0.422138	X 1,0556564

Table 17.6.2 : Corrective factors applied to each AE51 aethalometer for a *60 seconds* timebase. The intercomparison of the S5-760 and S5-899 models happened in another context.

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17.7. Seasonal correction

	A	B	C	D	E	F	G	H	I	J	K
1	Stat,,:		41N043	41R001	41R002	41R012	x-mean	x-maxi		hourly min	daily background
2	Deci,,:		0	0	0	0	0	0			
3	Maxi,,:										
4	Mean,,:										
5	Min,,,:										
6	Number:										
7	Values:										
8	20210501	00:30:00	1	1,2		0,83	1,01	1,2		0,83	
9	20210501	01:00:00	1,12	0,72		0,79	0,88	1,12		0,72	
10	20210501	01:30:00	0,88	0,76		0,82	0,82	0,88		0,76	
11	20210501	02:00:00		0,81		0,84	0,83	0,84		0,81	
12	20210501	02:30:00	2,08	0,99		0,83	1,3	2,08		0,83	
13	20210501	03:00:00	1,24	0,68		0,73	0,88	1,24		0,68	
14	20210501	03:30:00	1,12	1,26		0,74	1,04	1,26		0,74	
15	20210501	04:00:00	1,19	1,52		0,8	1,17	1,52		0,8	
16	20210501	04:30:00	1,17	1,59		0,85	1,2	1,59		0,85	
17	20210501	05:00:00	1,66	1,45		1,21	1,44	1,66		1,21	
18	20210501	05:30:00	1,43	1,88		0,99	1,43	1,88		0,99	
19	20210501	06:00:00	1,73	1,96		0,87	1,52	1,96		0,87	
20	20210501	06:30:00	1,8	1,64		0,82	1,42	1,8		0,82	
21	20210501	07:00:00	2,74	1,42		0,99	1,72	2,74		0,99	
22	20210501	07:30:00	1,86	1,36		1,03	1,42	1,86		1,03	
23	20210501	08:00:00	1,38	1,14		0,86	1,13	1,38		0,86	
24	20210501	08:30:00	1,4	1,06		0,94	1,13	1,4		0,94	
25	20210501	09:00:00	1,3	1,07		0,64	1	1,3		0,64	
26	20210501	09:30:00	0,62	0,71		0,83	0,72	0,83		0,62	
27	20210501	10:00:00	0,67	0,49		0,67	0,61	0,67		0,49	
28	20210501	10:30:00	0,29	0,41		0,41	0,37	0,41		0,29	
29	20210501	11:00:00	0,31	0,35		0,2	0,29	0,35		0,2	
30	20210501	11:30:00	0,43	0,42		0,49	0,45	0,49		0,42	
31	20210501	12:00:00	0,45	0,29		0,21	0,32	0,45		0,21	
32	20210501	12:30:00	0,39	0,41		0,39	0,4	0,41		0,39	
33	20210501	13:00:00	0,22	0,33		0,36	0,3	0,36		0,22	
34	20210501	13:30:00	0,6	0,51		0,18	0,43	0,6		0,18	
35	20210501	14:00:00	0,51	0,19		0,4	0,37	0,51		0,19	
36	20210501	14:30:00	0,29	0,72		0,33	0,45	0,72		0,29	
37	20210501	15:00:00	0,32	0,69		0,18	0,4	0,69		0,18	
38	20210501	15:30:00	0,46	0,68		0,43	0,52	0,68		0,43	
39	20210501	16:00:00	0,48	0,77		0,16	0,47	0,77		0,16	
40	20210501	16:30:00	0,26	0,65		0,4	0,44	0,65		0,26	
41	20210501	17:00:00	0,65	0,7		0,18	0,51	0,7		0,18	
42	20210501	17:30:00	0,38	0,23		0,16	0,26	0,38		0,16	
43	20210501	18:00:00	0,35	0,89		0,34	0,53	0,89		0,34	
44	20210501	18:30:00	0,38	0,43		0,29	0,37	0,43		0,29	
45	20210501	19:00:00	0,28	0,47		0,25	0,33	0,47		0,25	
46	20210501	19:30:00	0,16	0,48		0,22	0,29	0,48		0,16	
47	20210501	20:00:00	0,38	0,39		0,1	0,29	0,39		0,1	
48	20210501	20:30:00	0,43	0,69		0,25	0,46	0,69		0,25	
49	20210501	21:00:00	0,27	0,72		0,34	0,44	0,72		0,27	
50	20210501	21:30:00	0,29	0,58		0,36	0,41	0,58		0,29	
51	20210501	22:00:00	0,41	0,55		0,28	0,41	0,55		0,28	
52	20210501	22:30:00	0,36	0,62		0,33	0,44	0,62		0,33	
53	20210501	23:00:00	0,49	0,68		0,4	0,52	0,68		0,4	
54	20210501	23:30:00	0,74	0,49		0,39	0,54	0,74		0,39	
55	20210501	24:00:00	0,73	0,57		0,33	0,54	0,73		0,33	0,50

Table 17.7.1 : Example of the calculations that were applied on the data from the concentrations of the telemetric measuring network. Four stations (41N043, 41R001, 41R002 and 41R012) of the Brussels network measure black carbon concentrations but the data can not always be validated. For each semi-hourly recording, the minimum concentration is registered and the mean of all these minima is calculated for each day (daily background).

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1		daily background	corrective factor
2	20210501	0,50	0,737
3	20210502	0,30	1,215
4	20210503	0,39	0,938
5	20210504	0,16	2,267
6	20210505	0,21	1,770
7	20210506	0,25	1,473
8	20210507	0,35	1,061
9	20210508	0,34	1,080
10	20210509	0,37	1,004
11	20210510	0,39	0,947
12	20210511	0,42	0,871
13	20210512	0,35	1,047
14	20210513	0,37	0,998
15	20210514	0,46	0,806
16	20210515	0,26	1,438
17	20210516	0,19	1,913
18	20210517	0,20	1,796
19	20210518	0,28	1,301
20	20210519	0,28	1,300
21	20210520	0,34	1,072
22	20210521	0,21	1,788
23	20210522	0,17	2,145
24	20210523	0,15	2,456
25	20210524	0,18	2,070
26	20210525	0,26	1,413
27	20210526	0,26	1,407
28	20210527	0,32	1,146
29	20210528	0,38	0,957
30	20210529	0,35	1,047
31	20210530	0,35	1,060
32	20210531	0,39	0,943
33	20210601	0,39	0,944
34	20210602	0,40	0,909
35	20210603	0,50	0,734
36	20210604	0,74	0,498
37	20210605	0,44	0,837
38	20210606	0,35	1,040
39	20210607	0,55	0,670

Table 17.7.2 : Example of the corrective factors that were applied to all of the concentrations data. The mean of all daily background concentrations was divided by each of them with the aim of getting one corrective factor per day.

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17.8. Positive outliers from the time series during participants' trips

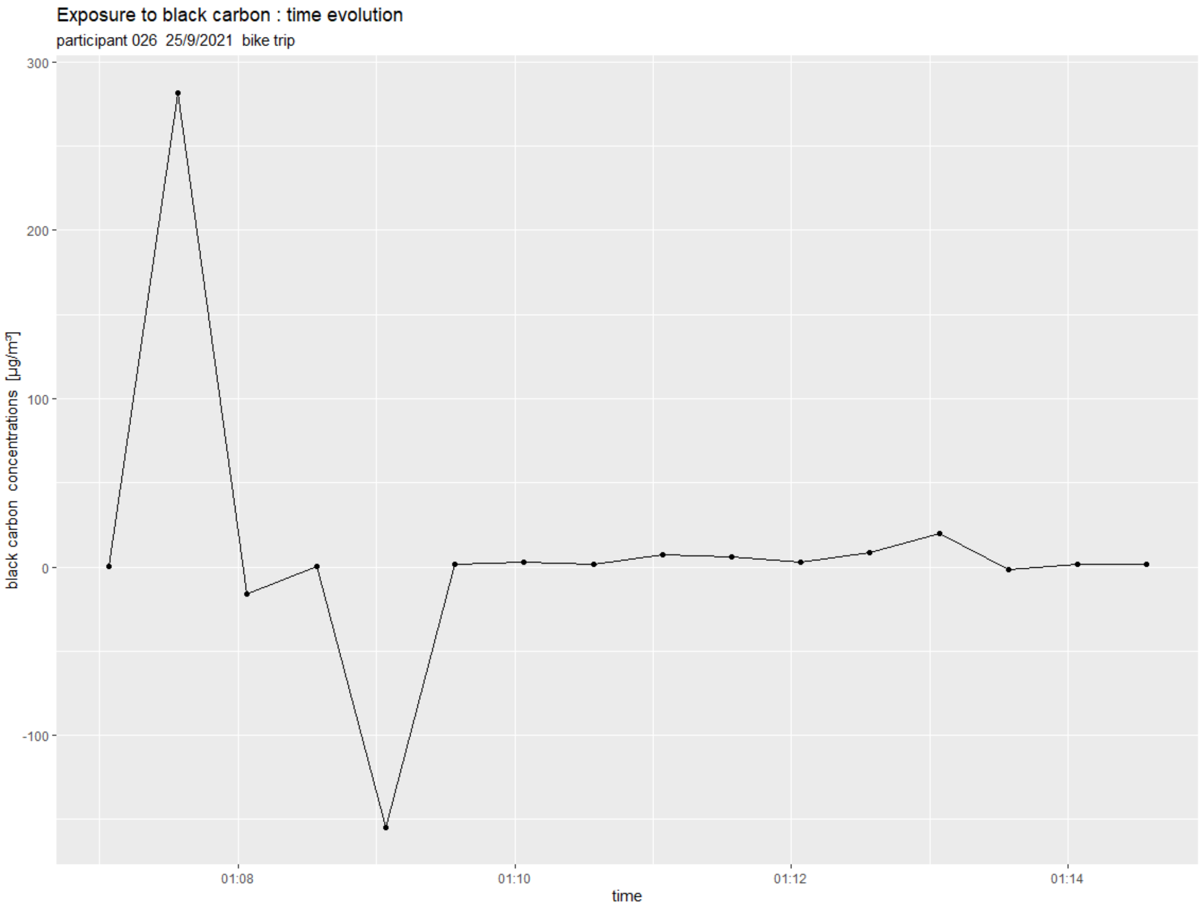

Figure 17.8.1 : Identification of positive outliers on black carbon concentrations time series from a participant's trip. The graphs take back all the initial values that exceeded the threshold 45 µg/m³. Other graphs were carried out to take into account the exceeding values that were obtained after the seasonal correction.

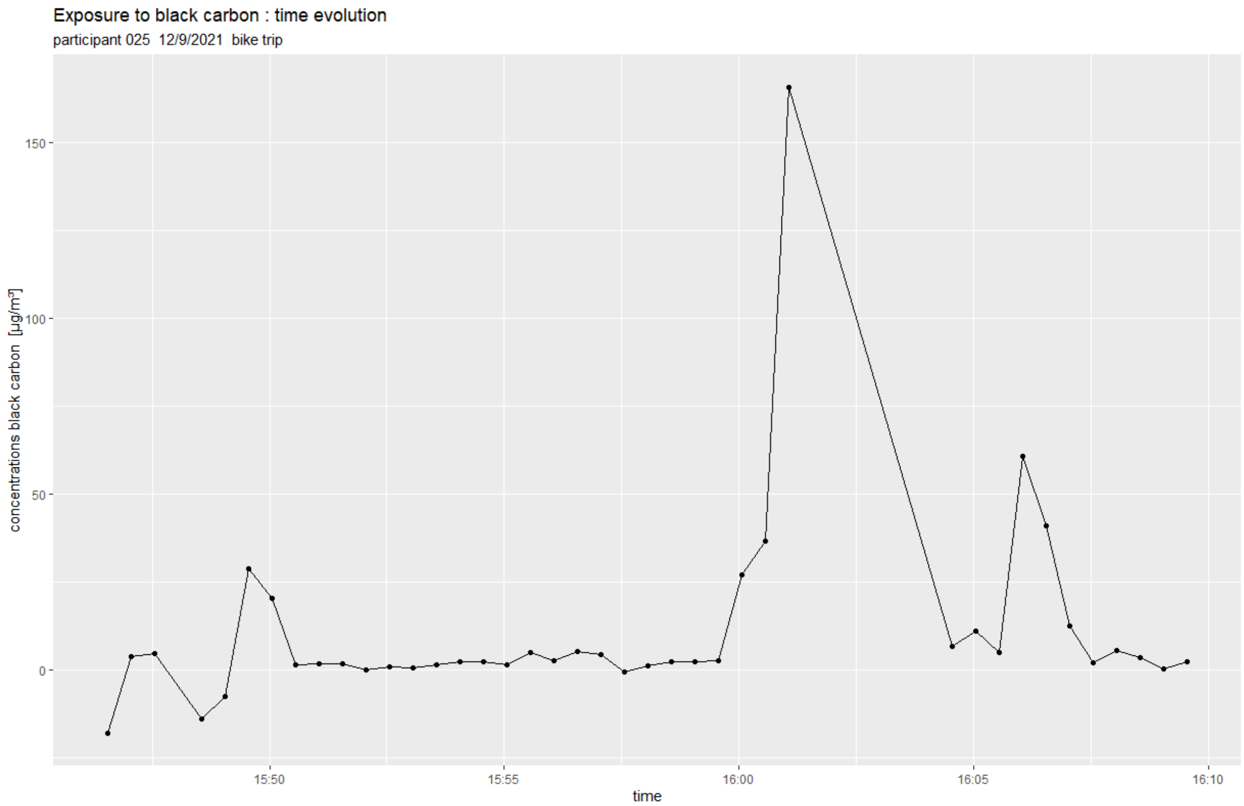

Figure 17.8.2 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

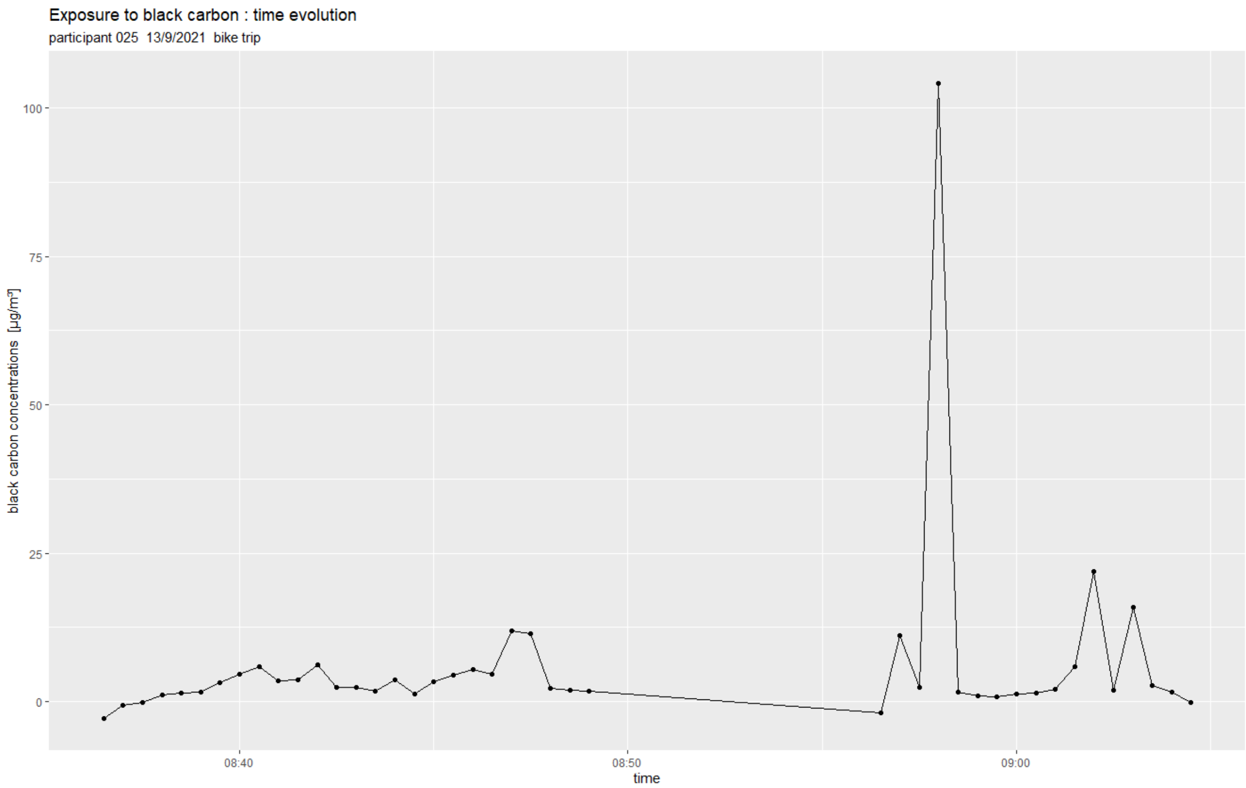

Figure 17.8.3 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

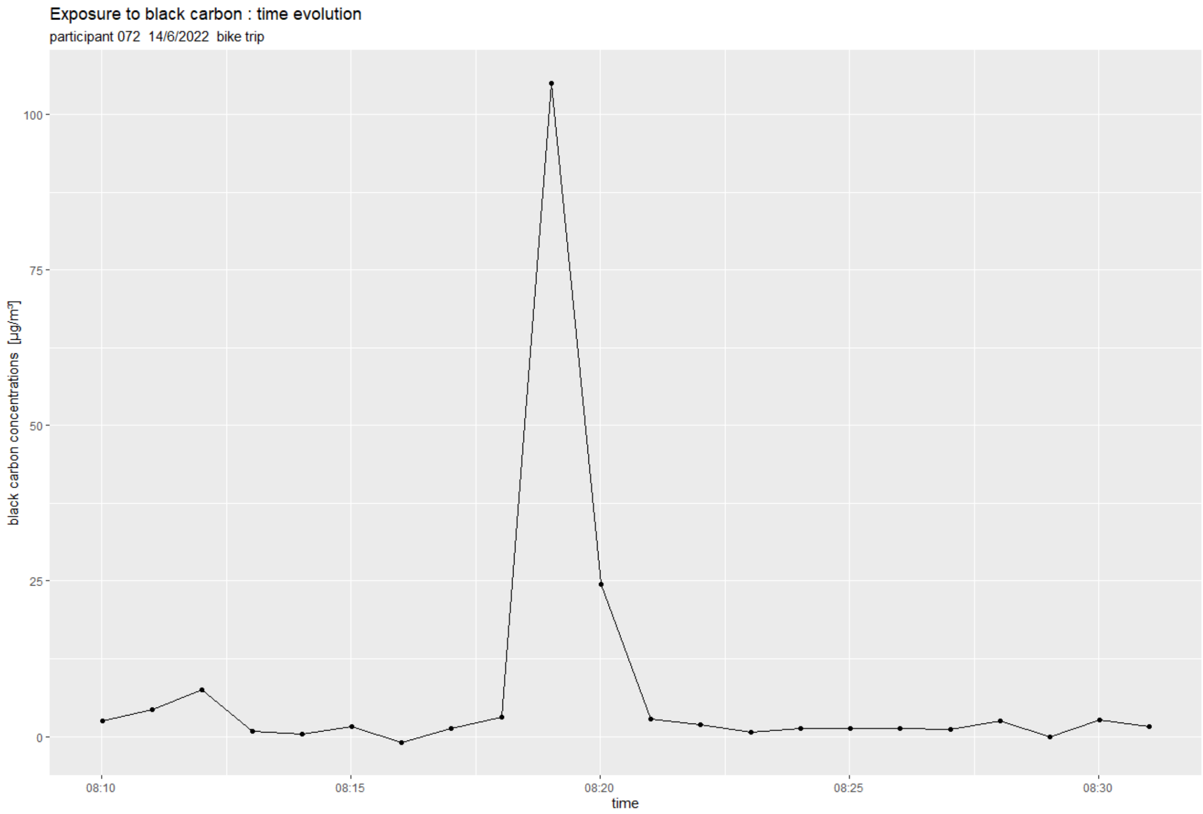

Figure 17.8.4 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

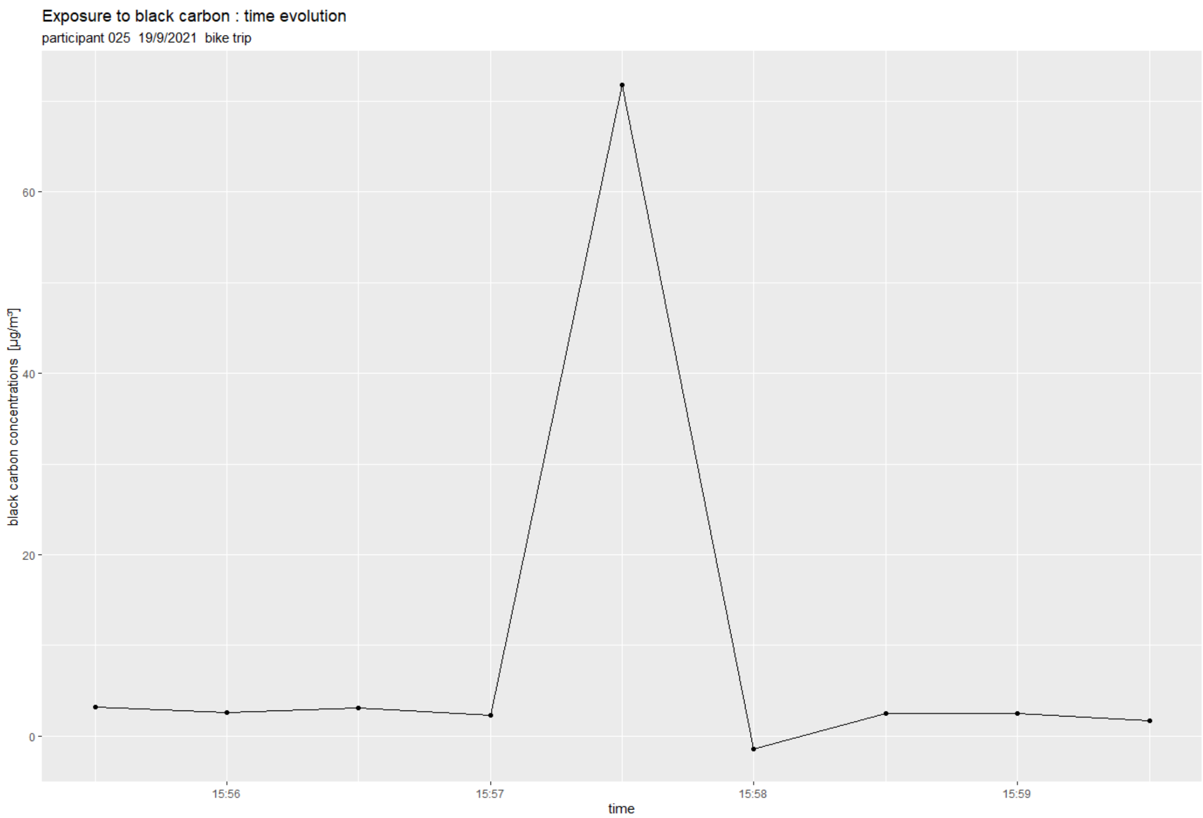

Figure 17.8.5 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

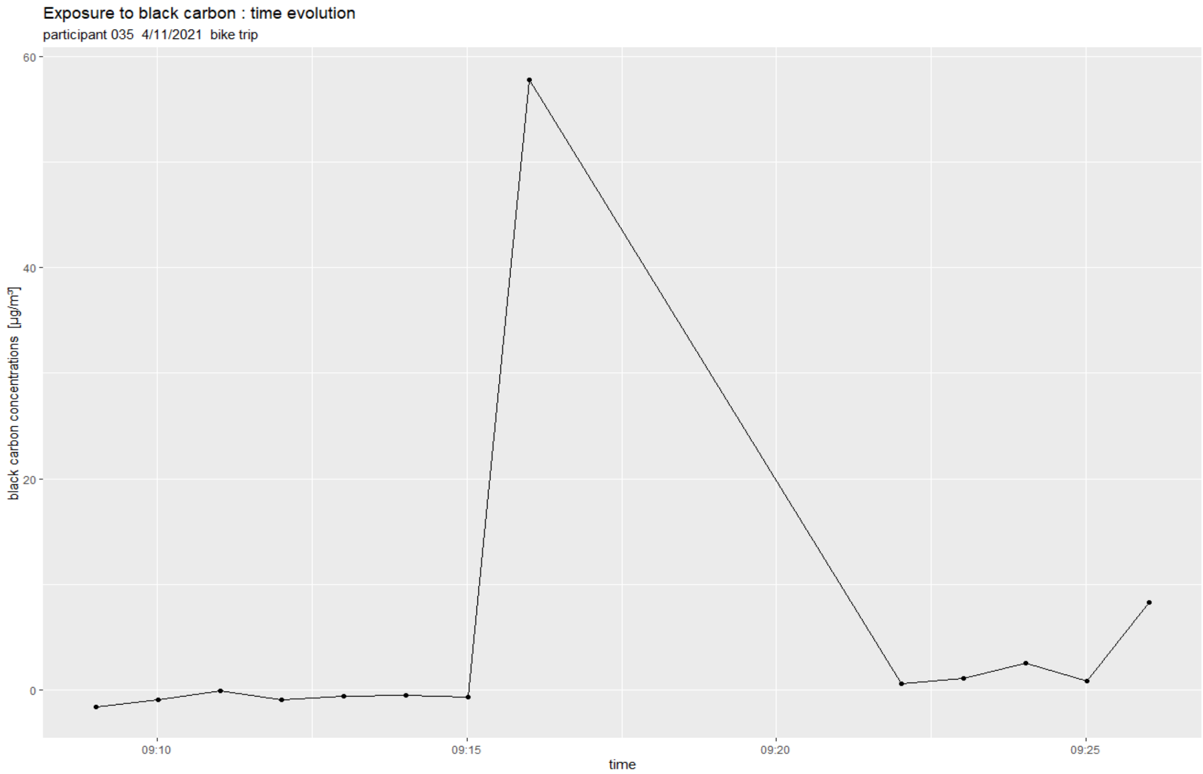

Figure 17.8.6 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

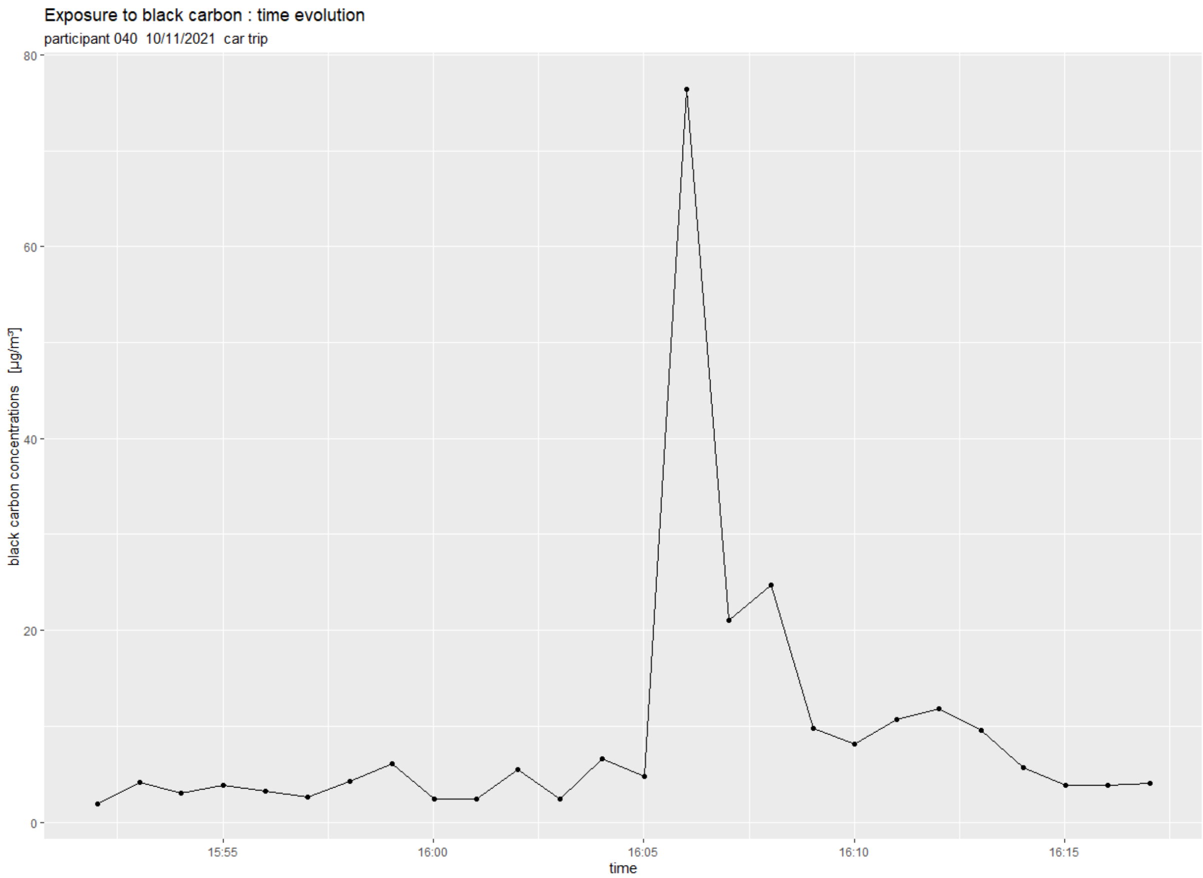

Figure 17.8.7 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

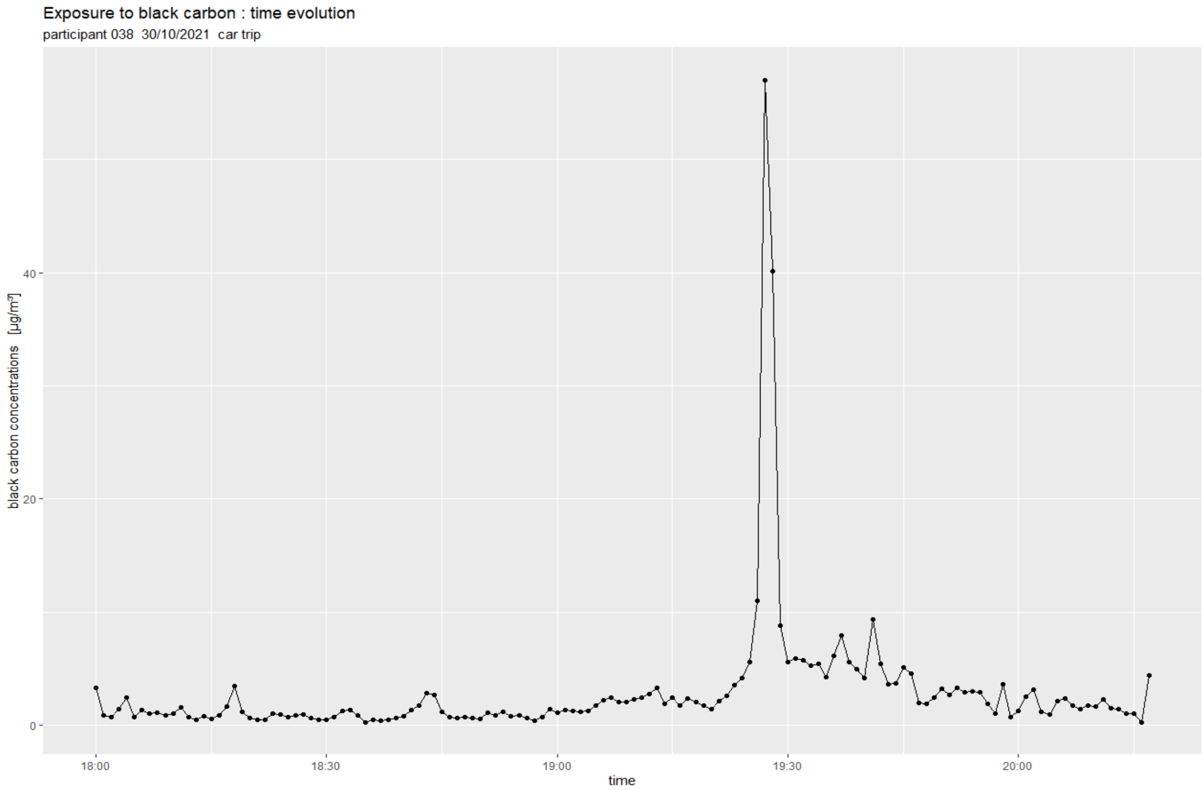

Figure 17.8.8 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

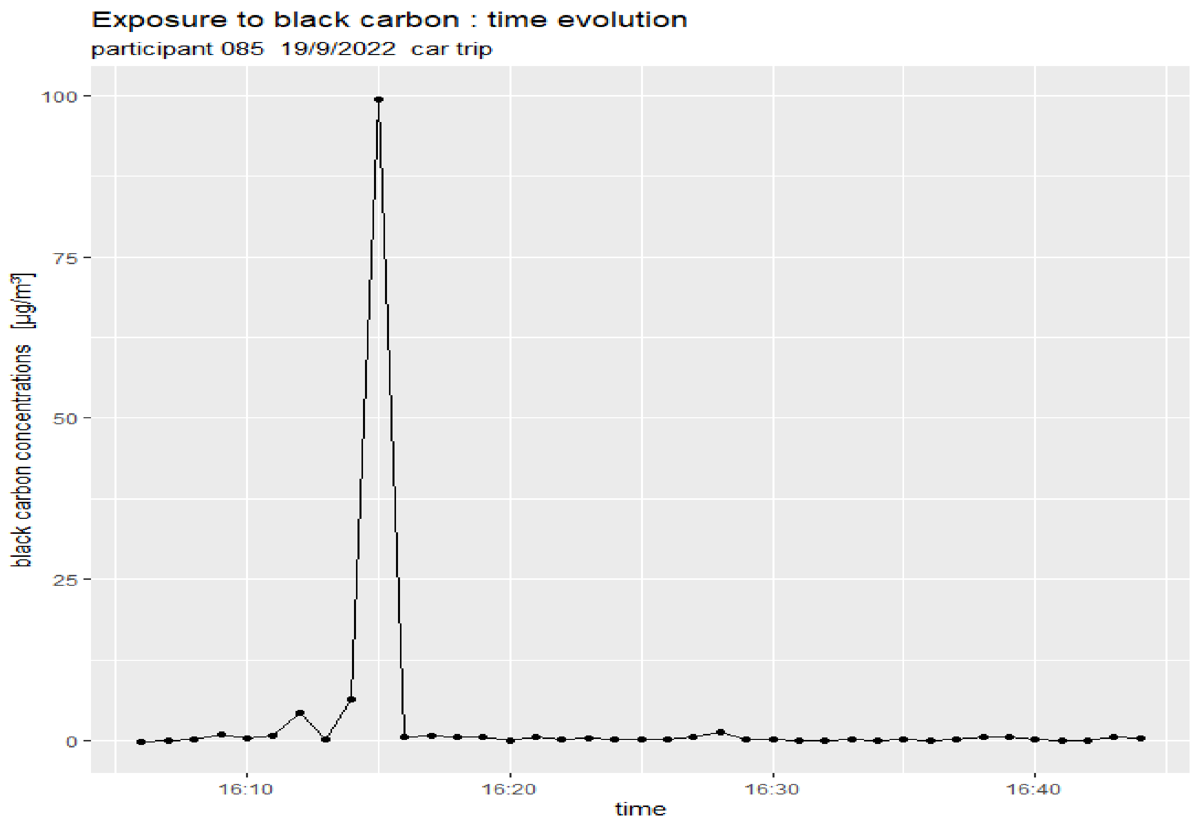

Figure 17.8.9 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

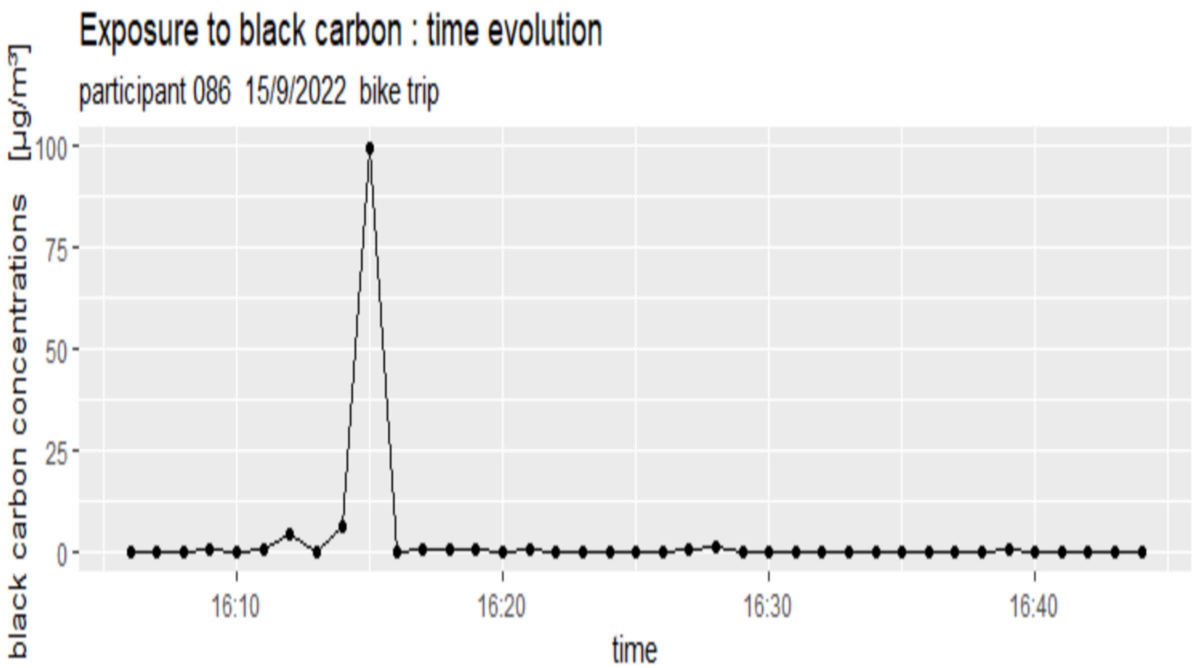

Figure 17.8.10 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

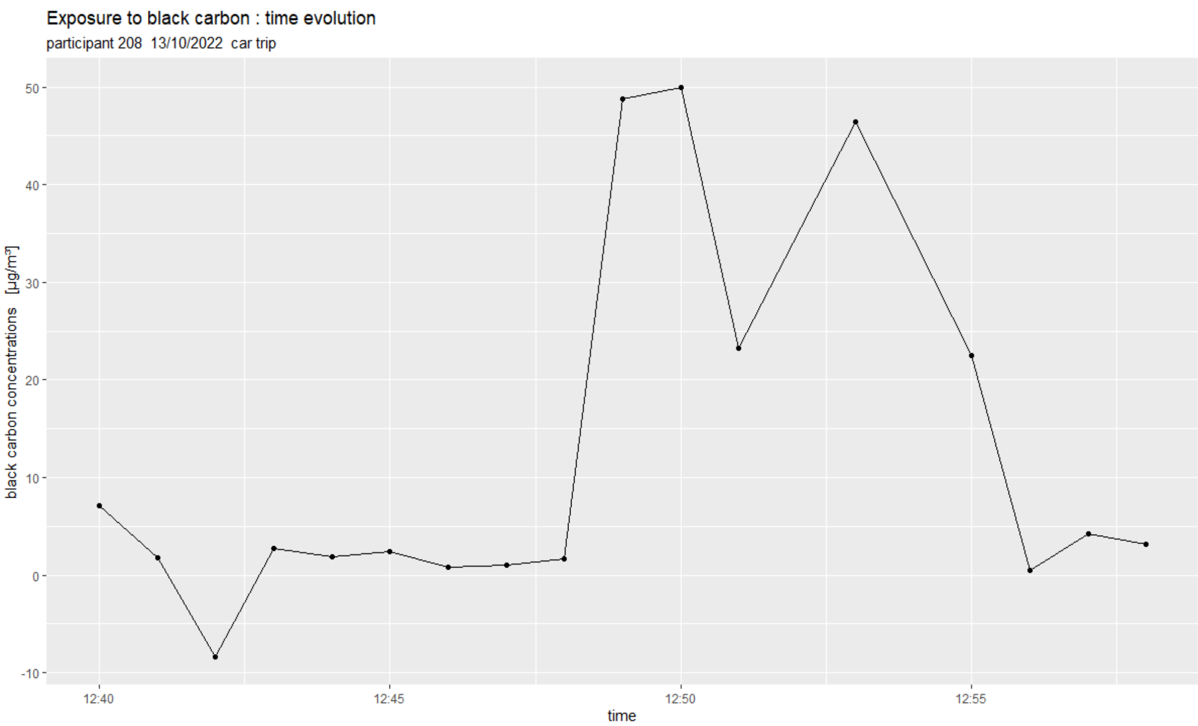

Figure 17.8.11 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

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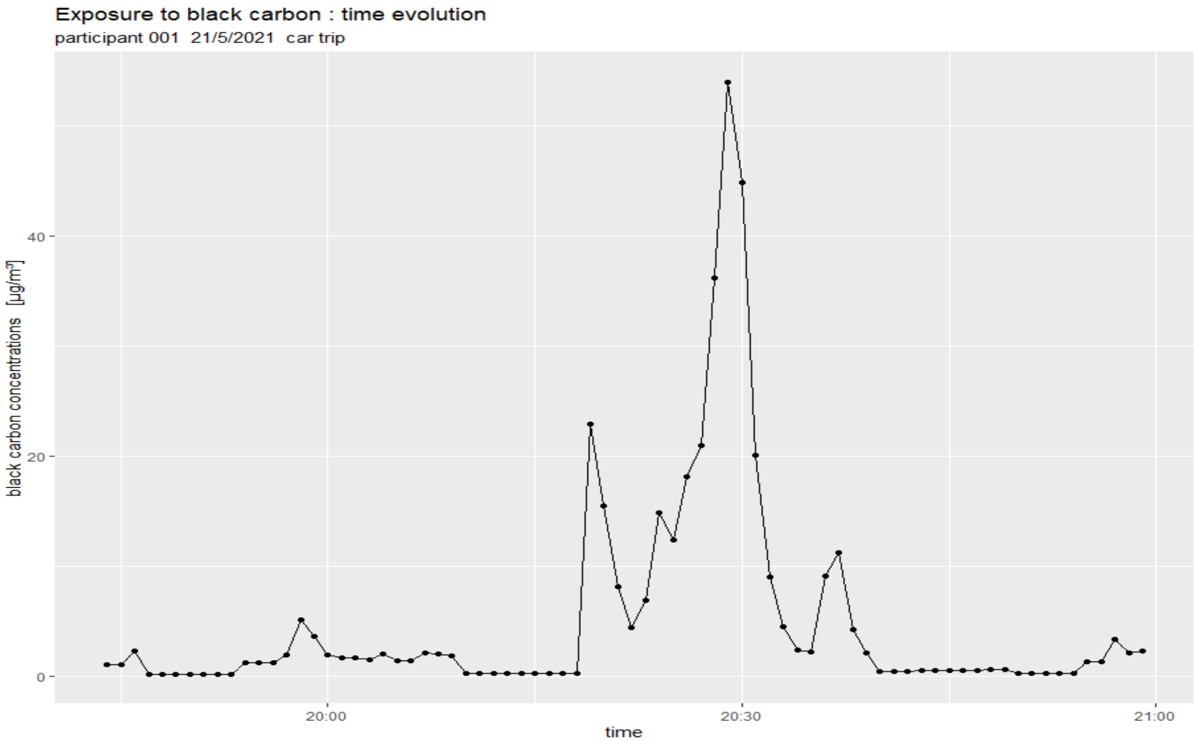

Figure 17.8.12 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

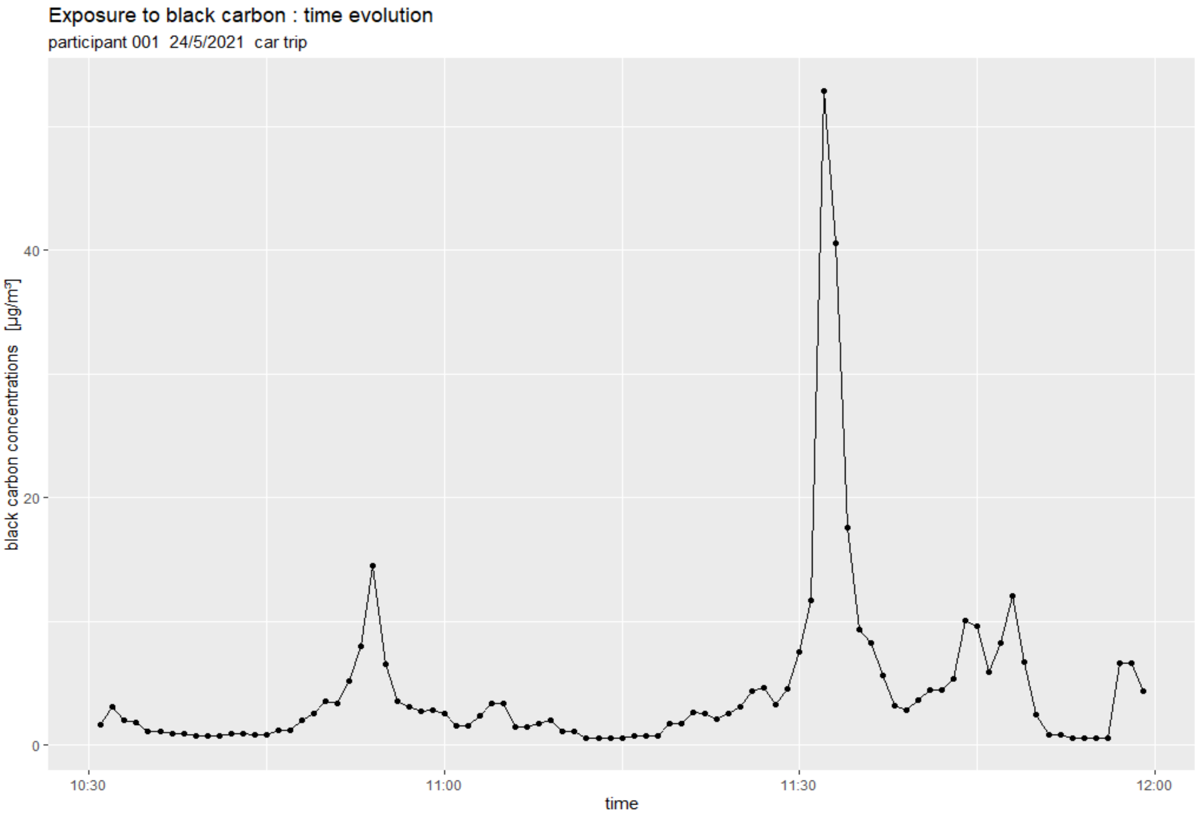

Figure 17.8.13 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

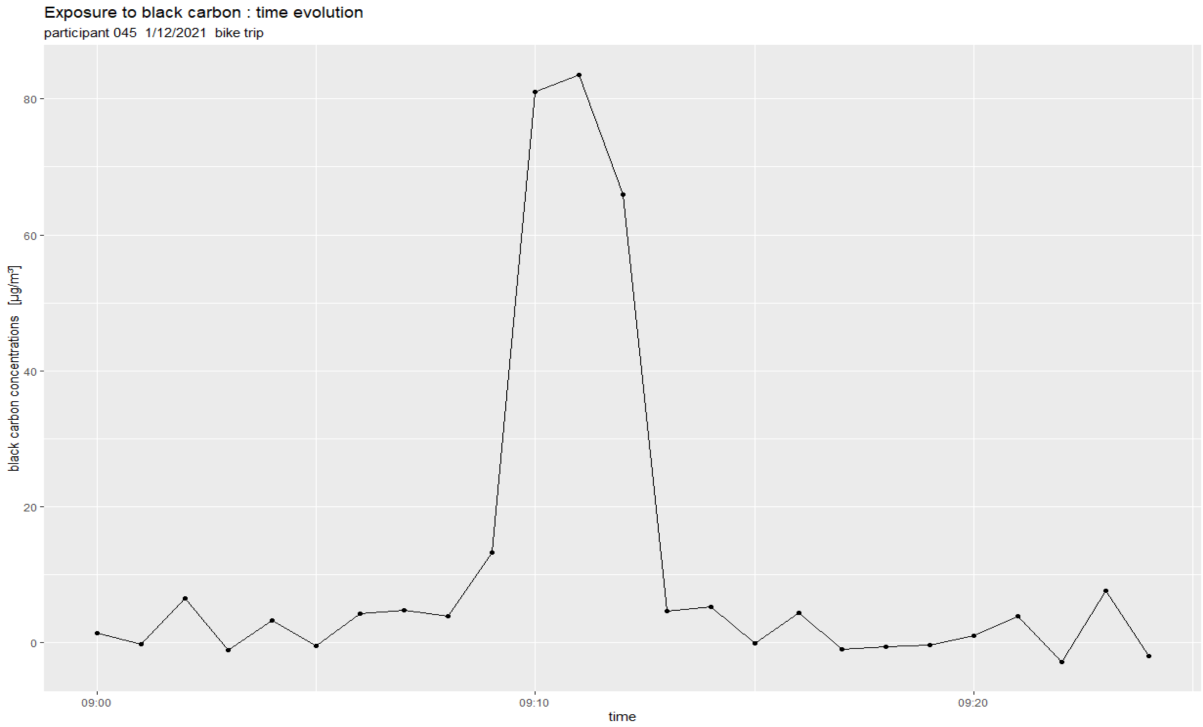

Figure 17.8.14 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

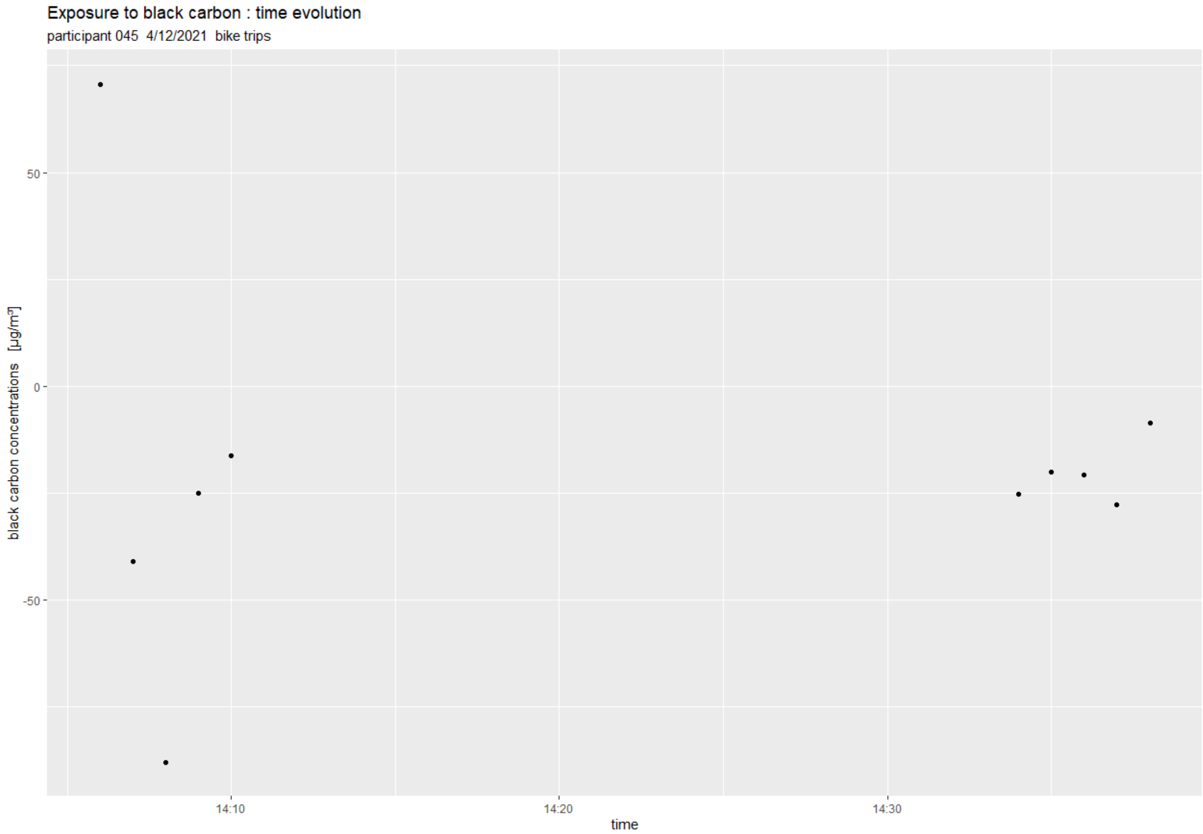

Figure 17.8.15 : Identification of positive outliers on black carbon concentration time series from a participant's trip

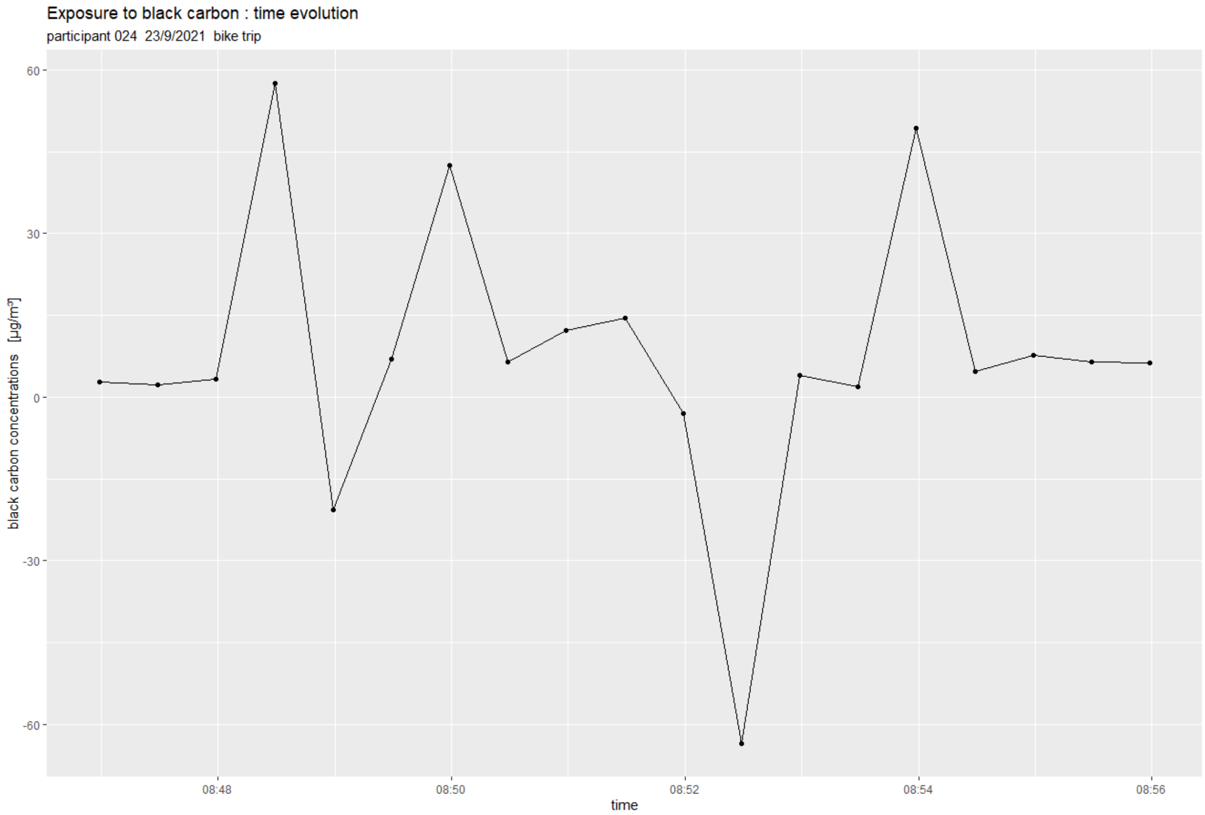

Figure 17.8.16 : Identification of positive outliers on black carbon concentrations time series from a participant’s trip.

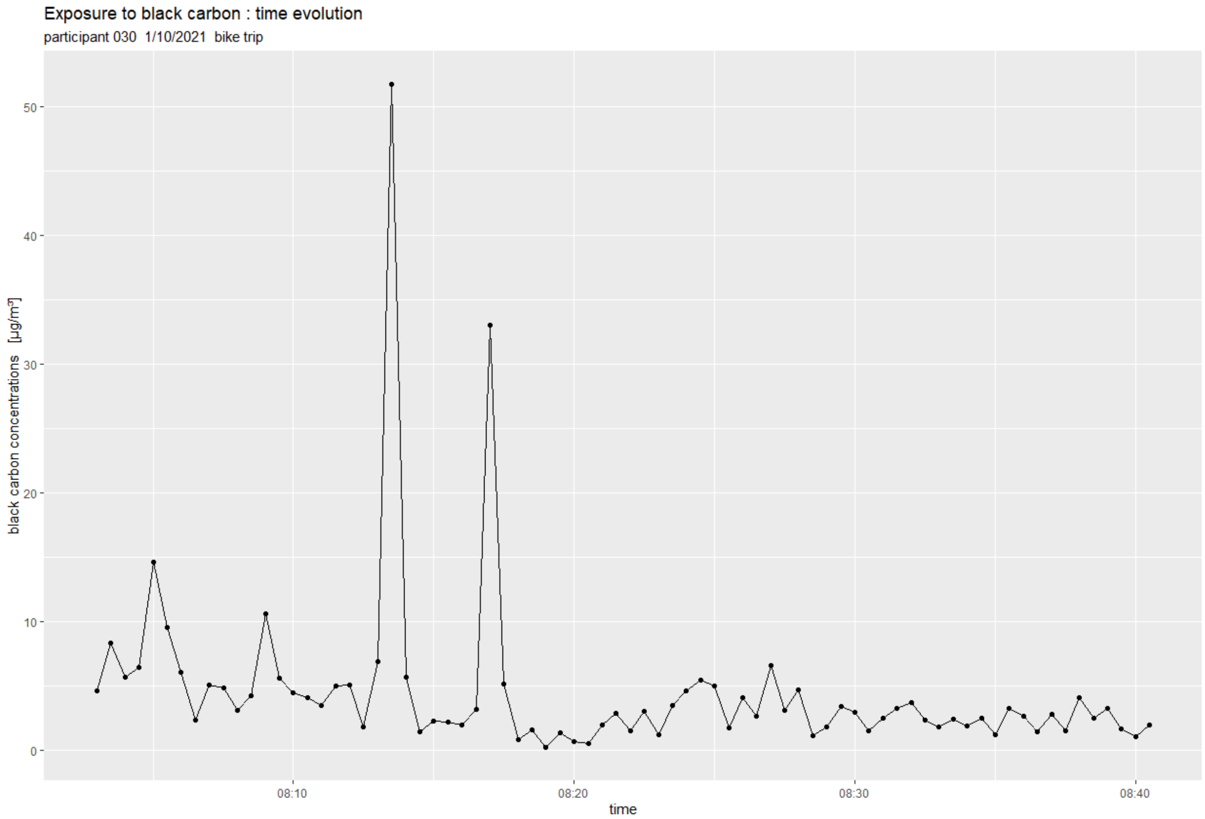

Figure 17.8.17 : Identification of positive outliers on black carbon concentrations time series from a participant’s trip.

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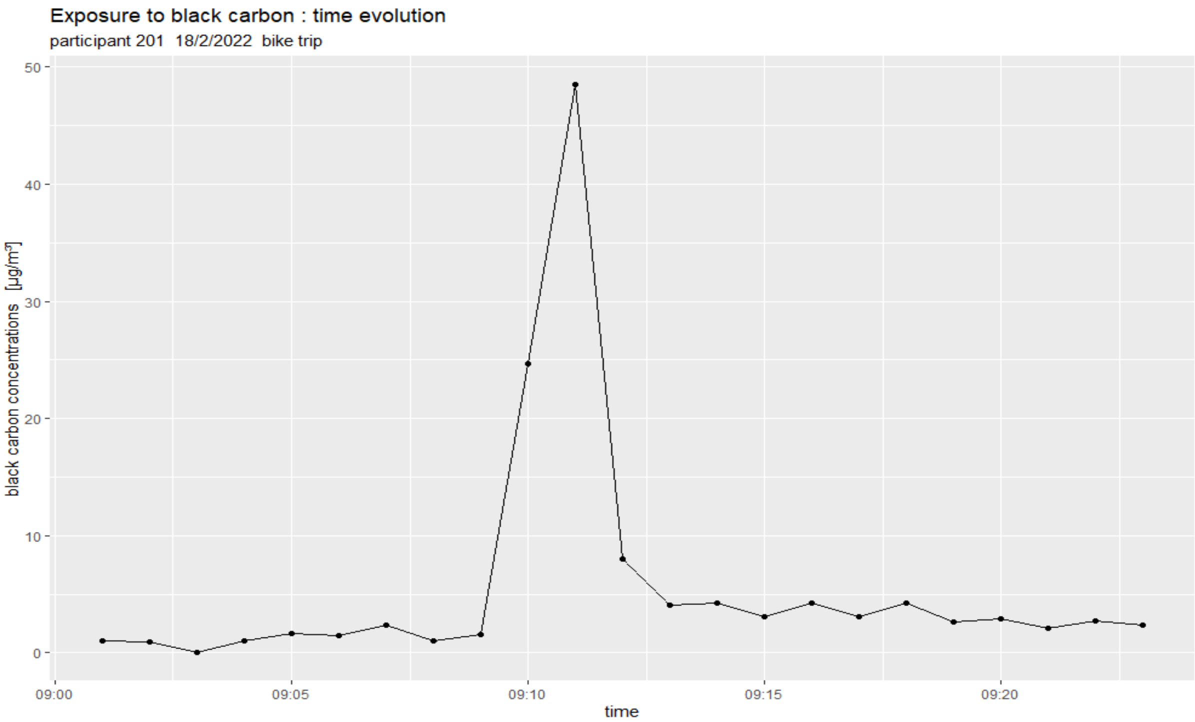

Figure 17.8.18 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

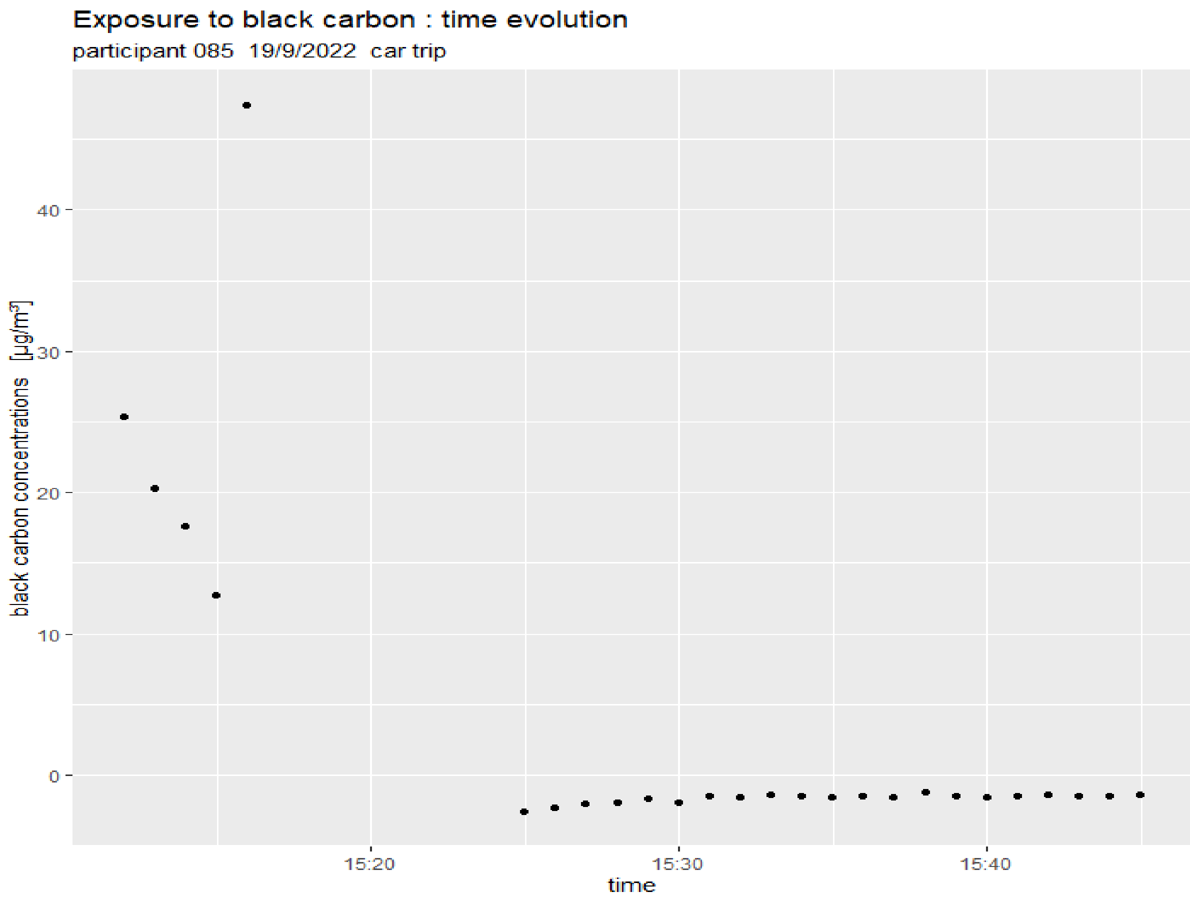

Figure 17.8.19 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

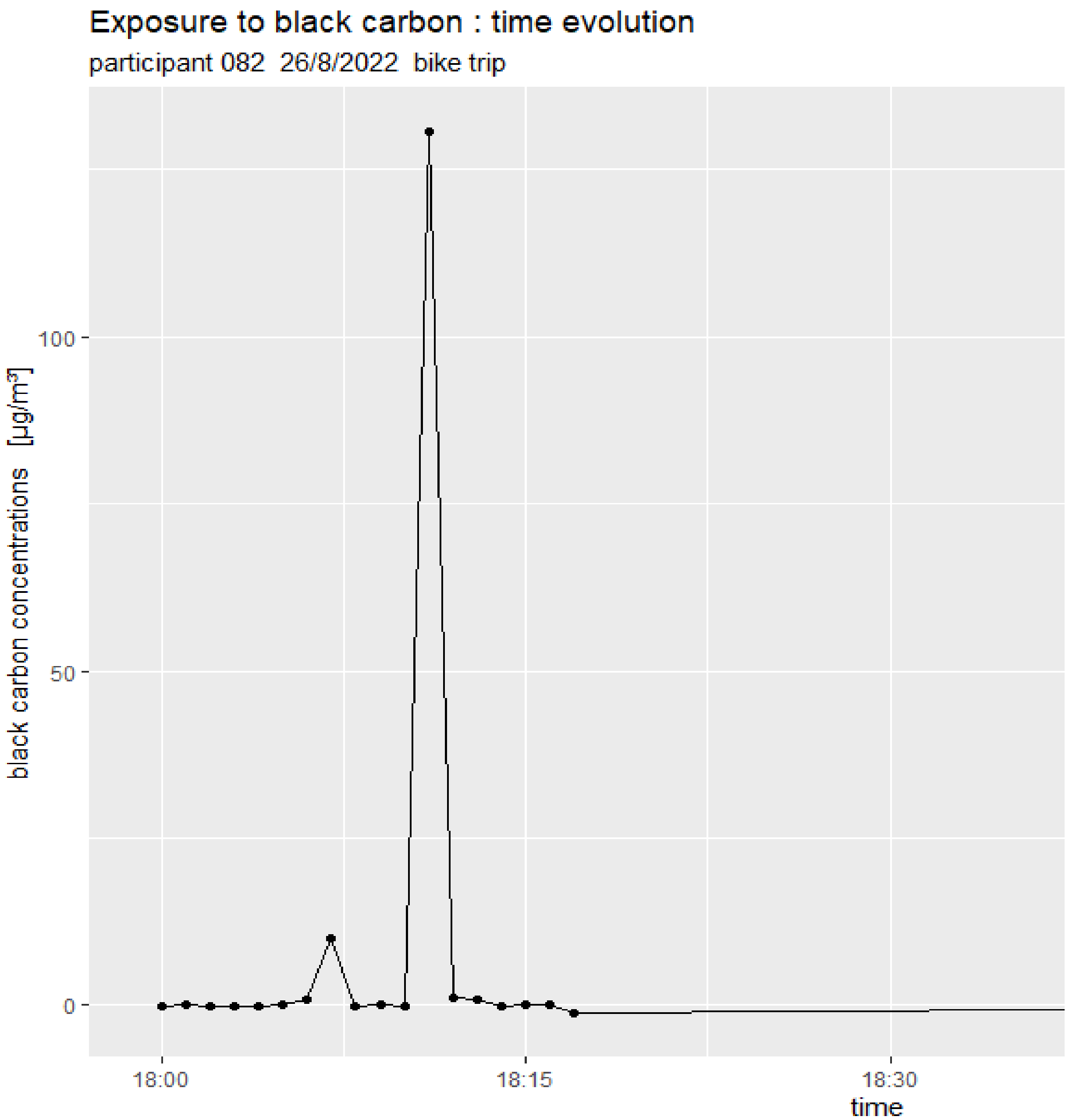

Figure 17.8.20 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

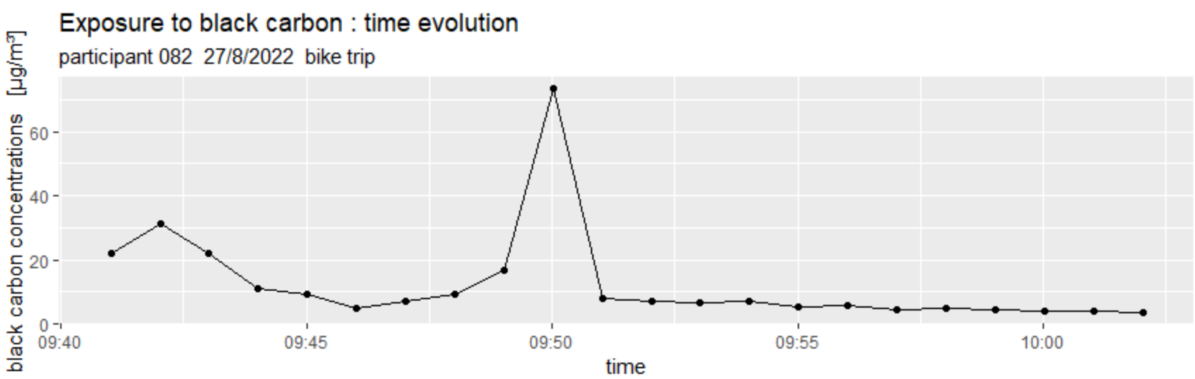

Figure 17.8.21 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

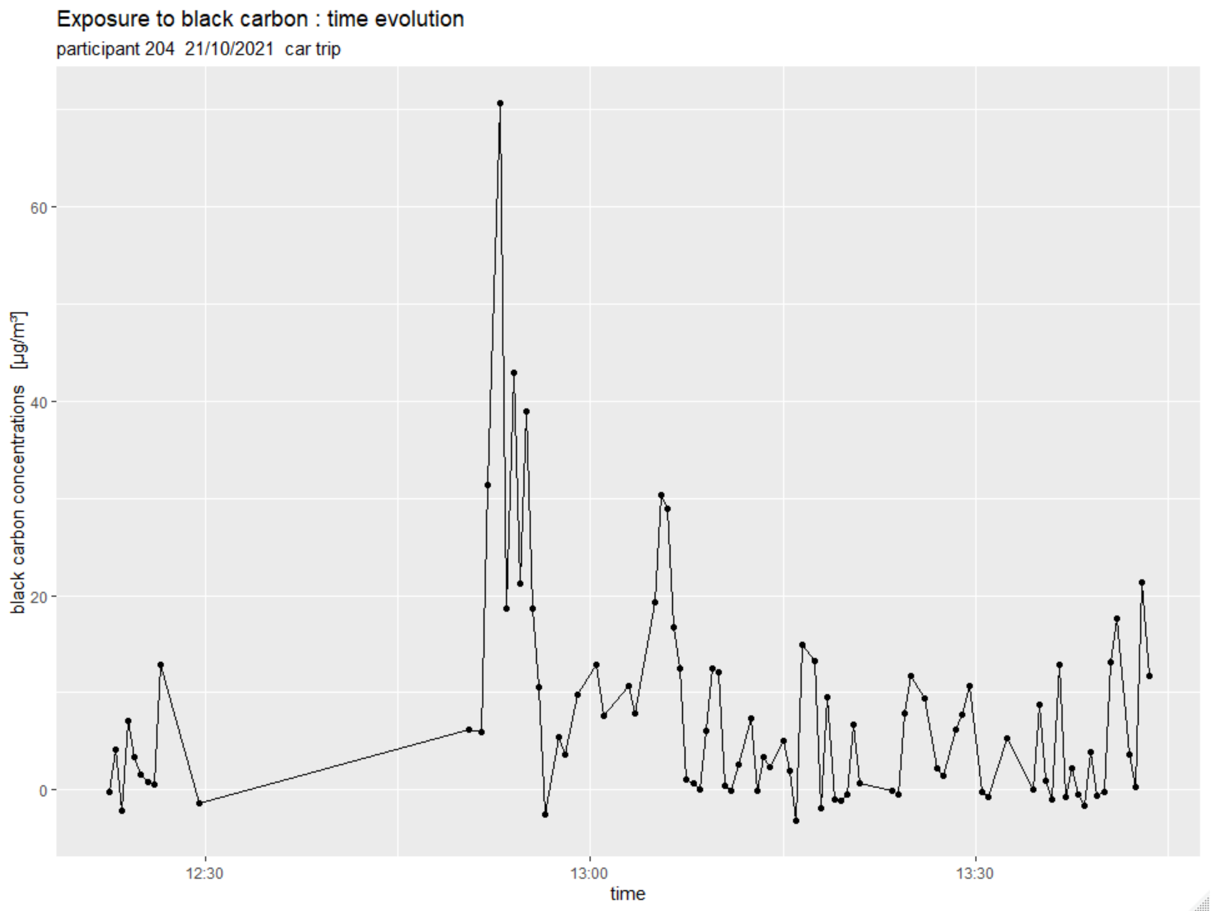

Figure 17.8.22 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

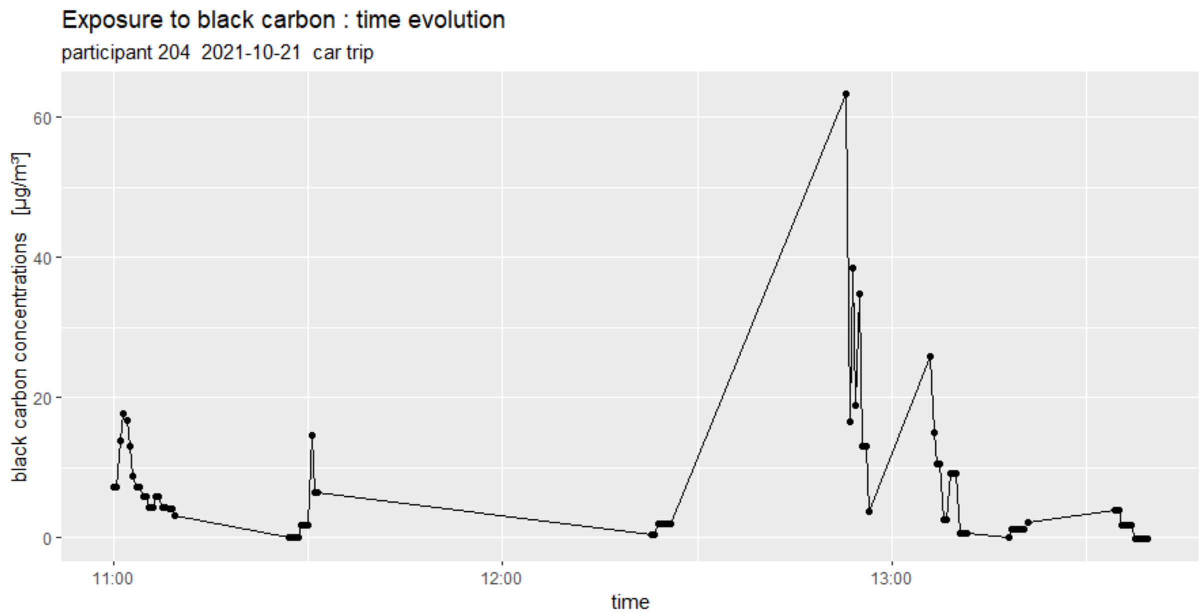

Figure 17.8.23 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

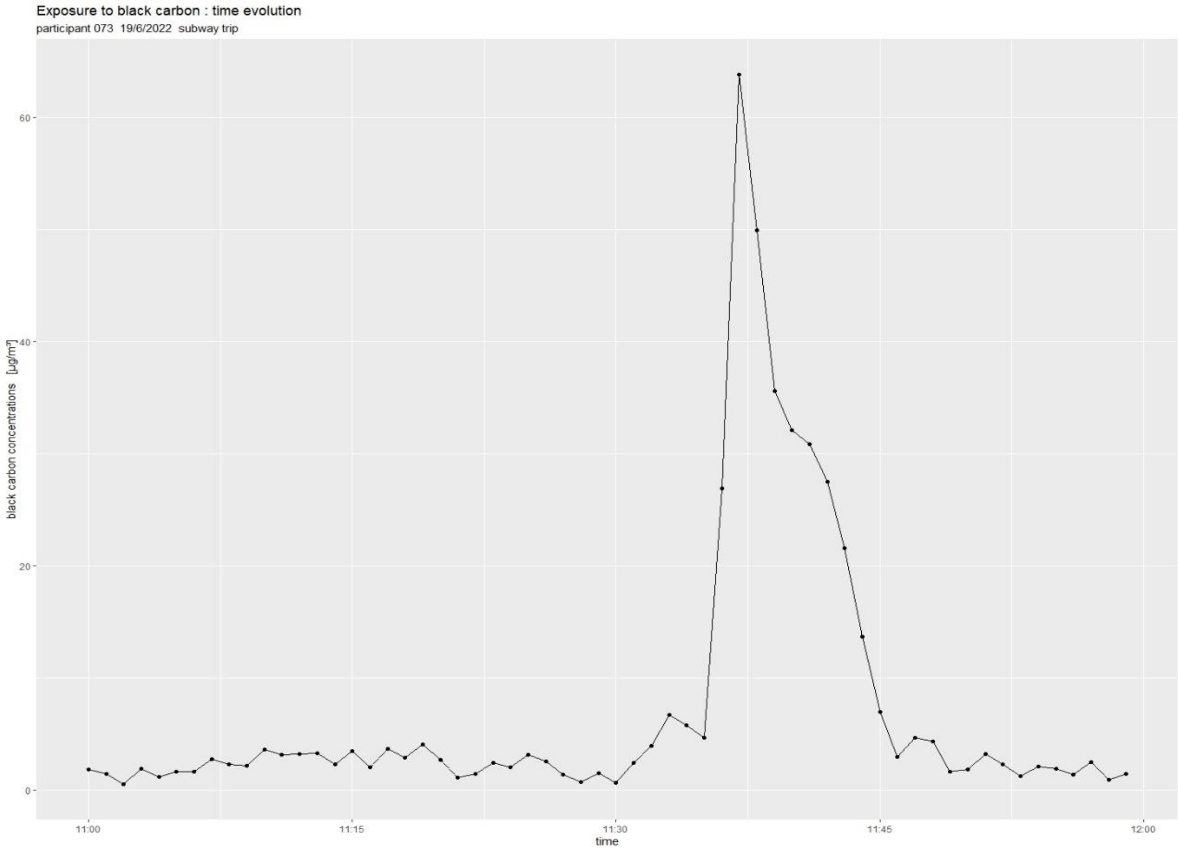

Figure 17.8.24 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

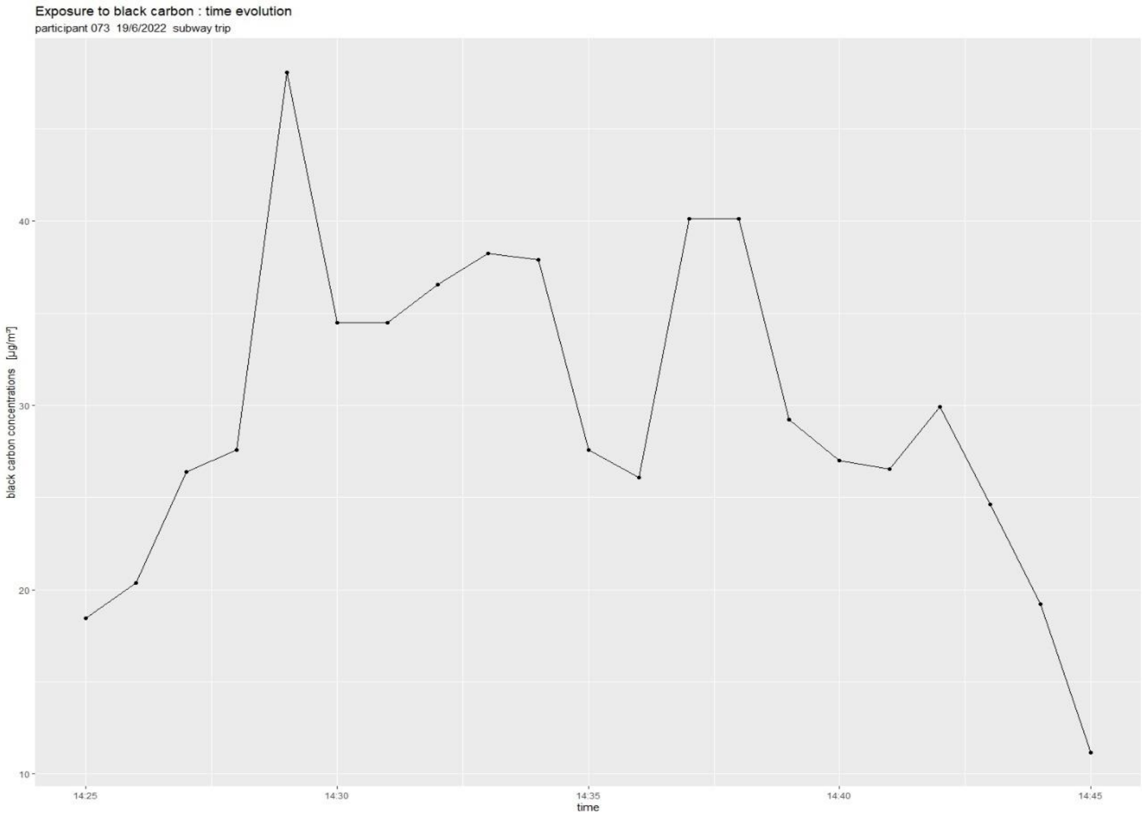

Figure 17.8.25 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

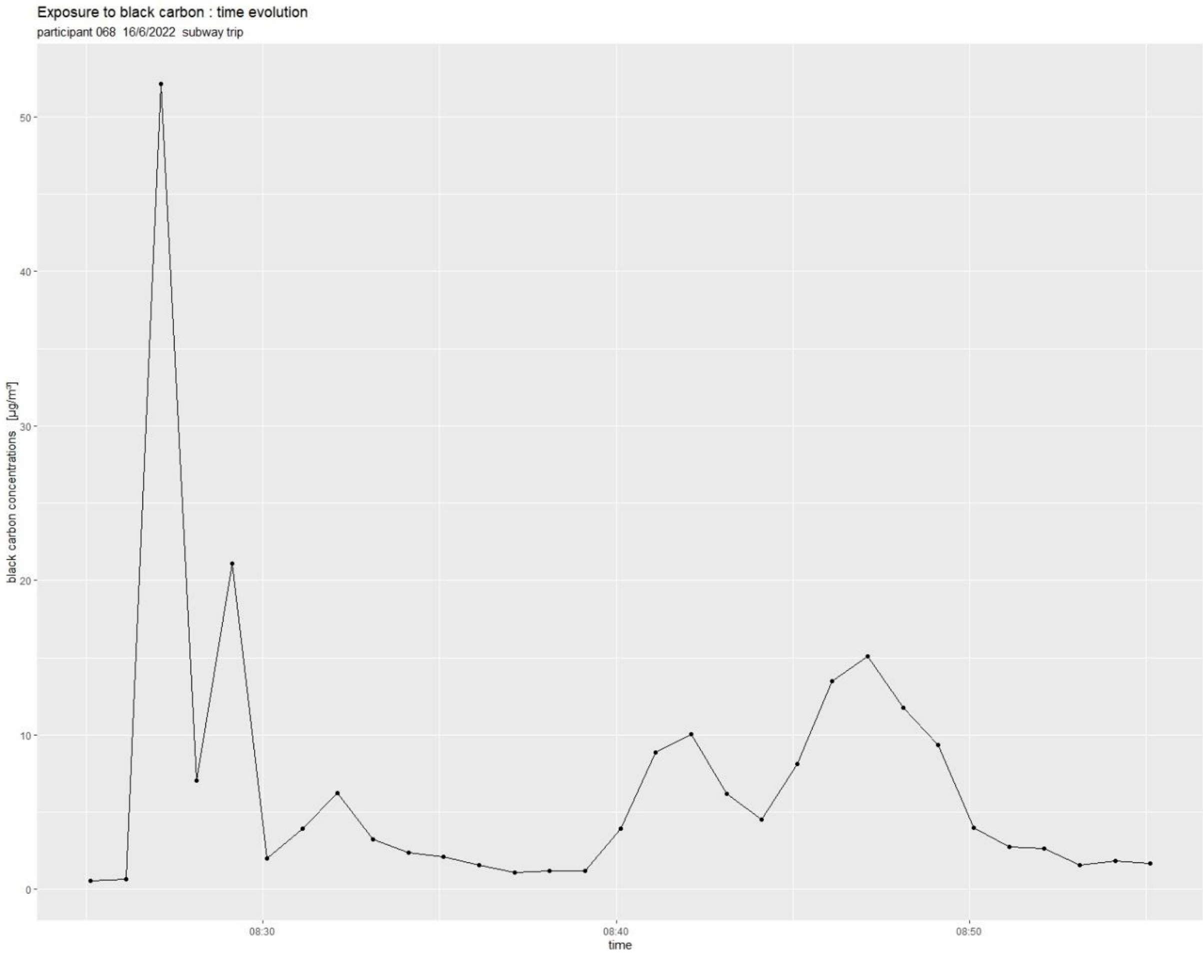

Figure 17.8.26 : Identification of positive outliers on black carbon concentrations time series from a participant's trip.

17.9. User logbooks

17.9.1. Paper logbook

EUROPEAN UNION
European Regional Development Fund

Cairgo bike : carnet de bord (black carbon)

Cairgo bike : logboek (black carbon)

CARNET DE BORD POUR LES MESURES DE BLACK CARBON

Nom : ………………………………… Prénom : ………………………………………

Tout au long de la journée, veuillez compléter dans le tableau suivant **les heures de début de chaque activité ou de chaque trajet**.

S'il s'agit d'un **trajet**, veuillez indiquer l'heure de début et le **mode de transport utilisé** (tram, métro, bus, voiture, à pied, vélo, vélo cargo, etc). Veuillez également préciser entre parenthèses le **mode que vous auriez utilisé (le mode habituel)** pour ce trajet si vous n'aviez pas participé au projet Cairgo bike et que vous n'aviez pas été informé du fait que des vélos cargos étaient disponibles pour sa réalisation. Dans la mesure du possible, en ce qui concerne les trajets effectués avec votre véhicule motorisé personnel, ainsi que ceux que vous auriez effectués de cette façon sans l'existence du projet (le mode habituel), il vous est demandé de **donner une estimation de l'intensité du trafic**, au moyen de l'échelle suivante reprenant l'intensité par ordre croissant : 0 / X / XX / XXX, où 0 signifie trafic libre (sans embouteillage) et XXX signifie trafic très chargé (avec des embouteillages importants).

S'il s'agit d'une **activité**, veuillez indiquer l'heure de début, **le lieu** et le **type d'activité** que vous effectuez (travail, courses, cuisine, pratique d'un sport, bricolage, etc). Cela nous permettra d'étudier les habitudes de modes transport employés en fonction du type d'activité réalisée. Veuillez également préciser s'il s'agit d'une activité en **intérieure ou extérieure**.

Attention, il est important qu'une séquence de différents déplacements combinés (trip chaining) ne soit pas reportée comme un simple trajet mais comme une suite d'activités avec des trajets entre chaque activité. Si vous vous rendez de votre lieu de travail à votre domicile et que vous faites des courses entretemps, veuillez donc mentionner cela en deux déplacements, à savoir 1) lieu de travail → magasin et 2) magasin → domicile.

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Afin de vous faire gagner du temps, nous suggérons que vous mentionniez ci-dessous **les lieux les plus fréquents** vers lesquels vous vous déplacez avec leur adresse, en les associant chacun à une lettre, de façon à pouvoir ne mentionner que ces lettres dans le tableau lorsque ces lieux sont concernés.

A : mon domicile (ex. : Rue de la Gare 56, Schaerbeek) :
B : mon lieu de travail (ex. : Rue de la Loi 16, Bruxelles) :
C : l'école de mes enfants (ex. : Av. Annie Cordy 15, Molenbeek) :
D : ….

Dans le but de pouvoir modéliser de façon précise, nous souhaiterions également que vous précisiez **chaque type de moyen de transport motorisé**, lorsque cela vous concerne (pe. votre voiture, votre moto). Ainsi, nous avons besoin de disposer des renseignements mentionnés sur la carte grise de votre (vos) véhicule(s). De la même façon que pour les lettres que vous employez pour vos destinations les plus fréquentes, nous vous invitons à réutiliser ces chiffres pur y faire référence dans le tableau.

Véhicule 1

- Catégorie (J) : ….
- Carburant (P.3) : ….
- Classe environnementale (V.9) : ….

Véhicule 2

- Catégorie (J) : ….
- Carburant (P.3) : ….
- Classe environnementale (V.9) : ….


C.9. N° titulaire: [redacted] N° BCE du titulaire: [redacted]

Z.1. Numéro national compagnie d'assurance: 00097

Identification du véhicule et caractéristiques techniques
D.1. Marque: [redacted] D.3. [redacted]
D.2.1. Type: U*****
D.2.2. Variante: UD9HR*
D.2.3. Version: UD9HR8/1
E. NIV: [redacted] E.1. Code: 463
F.1. Masse maximale techn.admissible: 2050 kg F.2. Masse maximale admissible nationale: ***** kg
G. Masse en ordre de marche: 1626 kg
J. Catégorie véhicule: M1
J.1. Genre national: BREAK
J.2. Type de carrosserie: AC BREAK
K. WVTA: e2*2001/116*0345*16 K.1. N° référence belge: ********
P.1. Cylindrée: 1560 cm³ P.2. Puissance: 82 kW P.3. Carburant: GASOIL
Q. Rapport puissance/poids: ***** kW/kg R. Couleur: Gris
S.1. Places assises y compris chauffeur: 5 S.2. Places debout: *** T. Vitesse maximale: 181 km/h
V.7. Emissions de CO2: 132 g/km V.9. Classe environnementale: Euro 5

Caractéristiques de l'immatriculation:
Immatriculation sous plaque Normale
Plaque attribuée le 27/06/2012

LOGBOEK VOOR METINGEN VAN BLACK CARBON

Naam : ……………………………… Voornaam : ……………………………………

Vul gedurende de hele dag de volgende tabel in met de begintijden van elke **activiteit of verplaatsing**.

Als het om een **verplaatsing** gaat, vermeld dan de begintijd en het gebruikte vervoermiddel (tram, metro, bus, auto, te voet, fiets, bakfiets, enz.). Gelieve tussen haakjes ook aan te geven **welke vervoerswijze u voor deze reis zou hebben** gebruikt **(de gebruikelijke vervoerswijze)** indien u niet had deelgenomen aan het Cairgo-fietsproject en niet op de hoogte was gebracht van het feit dat er bakfietsen ter beschikking waren. Telkens als u een verplaatsing uitvoert met uw eigen gemotoriseerd voertuig, alsook wanneer u de verplaatsing zou hebben uitgevoerd met uw eigen gemotoriseerd voertuig (de gebruikelijke vervoerswijze), verzoeken we u om ons een **inschatting te geven van de intensiteit of de drukte van het verkeer**. Gebruik hiervoor de volgende schaal : 0 / X / XX / XXX, waarbij 0 staat voor vrij verkeer (zonder file) en XXX voor zeer druk verkeer (met zware files).

Als het om een **activiteit** gaat, vermeld dan de **begintijd, de plaats en de soort activiteit** (werk, winkelen, koken, een sport beoefenen, doe-het-zelven, enz.) Dit zal ons in staat stellen de transportgewoonten te bestuderen naargelang de soort activiteit die wordt uitgeoefend. Geef ook aan of het om een binnen- of buitenactiviteit gaat.

Het is van belang dat een opeenvolging van verschillende gecombineerde verplaatsingen ("trip chaining") niet wordt gerapporteerd als één enkele verplaatsing, maar als een opeenvolging van activiteiten met verplaatsingen tussen elke activiteit. Indien u bv. van uw werk naar huis rijdt en onderweg boodschappen doet, dient u dit op te splitsen in twee verplaatsingen, zijnde 1) werk → winkel en 2) winkel → thuis.

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Om tijd te besparen, stellen wij voor dat u hieronder **de locaties vermeldt, die u het vaakst aandoet met de daarbij horende adressen**. U associeert elke plaats met een letter, zodat u in de tabel alleen deze letters dient te vermelden wanneer het om deze plaatsen gaat.
A : thuis (vb. : Stationsstraat 56, Schaarbeek)
B: mijn plaats van tewerkstelling (vb. : Wetstraat 16, Brussel)
C: de school van mijn kinderen (vb. : Annie Cordylaan 15, Molenbeek)
D: ………..

Om nauwkeurige berekeningen uit te kunnen voeren, dienen we voor elke verplaatsing te weten **met welk type gemotoriseerd voertuig** u zich verplaatst. Dit geldt enkel voor de verplaatsingen met gemotoriseerde voertuigen die in uw bezit zijn (bv. uw eigen auto(s), uw motorfiets). We zouden dus graag u informatie hierover ontvangen, zoals vermeld op het inschrijvingsdocument van uw voertuig(en). Net zoals naar de adressen die u het vaakst aandoet verwijst met een letter, verwijst u naar het gemotoriseerde voertuig met het corresponderende cijfer.

Voertuig 1
- Categorie (J): ....
- Brandstof (P.3): ....
- Milieuklasse (V.9): …

Voertuig 2
- Categorie (J): ....
- Brandstof (P.3): ....
- Milieuklasse (V.9): ...


C.9. Identificatie houder: [redacted] Expeditiecode: [redacted]
Z.1. Nationaal codenummer verzekeringsmaatschappij: [redacted]

Identificatie van het voertuig en technische kenmerken
D.1 Merk: [redacted] D.3. [redacted]
D.2.1. Fabriekstype: 6J
D.2.2. Variant: SCCFWAX0
D.2.3. Versie: SGNFM52R0317MGGI
E VIN: [redacted] E.1. Code: 593
F.1 Tech. toelaatbare maximummassa: 1586 kg G Massa in rijklare toestand: 1135 kg
J Voertuigcategorie: M1
J.1. Nationale Aard: VOERTUIG MEERDERE DOELEINDEN (AF)
J.2. Koetswerktype: VOERTUIG MEERDERE DOELEINDEN (AF)
K WVTA: e9*2001/116*0067*18 K.1. Belg referentienr.: ********
P.1. Motorinhoud: 1199 cm³ P.2. Motorvermogen: 55 kW P.3. Brandstof: DIESEL
Q Verhouding vermogen/gewicht: ***** kW/kg R Kleur: GRIJS
S.1 Zitplaatsen bestuurder inbegrepen: 5 S.2 Staanplaatsen: ** T Maximum snelheid: 168 km/h
V.7. CO2-uitstoot: 99 g/km V.9. Milieuklasse: EURO 5

Inschrijving onder commerciële kentekenplaat
Plaat: *************** Aard: *************************************

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Exemple :

Heure de début ***Startuur***	**Activité** ***Activiteit***	**Lieu** ***Plaats***	**Intérieur (V) Extérieur (X)** ***Binnen (V) Buiten (X)***	**Mode de transport** (indiquez le mode habituel entre parenthèses et l'intensité du trafic pour les trajets motorisés) **Vervoermiddel** (geef de gebruikelijke vervoerswijze tussen haakjes aan en de intensiteit van het verkeer voor de gemotoriseerde trajecten)
8h15	Petit-déjeuner avant départ	A	V	-
8h30	-	-	-	Trajet en vélo cargo (avec véhicule 1 ; XXX)
8h50	Travail	B	V	-
11h30	-	-	-	Trajet à pied
12h00	Restaurant	Rue de l'église 3 à Evere	V	-
13h00	-	-	-	Trajet à pied
13h45	Visite chantier	Adresse du chantier	X	-

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Heure de début ***Startuur***	**Activité** ***Activiteit***	**Lieu** ***Plaats***	**Intérieur (V) Extérieur (X)** ***Binnen (V) Buiten (X)***	**Mode de transport** (indiquez le mode habituel entre parenthèses et l'intensité du trafic pour les trajets motorisés) **Vervoermiddel** (geef de gebruikelijke vervoerswijze tussen haakjes aan en de intensiteit van het verkeer voor de gemotoriseerde trajecten)
15h30	-	-		Trajet à pied
15h45	Récupération du vélo-cargo au travail	B	X	-
16h00	-	-	-	Trajet en vélo cargo (avec véhicule 1 ; XX)
16h30	Aller chercher les enfants à l'école	C	X	-
17h00	-	-	-	Trajet en vélo cargo (avec véhicule 1 ; XXX)
17h05	Retour à la maison	A	V	-
17h30	-	-	-	Trajet en vélo cargo (à pied)

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Heure de début ***Startuur***	**Activité** ***Activiteit***	**Lieu** ***Plaats***	**Intérieur (V) Extérieur (X)** ***Binnen (V) Buiten (X)***	**Mode de transport** (indiquez le mode habituel entre parenthèses et l'intensité du trafic pour les trajets motorisés) **Vervoermiddel** (geef de gebruikelijke vervoerswijze tussen haakjes aan en de intensiteit van het verkeer voor de gemotoriseerde trajecten)
17h45	Promenade	Bois du Laerbeek	X	-
18h30	-	-	-	Trajet en vélo cargo (à pied)
18h40	Courses	CARREFOUR MARKET, av des anciens combattants à Evere	V	-
19h00	-	-	-	Trajet en vélo cargo (à pied)
19h10	Soirée à la maison	A	V	-

Avez-vous rencontré des difficultés lors de cette journée ?

L'appareil s'éteint tout seul car oubli de recharger la batterie le soir. Projection d'eau. Impossibilité de bien stabiliser l'appareil durant un trajet à vélo.

CAIRGO BIKE

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17.9.2. Online logbook

Are you recording this trip for a past day ? Then, please indicate the day you did this trip. As much as possible, please choose this option only if you remember well the data of tris trip.

- ○ no
- ○ yes (please mention a date)

Departure address : please state the exact address.

- ○ A : home
- ○ B: workplace
- ○ C: school
- ○ D: nursery
- ○ E: sport, leisure
- ○ other : exact address

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Destination address

◯ A : home

◯ B : workplace

◯ C: school

◯ D: nursery

◯ E: sport, leisure

◯ other : please mention the exact address

Departure time (please write this way : 10:00)

bv. / p.e. 20:15

Arrival time (please write this way : 10:00)

bv. / p.e. 20:15

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Please mention the means of transport you are using for this trip.

- ○ by foot
- ○ traditional / electric bike
- ○ cargo bike / longtail
- ○ vehicle 1
- ○ vehicle 2
- ○ vehicle 3
- ○ shared car (Cambio, Poppy,...)
- ○ bus
- ○ tram
- ○ metro
- ○ train
- ○ motorcycle
- ○ other : please mention the means of transport

Please mention the means of transport you would have used if you had not participated in the Cairgo bike project and if you did not have a cargo bike.

- ○ by foot
- ○ traditional / electric bike
- ○ vehicle 1
- ○ vehicule 2
- ○ vehicle 3
- ○ shared car (Cambio, Poppy,...)
- ○ bus
- ○ tram
- ○ metro
- ○ train
- ○ motorcycle
- ○ andere: geef aan

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Please give an assessment of the traffic intensity: 1 = free traffic, 10 = stationary traffic with long queue.

What was the purpose of the trip ? What did you do once you arrived at your destination ?

- ◯ back home
- ◯ shopping
- ◯ work place
- ◯ drop off / picking up the children
- ◯ sport recreation
- ◯ do-it-yourself shop
- ◯ other (please mention the activity)

Is the activity you are travelling for indoors or outdoors ? Does the aethalometer measure indoor or outdoor air concentrations during this activity ?

- ◯ outdoor
- ◯ indoor

Do you have any comments about this route ?

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17.10. Code script relative to the detection of the displacement moments

```r
# We process the raw GPS data
gps_raw <- gps_raw %>%
  select(-index) %>%
  mutate_at(vars(date1, date2), list(~ parse_datetime(., "%d/%m/%Y"))) %>%
  mutate_at(vars(time1, time2), list(~ hms(.))) %>%
  # create a time variable computed with the date and time variables,
  mutate(Date1 = date1 + time1) %>%
  mutate(Date2 = date2 + time2) %>%
  # remove last . character in coordinates
  mutate_at(vars(lat, lon), list(~ as.numeric(stri_replace_last_fixed(., ".", "")))) %>%
  # filter temporary variables created, rename time variable as date and append the filename of origin
  select(-starts_with("date", ignore.case = FALSE), -starts_with("time", ignore.case = FALSE)) %>%
  relocate(starts_with(("Date")), .before = lat) %>%
  mutate(result = sqrt( (lag(lon) - lon)^2 + (lag(lat) - lat)^2) ) %>%
  # select variable for time averaging
  select(Date1, lon, lat, result) %>%
  rename(date = Date1) %>%
  # order by date
  arrange(date)
```

Figure 17.10.1 : Implementation of a calculation related to the changes of longitude and latitude values between two successive data points. This code was applied on the MA200 data. This code scripts enables to create a new column “result”, on which the start and end of trips are identified.

17.11. Individual reports : example of mapping of trips and recorded concentrations

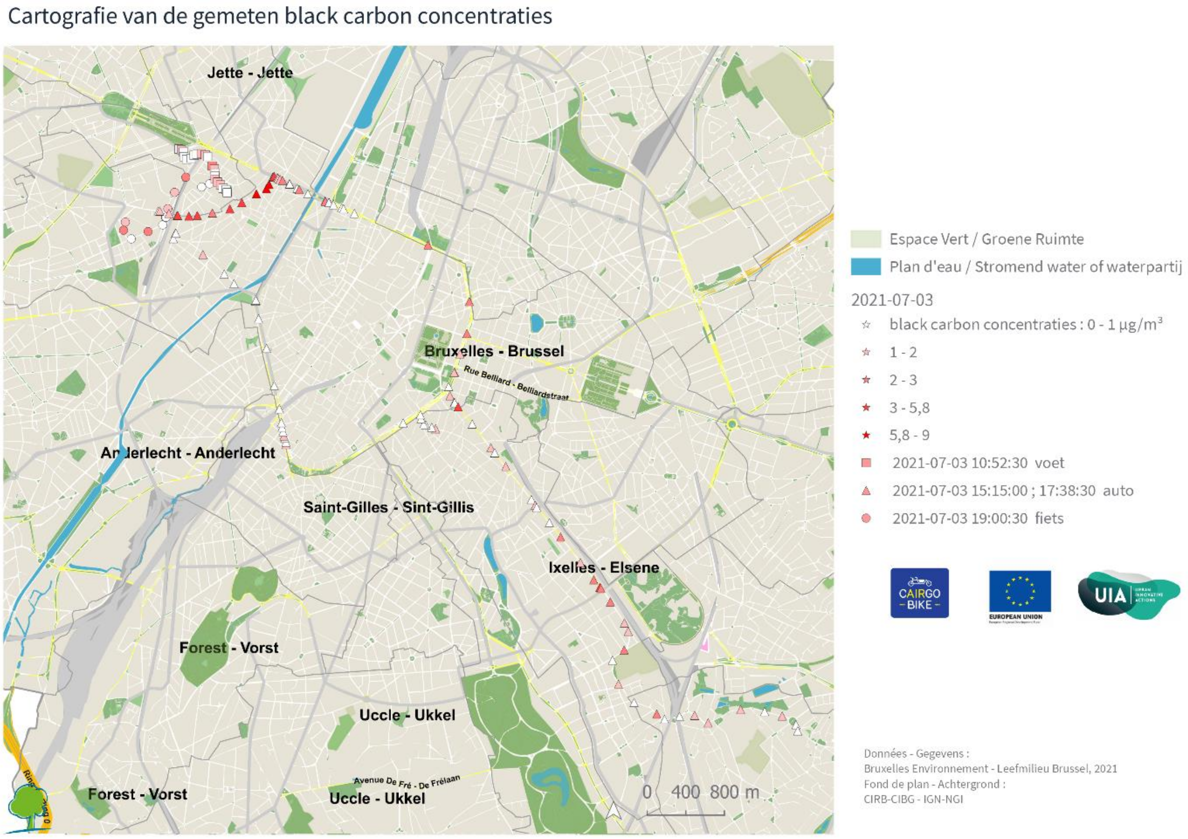

Figure 17.11.1 : Example of map that that accompanied the individual reports which were sent to the citizens who had have used an aethalometer. Several trips were often shown on the same map and different symbols were chosen for each travel mode.

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17.12. General data concentrations from the Cairgo Bike project : data out of the Brussels area

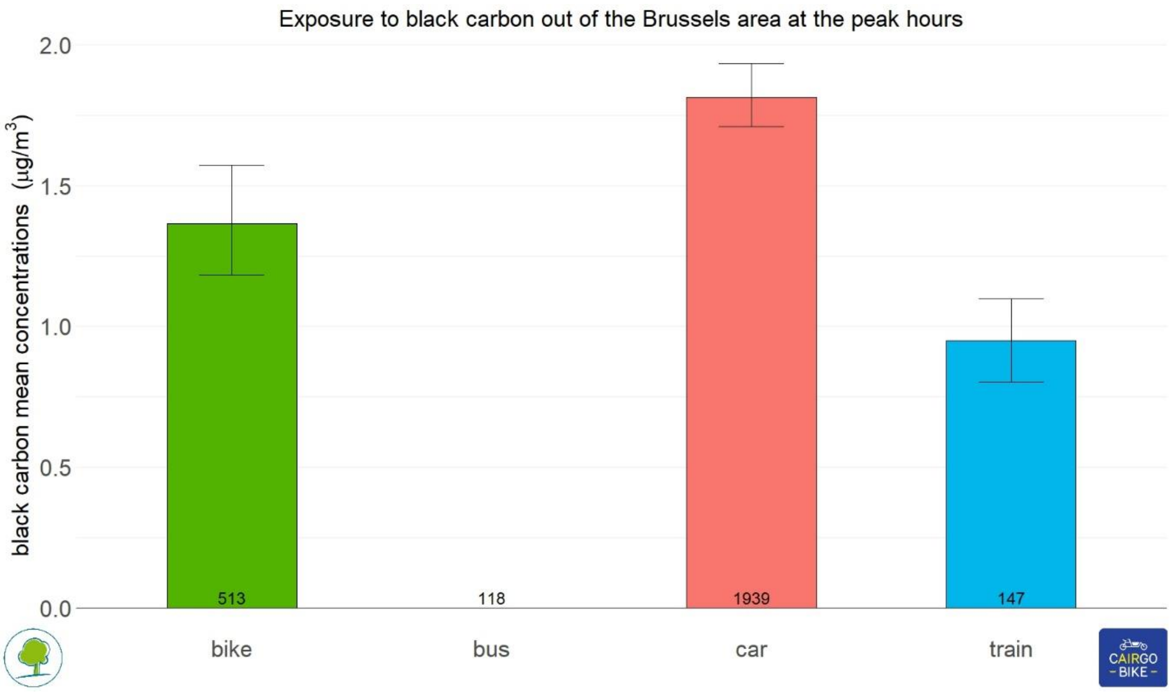

Figure 17.12.1 : Mean concentrations by transport mode from the whole data set of the participants' trips corresponding to all the measurement points that were collected out of the territory of the Brussels area in the peak hours. The number which appears on each column is related to the measurement points that were taken into account to obtain the values. If less than 120 data points were collected, no column appears.

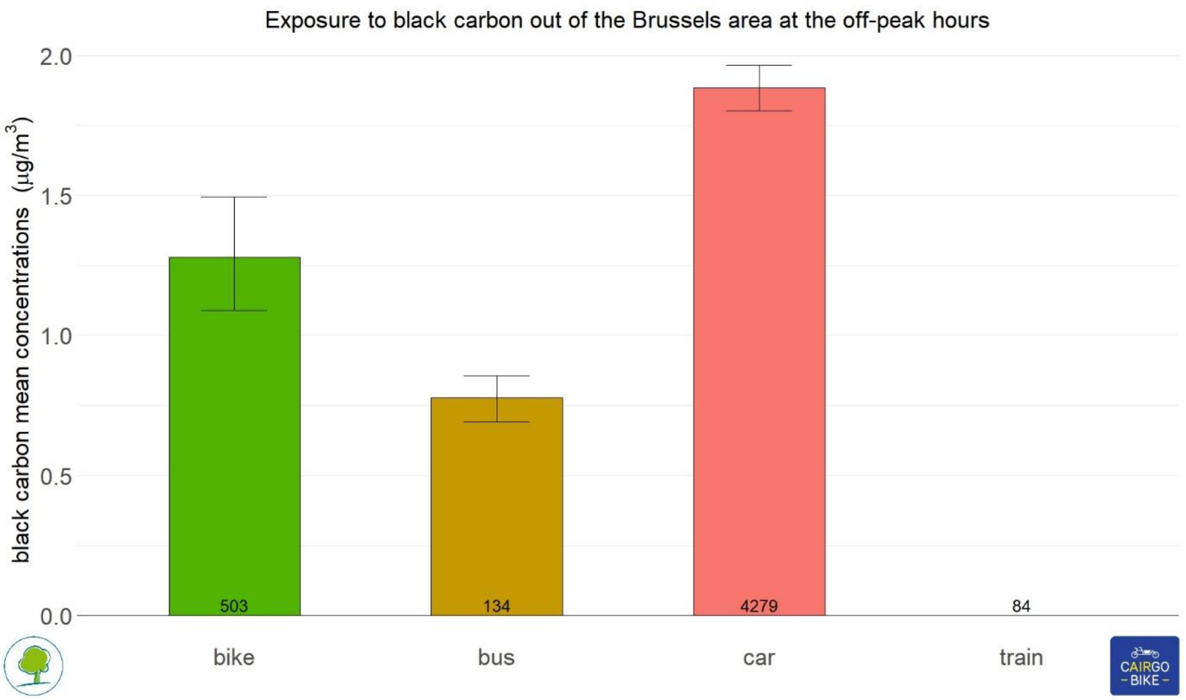

Figure 17.12.2 : Mean concentrations by transport mode from the whole data set of the participants' trips corresponding to all the measurement points that were collected out of the territory of the Brussels area in the off-peak hours. The number which appears on each column is related to the measurement points that were taken into account to obtain the values.

Transport mode	Complete data		Data from the peak hours		Data from the off-peak hours	
	BC [µg/m³]	n	BC [µg/m³]	n	BC [µg/m³]	n
bike	1.32 [1.19 – 1.48]	1016	1.36 [1.18 – 1.57]	513	1.28 [1.09 – 1.5]	503
bus	0.53 [0.47 – 0.6]	252	-	118	0.78 [0.69 – 0.86]	134
car	1.86 [1.79 – 1.94]	6218	1.81 [1.71 – 1.93]	1939	1.88 [1.8 – 1.97]	4279
train	1.65 [1.41 – 1.91]	231	0.95 [0.8 – 1.1]	147	-	84

Table 17.12.1 : Black carbon mean concentrations by transport mode, at the peak and the off-peak-hours and out of the Brussels area that were obtained after the whole data collection. The number "n" corresponds to the number of data points that were collected to get these values. As explained above, the data sets that include less than 120 data points were not taken into account.

17.13. Roadway ranking and cycling infrastructure

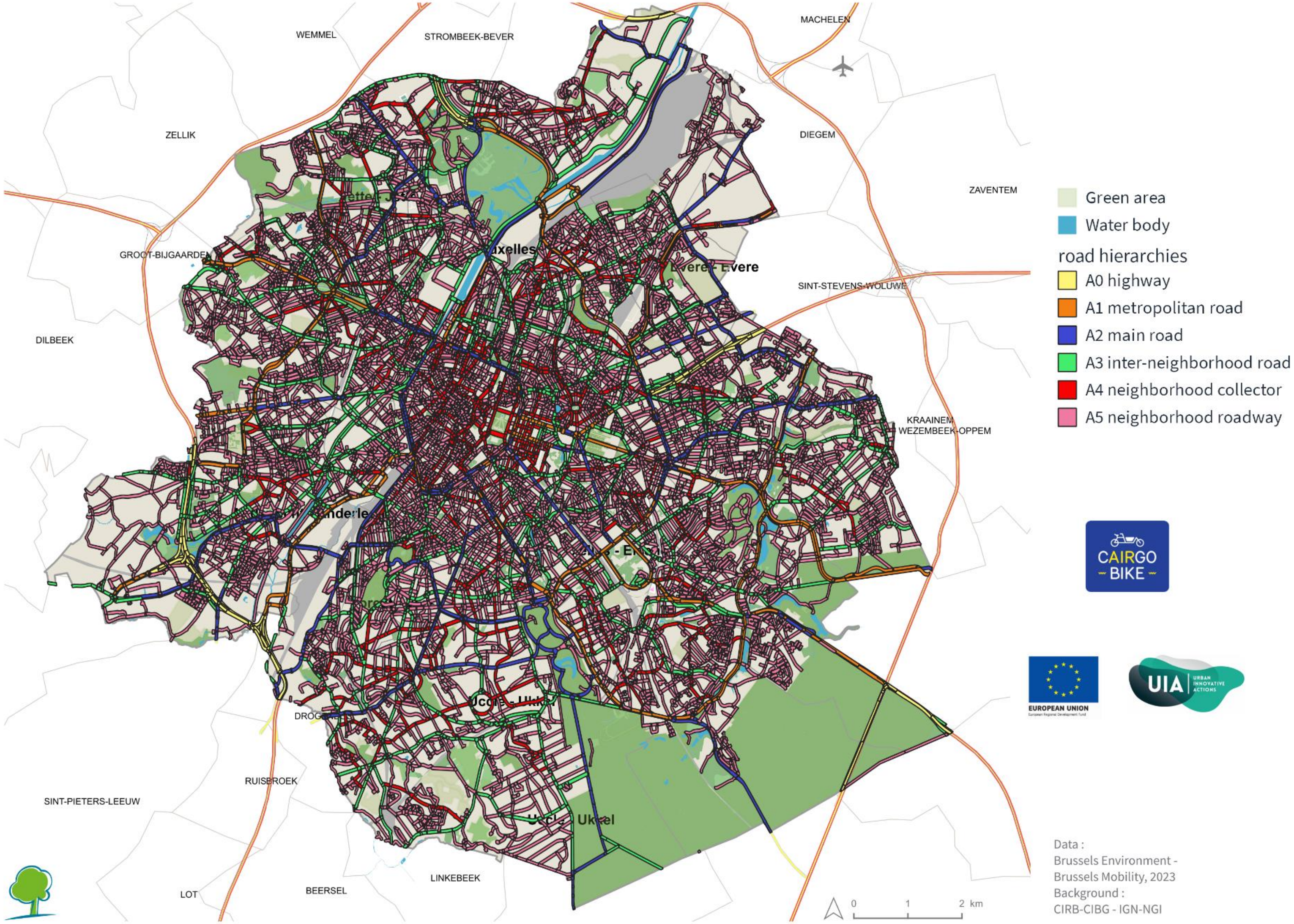

Figure 17.13.1 : Roadway ranking based on the hierarchy from the mobility project Iris 2. The different classes were defined in function with different parameters, such as the maximal speed, the intensity and the road width.

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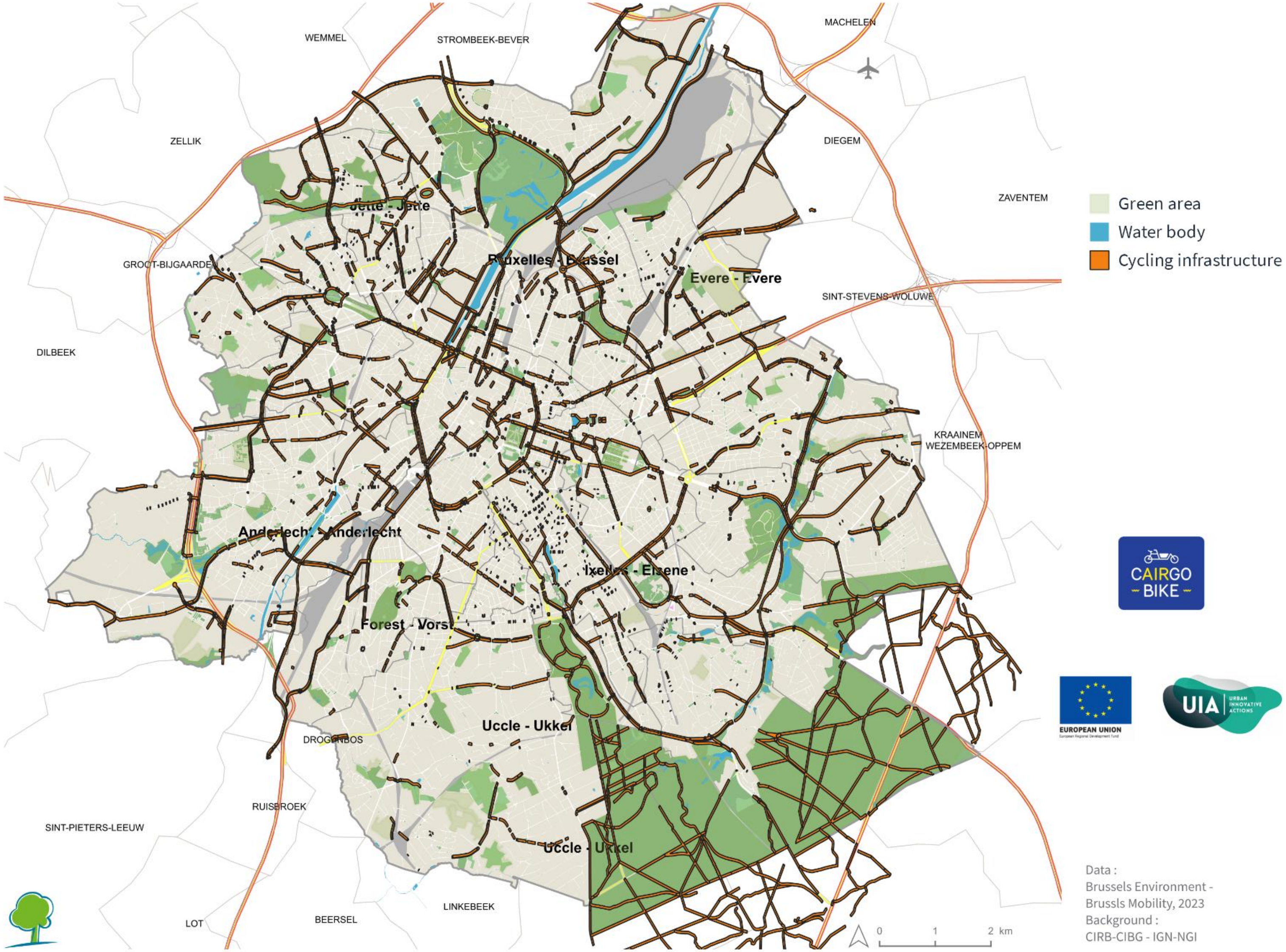

Figure 17.13.2 : Cycling infrastructure of the Brussels area. The GIS layer is not comprehensive but consists of the data that are processed and made available by the official government departments of the Capital Region Brussels Mobility. A buffer was applied to the GIS layer so that the segments are more visible at this scale, that is why the lines were transformed to polygons.

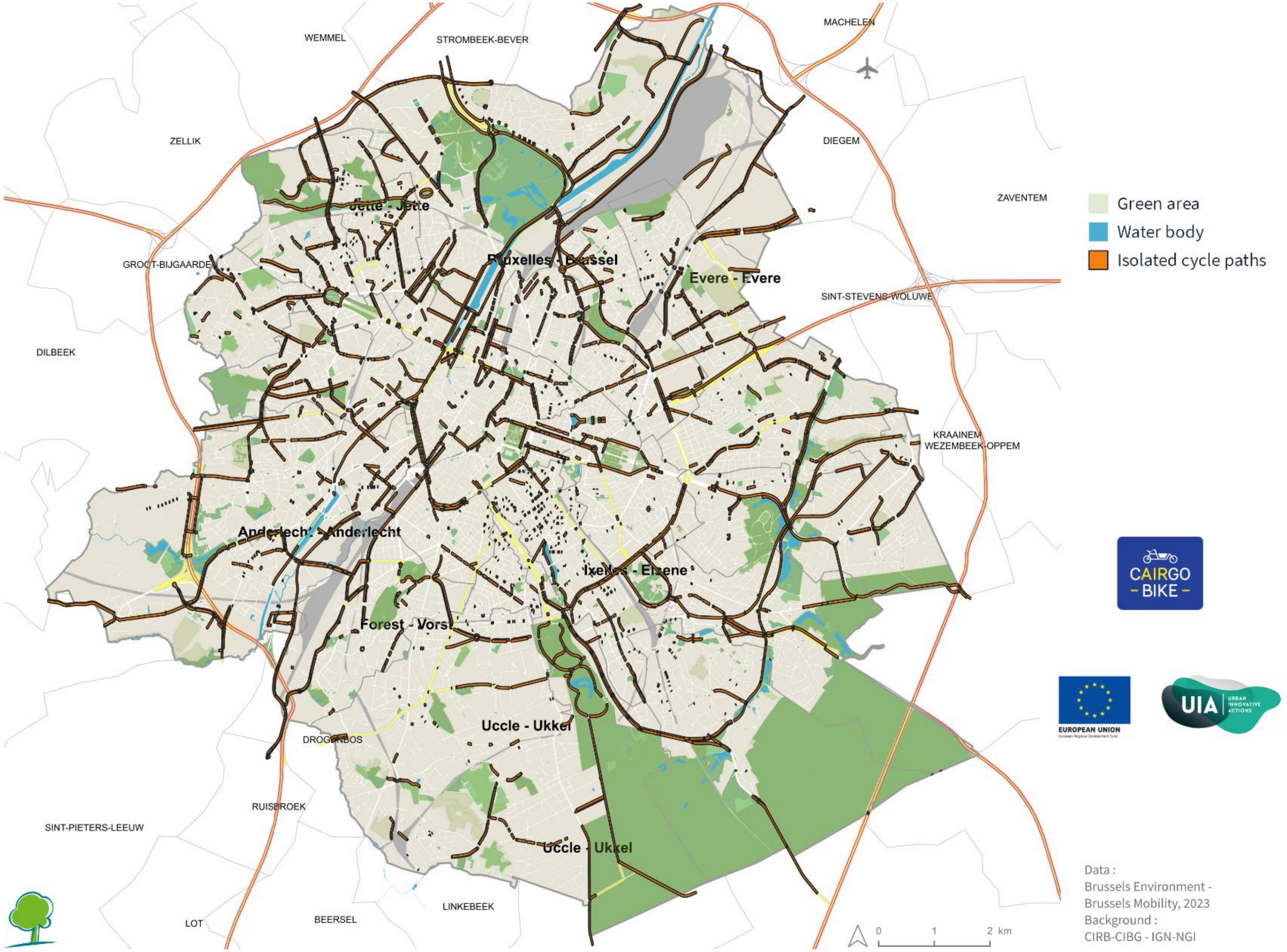

Figure 17.13.3 : Isolated cycle paths. The attributes values were selected from the previous GIS layer in order to make appear the segments that corresponded to real cycle paths that are isolated from motorised vehicles cars on the roadway. A buffer was applied to the GIS layer so that the segments are more visible at this scale, that is why the lines were transformed to polygons.

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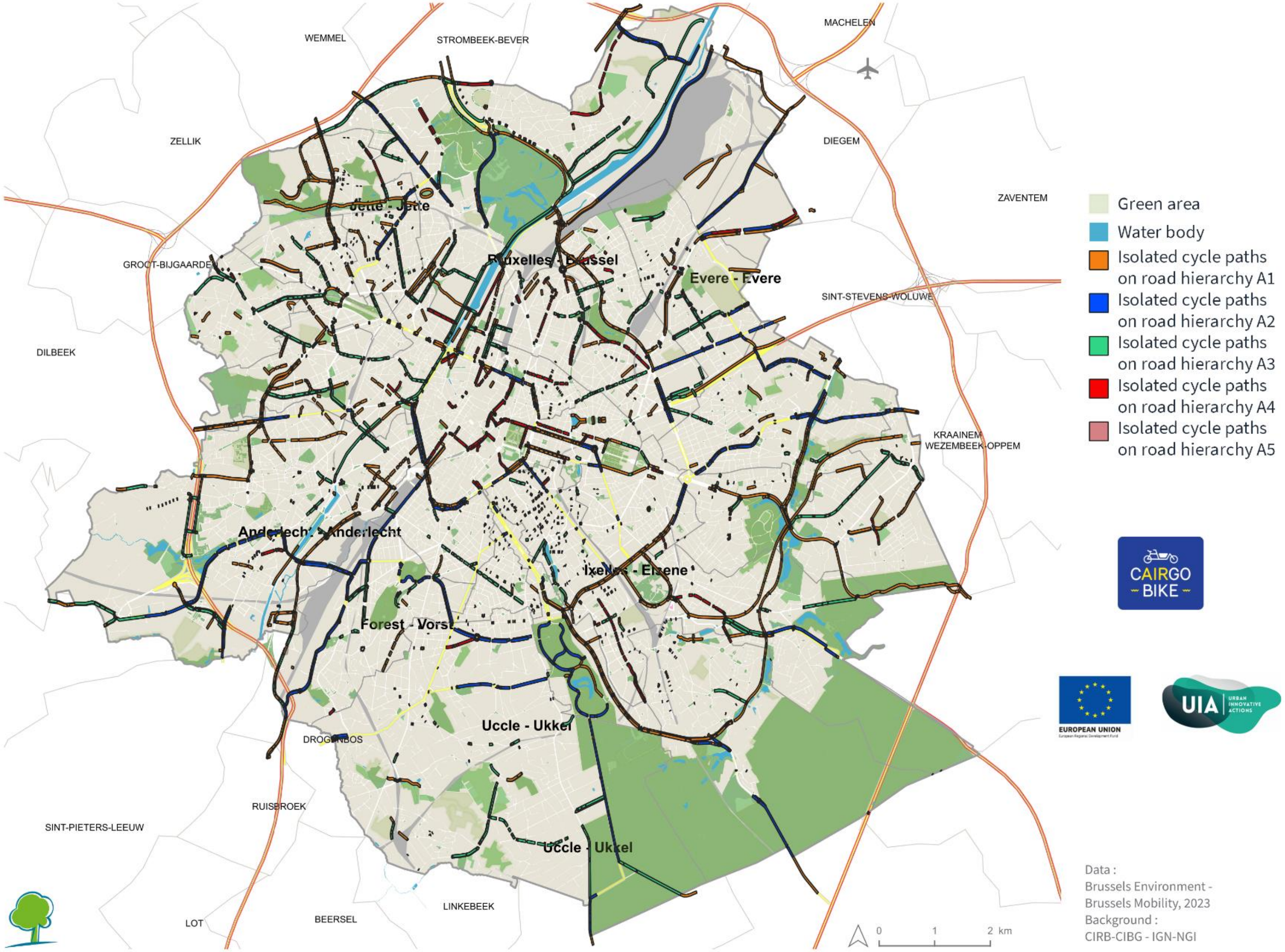

Figure 17.13.4 : Isolated cycle paths on road hierarchies A1, A2, A3, A4 and A5. The attributes values were selected from the previous GIS layer in order to make appear the segments that corresponded to real cycle paths that are isolated from motorised vehicles on the roadway. A buffer was applied to the GIS layer so that the segments are more visible at this scale, that is why the lines were transformed to polygons. The colour code is the same as the one of the figure 17.13.1.

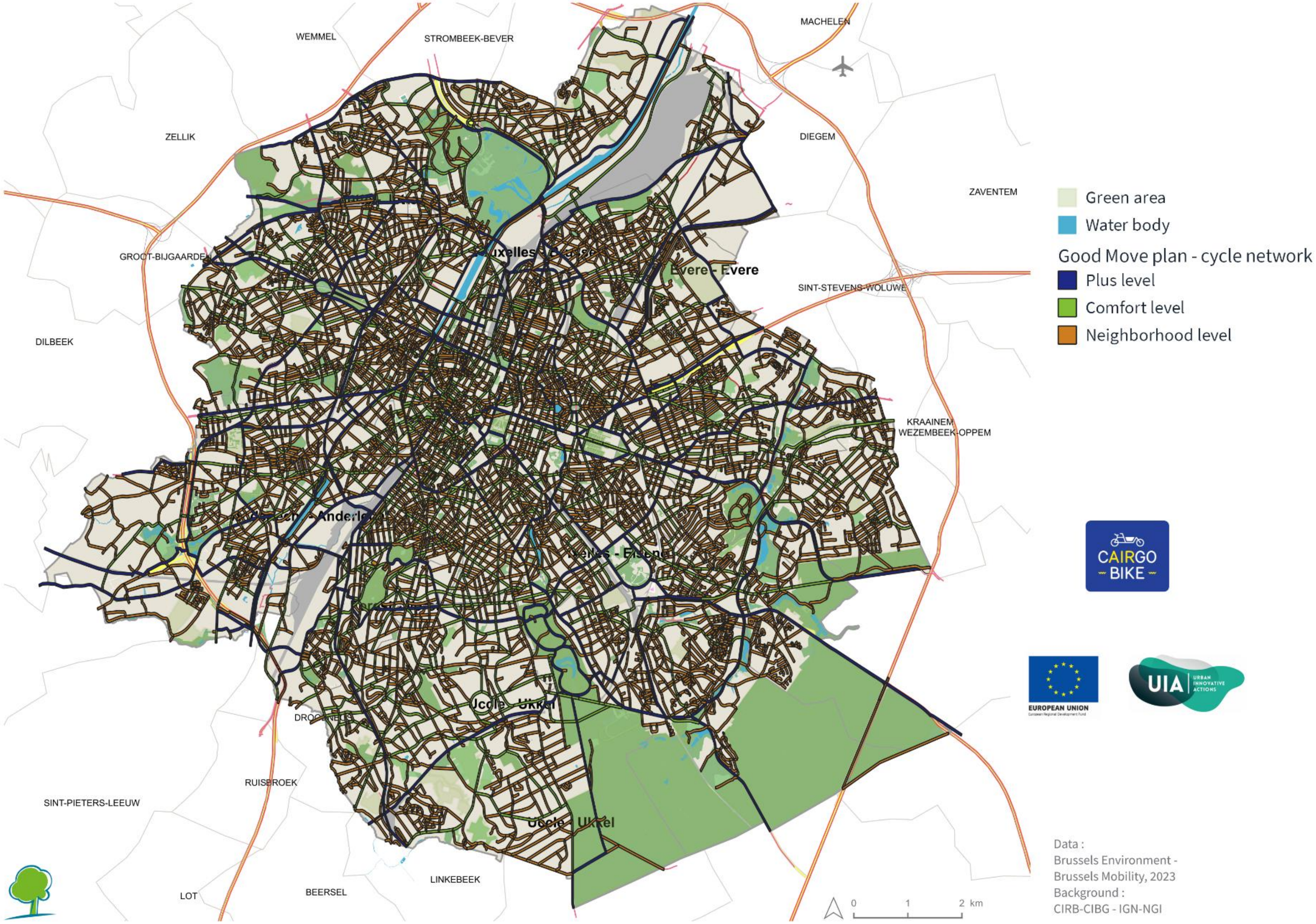

Figure 17.13.5 : Cycle network from the Good Move plan. A buffer was applied to the GIS layer so that the segments are more visible at this scale, that is why the lines were transformed to polygons.

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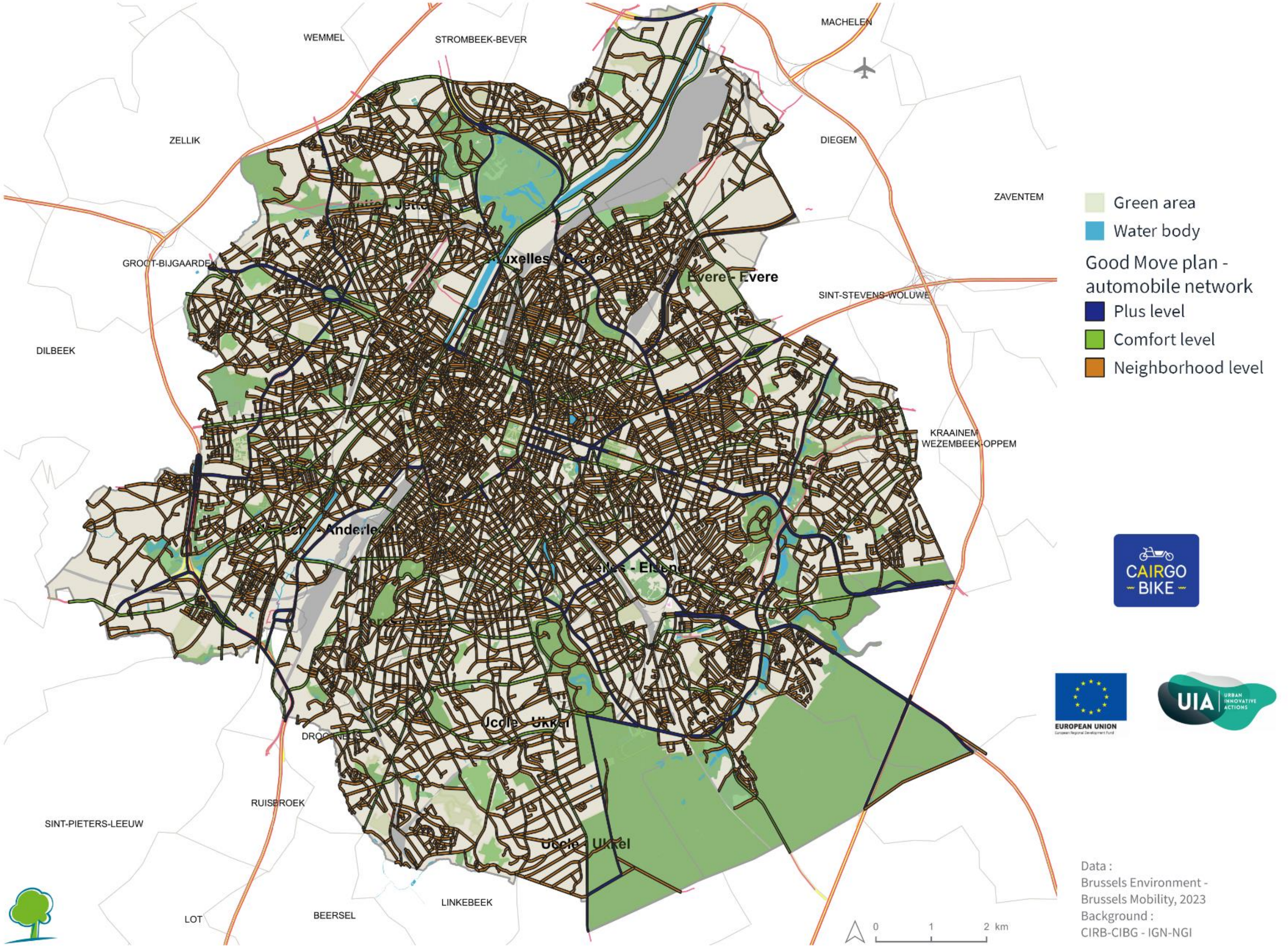

Figure 17.13.6 : Automobile network from the Good Move plan. A buffer was applied to the GIS layer so that the segments are more visible at this scale, that is why the lines were transformed to polygons.

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