Clean Air Action Days

Anti-Idling Campaign

Monitoring Report

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King's College London

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1. Summary

In March 2016, a major anti-idling campaign was conducted on two consecutive weeks at locations across London. As part of the campaign, air quality monitoring was undertaken to assess the impact of the action.

The analysis investigated the frequency and magnitude of black carbon peaks in the top 10% of the measurements as indicators of idling events and compared non-action days to action days.

The results indicate that anti-idling action may be more effective at some locations than others. At suitable locations however, the study showed a 20-30% reduction in peak concentrations on action days compared to non-action days.

2. Background

On March 9th and 16th 2016, Cross River Partnership's Clean Air Better Business partners, working in conjunction with Global Action Plan, conducted a major anti-idling campaign across the capital to raise awareness of air pollution and in particular the impact that idling can have on local air quality.

On these action days, teams of trained volunteers, recruited via boroughs and Business Improvement Districts, approached drivers of parked vehicles between 8-10am at multiple locations across London to engage drivers in a positive way and to ask them to switch their engines off.

Over the two action days, hundreds of drivers were engaged and the project reached almost 4 million people online.

Whilst projects such as these can be effective at raising awareness and promoting behaviour change, there are limited studies which attempt to measure the impact that anti-idling campaigns have on local air quality.

3. Aims

This project aimed to measure and evaluate the effect of anti-idling actions on local air quality compared to non-action days.

4. Method

The monitoring method involved using small sensors to measure concentrations of black carbon (a component of $PM_{2.5}$ particulate pollution associated with diesel exhaust emissions) at four locations during the 8-10 am action timeframe and during the same period on the preceding day.

4.1 Sampling strategy

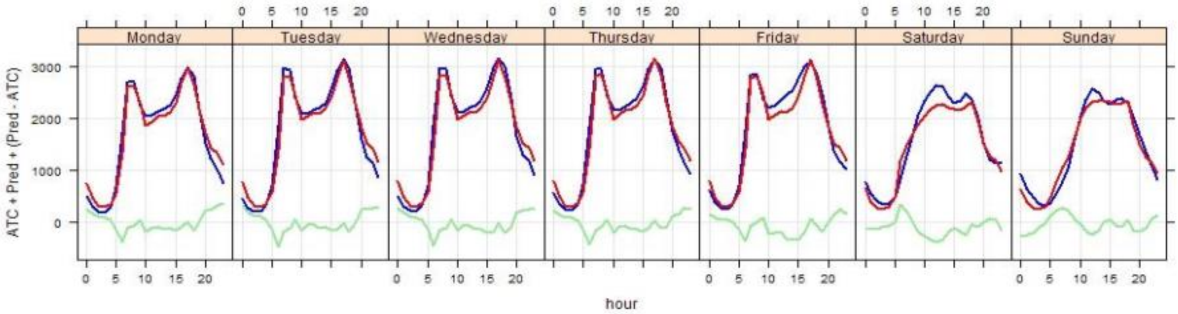
In order to assess the impact of the anti-idling action, it was necessary to measure at the locations on non-action days for comparison.

Wednesdays were chosen as the action days as being representative of a mid-week morning in terms of delivery and transport activities.

The 8-10 am timeframe was selected as a period of the day when deliveries to shops and offices and transport pick-ups and drop offs are frequent thus maximising the opportunity to detect a signal from idling vehicles.

Research by King's for Defra indicates average traffic flows on Tuesdays and Wednesdays are similar (Sean Beevers, 2009). Figure 1 below (from that report) shows average traffic flows by hour and day over the course of a week in London. Morning and evening rush hours are clearly visible on weekdays.

Figure 1 Diurnal traffic flows of typical week in London (2006 and 2007) (Sean Beevers, 2009)



Non-action day measurements were taken on the days preceding the action days in case the intervention action resulted in significant behaviour change by regular delivery drivers/parents on the subsequent day.

The campaign was run twice in consecutive weeks in mid-March 2016 both in order to increase the reach and size of the campaign and to increase the experimental data set.

4.2 Equipment

The monitors selected for this study were AethLabs microAeth AE51 (https://aethlabs.com/microaeth).

These instruments measure black carbon, a primary component of diesel exhaust particulate matter. They are small, reliable, portable and importantly can measure at high time frequencies. These characteristics made this instrument a good choice for this study where it was desirable to be able to position a small unobtrusive monitor as close as possible to the emission source and detect short-term peaks in concentration as indicators of idling events.

The microAeth works by drawing in ambient air at a set flow rate onto a small filter stip. As particulate accumulates on the filter, the instrument measures the rate of change in the absorption of light passing through the filter at 880nm. This rate of change in light absorption, combined with the flow rate is then expressed as a mass (ng) of black carbon (BC) per meter cubed of air (m^3).

The instruments were set to a standard flow rate of 100 ml of air per minute and 1 minute averaging. At these settings, the instrument has a precision of +/- 0.1 BC ug/m3 (AethLabs, 2016).

The instruments were sealed in a weatherproof box with an inlet at the bottom and tied to sign posts at each of the study locations at approximately 1m height between 6 am and 11 am on each of the study days (Figure 2). Only data between 8 am and 10 am from each of the instruments was used in the analysis.

Figure 2 Placement of microAeth fixed to sign pole in weather proof box

The Aethalometers used for the subtraction of background concentrations of black carbon from the measurement results is the Rack Mounted Aethalometer AE22 manufactured by Magee Scientific. The principal of operation is the same as the microAeth

4.3 Locations

Four locations were selected as being representative of different types of activity areas whilst also providing a spread across the city.

4.3.1 City of London (St Martin's Le Grand)

The City of London location was a coach bay used by private company coaches through the day. The bay was in use with idling buses on each morning during the study. St Martin's Le Grand runs North to South (Figure 2). The monitor was located on the Eastern side of the road on a sign post by the bay (Figure 3).

Figure 3 Map of City of London measurement location

Figure 4 Photo of City of London measurement location

4.3.2 West End (Great Marlborough Street)

The West End location was a parking bay outside 44, Great Marlborough Street. The road is lined with shops and offices and is generally busy throughout the day. The location was in use with early morning delivery vans on each day of the study. Great Marlborough Street runs East to West (Figure 4). The monitor was located on the South side of the street on a sign post. (Figure 5).

Figure 5 Map of West End measurement location

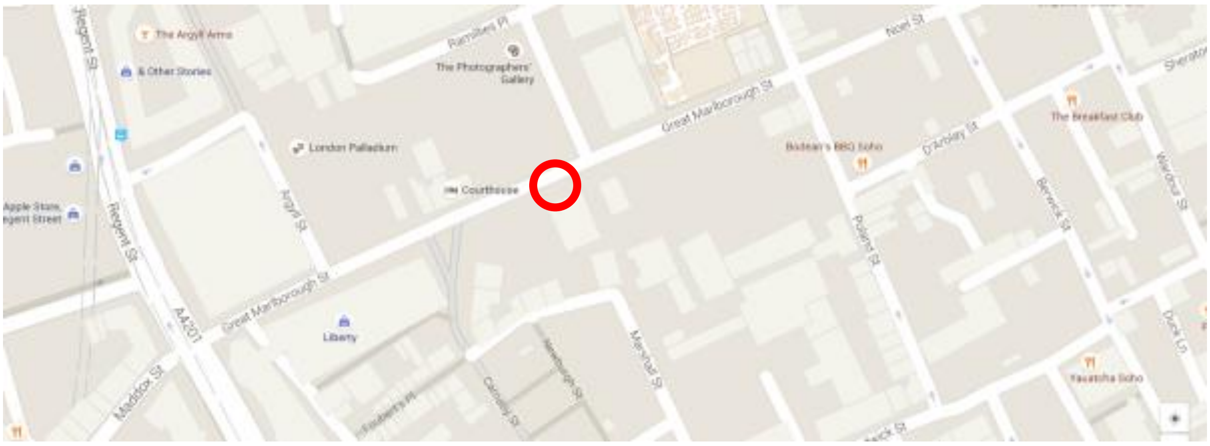


Figure 6 Photo of West End measurement location

4.3.3 Waterloo (The Cut)

The Waterloo location was a delivery bay used by vans delivering to the shops along the street. It was constantly in use on each morning of the study. The Cut runs East to West (Figure 6). The monitor was located on the South side of the street on a sign pole directly by the bay (Figure 7).

Figure 7 Map of Waterloo measurement location

Figure 8 Photo of Waterloo measurement location

4.3.4 Wandsworth (St Joseph's Primary School)

The final location in the study was a drop off bay outside a primary school in Wandsworth. This location was different to the others in that it was mainly in use between 8:30 - 9:00 as children are dropped off for school. Oakhill road runs East to West (Figure 8). The monitor was located on the South side of the street on a pole by the drop-off bay.

Figure 9 Map of Wandsworth measurement location

Figure 10 Photo of Wandsworth measurement location

4.4 Data preparation

4.4.1 Non-linear loading correction

Aethalometers and microAeths calculate black carbon (BC) concentrations from the rate of change of light transmission through the filter. The faster the filters turns black, the higher the instrument infers the black carbon concentration to be. Aethalometers and microAeths assume that there is a linear relationship between the rate of loading the concentration. However, research by (Virkkula, 2007) showed that this is not the case and in fact as the loading on the filter increases, the rate of change in the attenuation may slow despite the concentration of black carbon staying the same or increasing.

Virkkula recommends correcting Aethalometer data to account for this non-linear performance. Both the microAeth and Aethalometer data were therefore corrected using the approach.

4.4.2 Removal of background BC concentrations

Since black carbon has a relatively long lifespan in the atmosphere (4-12 days) and can travel long distances (>1000km) (Cape, 2012), the black carbon sampled at each of the locations will be from a mixture of local and regional sources.

To gain a more accurate measure of the local black carbon emissions, regional 'background' black carbon concentrations were subtracted from the microAeth data. This involved subtracting black carbon concentrations measured by an Aethalometer located at an urban background monitoring station in North Kensington from the final microAeth data set to yield a local 'increment' data set.

All plots in the Results section used this 'increment' data. Only data between 8am and 10am from each of the instruments was used in the analysis.

5. Results

When attempting to compare the measurements from an action day to a non-action day, there are two main variables to consider; the weather and the number of vehicles using the bays on each day.

For the latter, whilst the enforcement teams did collect driver engagement data on the action days, including type of vehicle and whether the driver switched off or not, the study did not have the scope to monitor the number and type of vehicles using the bays on non-action days.

Given, as described in section 4.1, that the traffic profiles of Tuesdays and Wednesdays in London are very similar and, lacking any specific vehicle count data, we must therefore assume that the usage of the bays was broadly similar on the action and non-action days. Indeed, part of the reasoning behind choosing Tuesdays and Wednesdays was because mid-week days are less likely to be affected by any unusual Friday/weekend/Monday usage patterns.

The weather is the other key variable which affects comparison between the action and non-action days. If, for example, a non-action day was a very still, high pollution day but on the action day it was blowing a gale – this would lead to an unfair comparison between the two days.

In this analysis, we have taken two approaches to deal with this.

The first was to remove background BC concentrations from the micoAeth data as described in section 4.4.2. This leaves an 'increment' data set that, whilst still influenced by roadside dispersion characteristics, should be more reflective of local emissions only.

The second approach was to look at the frequency and magnitude of BC peaks as indicators of idling events. Because pollution tends to trend up and down gradually, even at a roadside site, and because the microAeths were set to 1 minute averages, a large peak or spike in the data is likely to represent an idling event and not simply passing traffic.

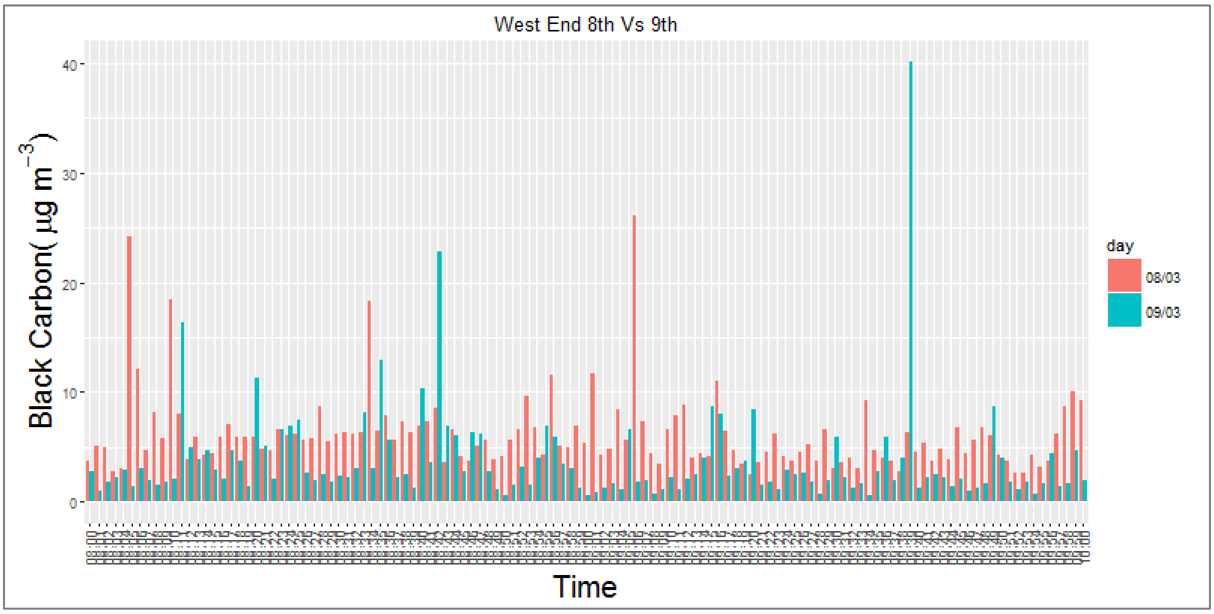
5.1 Time Series

A simple time series plot of 1 minute mean concentrations of the action days vs the non-action days can provide an overview of the number and size of BC peaks measured each day.

Figure 11 shows the 8th March non-action day in pink vs the 9th March action day in green at the West End location.

If the anti-idling action had an effect, we expect to see fewer peaks on the action day compared with the non-action day.

Figure 11 West End time series 8th March vs 9th March



All time series plots are contained in the appendix section 8.1.

5.2 Density distribution

The time series plots give a general view of the action days vs the non-action days. However, because of the influence of weather discussed in section 5, a more qualified approach is required to fairly compare the difference.

We are interested in the frequency and magnitude of the peaks on each of the days as indicators of idling events. We therefore need a way of defining what a 'peak' is. In this analysis we define peaks as the top 10% of measurements. In the analysis below, we use the median of the top 10% of measurements – this is the same as the 95th centile.

If the time series charts are expressed as frequency distribution plots, a new view of the data emerges which shows how the measurements are spread from the lowest to the highest.

The density distribution plot in Figure 12 shows measurements from the non-action day March 15th in pink and action day on March 16th in green at the City of London location.

It highlights four things:

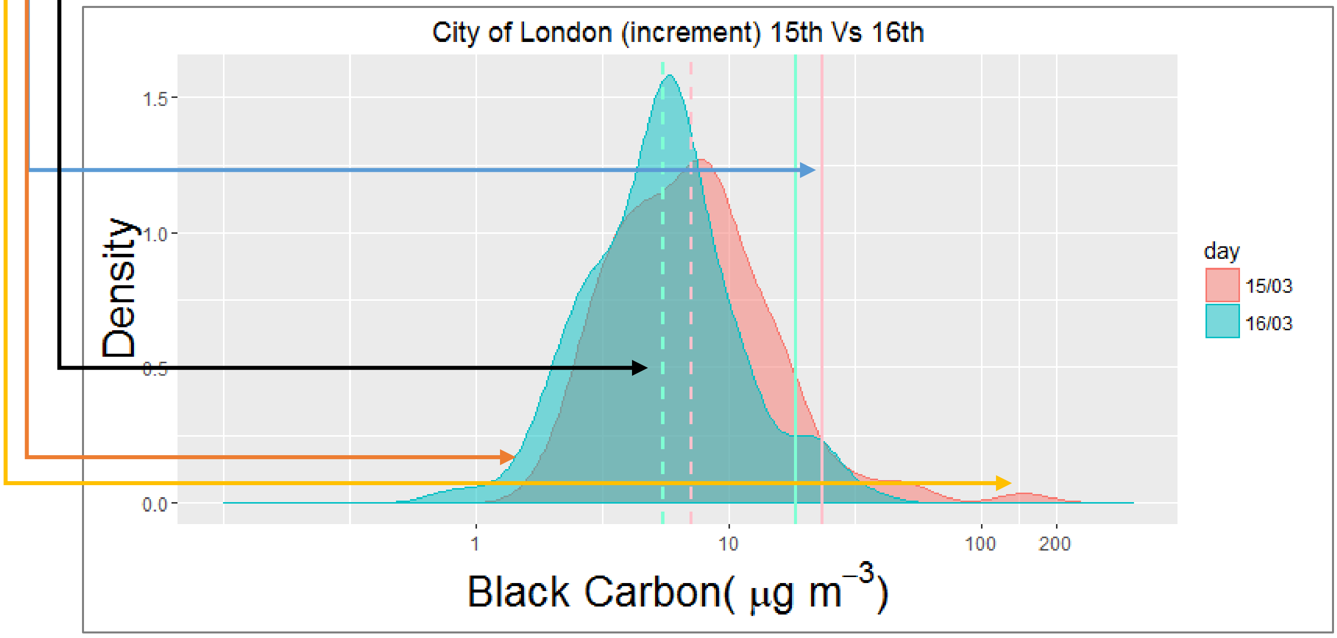
1 – The lowest concentrations on the 16th are lower than those on the 15th.

2 – The highest concentrations on the 15th are higher than those on the 16th.

3 – The median (dotted line) of the measurements on the 16th was lower than that of the 15th

4 – The 95th percentile of measurements (solid line) was higher on the 15th than on the 16th

Figure 12 Density distribution plot (log scale) West End 15th March vs 16th March



The medians of each data set will largely be a function of the ambient roadside concentrations on that day. The frequency and magnitude of peaks in the top 10% of the data, which we take to be idling events, determines how far the data 'spreads' to the right of the median.

We can use this 'spread' or 'distance' between the median and the median of the top 10% of measurements (the 95th percentile) as a measure to more fairly compare the days. If the anti-idling action has been successful in reducing the frequency and magnitude of idling spikes on the action days, then the 'distance' between the median and the 95th percentile should be less than on the non-action days.

All density distribution plots are contained in the appendix section 8.2.

6 Analysis

By measuring the difference between the median and 95th percentile, an assessment can be made on how effective the action has been on reducing the frequency and magnitude of idling peaks on the action days.

Table 1 below shows the differences between the median and the 95th percentile of each day. The changes in the difference of the action days are then expressed as a percentage of the non-action days at the end of the table to show if the action day was lower or higher than the non-action day and by how much.

Table 1 Medians, 95th percentiles and differences in µg/m3 for each day

Location	**Day**						
	8th			9th			Difference of 9th as % of 8th
	Median	95th percentile	Difference	Median	95th percentile	Difference	
City	9.5	23.8	14.3	15.9	34.9	19.0	32.9
West End	5.6	11.6	6.0	2.4	8.7	6.3	4.8
Waterloo	15.6	53.2	37.6	9.4	39.8	30.4	-19.0
Wandsworth	2.1	15.6	13.4	0.9	9.4	8.5	-36.3
Location	**Day**						
	15th			16th			Difference of 16th as % of 15th
	Median	95th percentile	Difference	Median	95th percentile	Difference	
City	7.1	23.7	16.5	5.5	18.4	12.9	-22.2
West End	2.9	7.8	4.9	3.1	7.9	4.8	-1.2
Waterloo	1.6	9.0	7.4	2.9	8.7	5.8	-21.5
Wandsworth	2.0	5.0	2.9	1.8	3.7	1.9	-36.2

7 Conclusions

The results indicate that the Waterloo and Wandsworth locations recorded the most significant and consistent reductions in number and magnitude of peaks on the action days with the Waterloo location showing an approximately 20% reduction and the Wandsworth location showing an approximately 36% reduction both times the experiment was run

The West End location recorded a very slight increase of 4.8% on the first action day and a very small decrease of -1.2% on the second action day. This suggests no overall effect at this location. Although this location was busy with lots of delivery drivers on each morning of the experiment, there are no dedicated loading bays here and as a result vans and lorries tend to spread out along this road. It's likely that the nature of this location made it difficult to measure a strong signal here.

The City of London location recorded a 22% decrease on the second action day which is in line with reductions at the Waterloo and Wandsworth locations. However, this location also recorded a fairly significant increase in peaks of 33% on the first idling day. The study did collect driver engagement data and a further examination of the correlation between the observed measurements and the driver engagement data may provide some insights here.

The Waterloo location, unlike the West End location, was well positioned to pick up a signal with the monitor placed very close to one of the only delivery bays on this stretch of road. Consequently, the bay is in near constant use through the morning as vans and lorries service the shops here. The more focussed nature of the delivery bay here likely also made it easier for volunteers to engage with drivers near the sensor (unlike the more spread out West End location). These factors are likely to have contributed to the monitor detecting a stronger and more consistent signal here.

The Wandsworth school location was also well suited to this study. The monitor was placed next to a two-bay drop-off and pick-up area on a relatively quiet residential street. Less passing traffic likely aided in the sensor detecting more of a signal from the morning drop-offs here. Similarly, the location was also well suited to targeted engagement action by the volunteers.

Idling at school gates is a problem across the capital and it was pleasing to see the greatest reduction in concentrations at this location.

Few studies exist which have attempted to measure the impact of anti-idling measures. Our study therefore necessitated the development of a novel approach to analysing the data which took into account the effect of weather on ambient concentrations and the prevalence of idling peaks in the data to enable a fairer comparison between non-action and action days.

The study indicates that under the right conditions, it appears possible to detect the effect of anti-idling action, and that under those conditions, anti-idling action can have a significant impact on local air quality.

Recommendations for future studies of this type would include cross-referencing the measurement data with the driver-engagement data, recording the number and type of vehicles using the locations on non-action and action days and control experiments with the sensros and idling vehicles.

We are thankful to the Mayor's Air Quality Fund for funding this project through Cross River Partnership's Clean Air Better Business programme, and to the boroughs, BIDs and volunteers who took part.

8 Appendix

8.1 Time series

8.1.1 8th March (non-action day) vs 9th March (action day)

Figure 13 West End time series 8th vs 9th

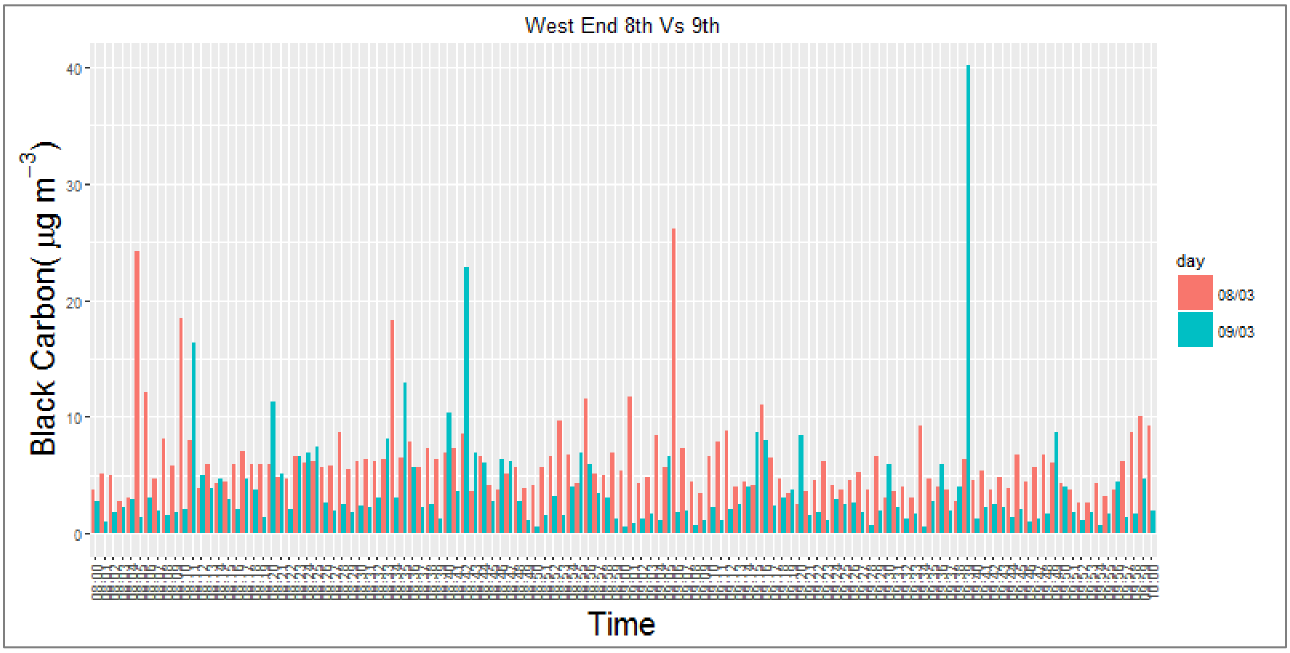


Figure 14 Waterloo time series 8th vs 9th

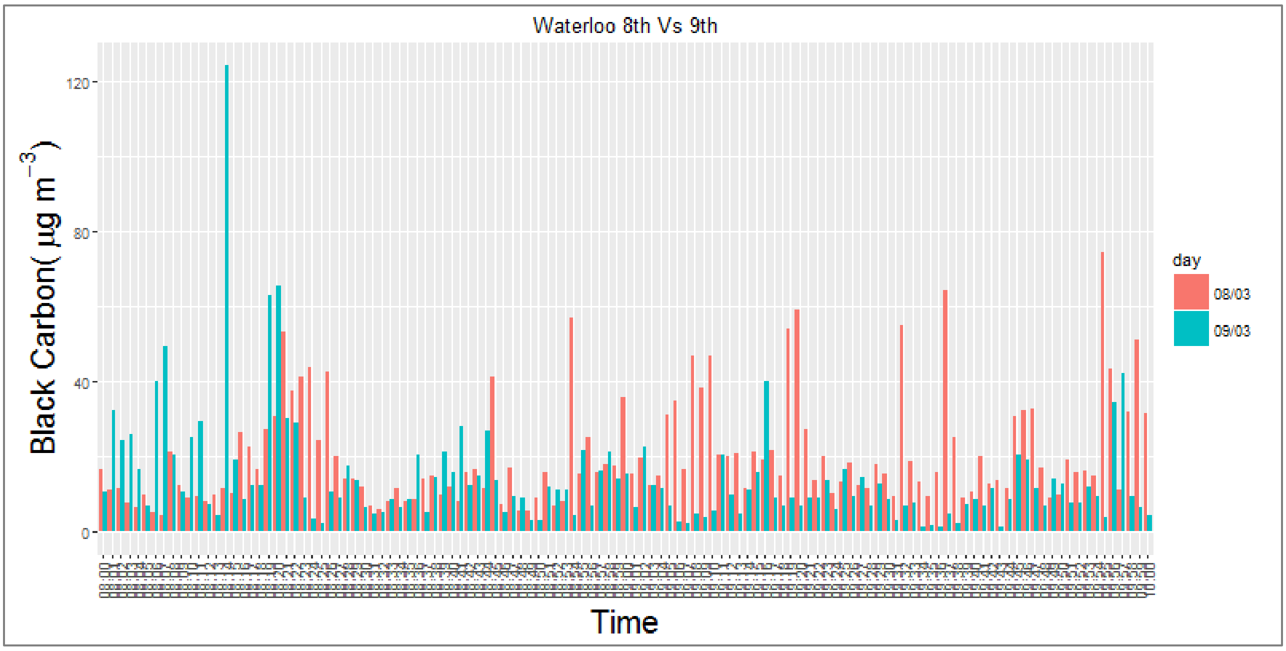


Figure 15 Wandsworth time series 8th vs 9th

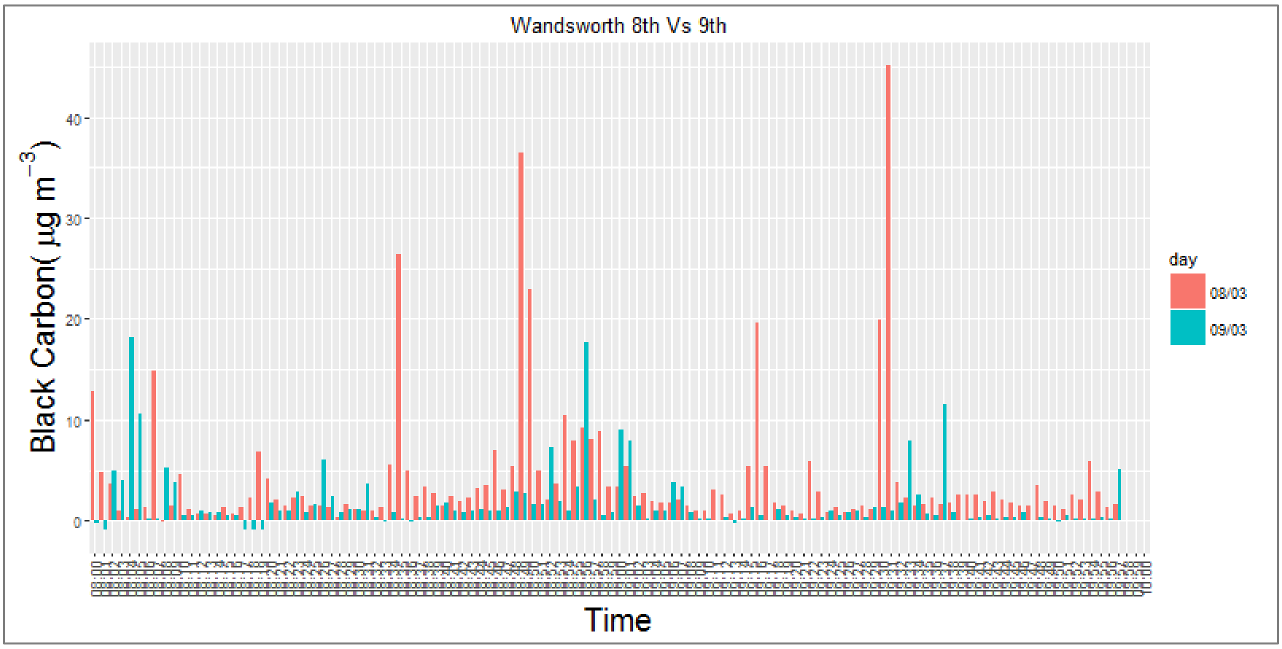
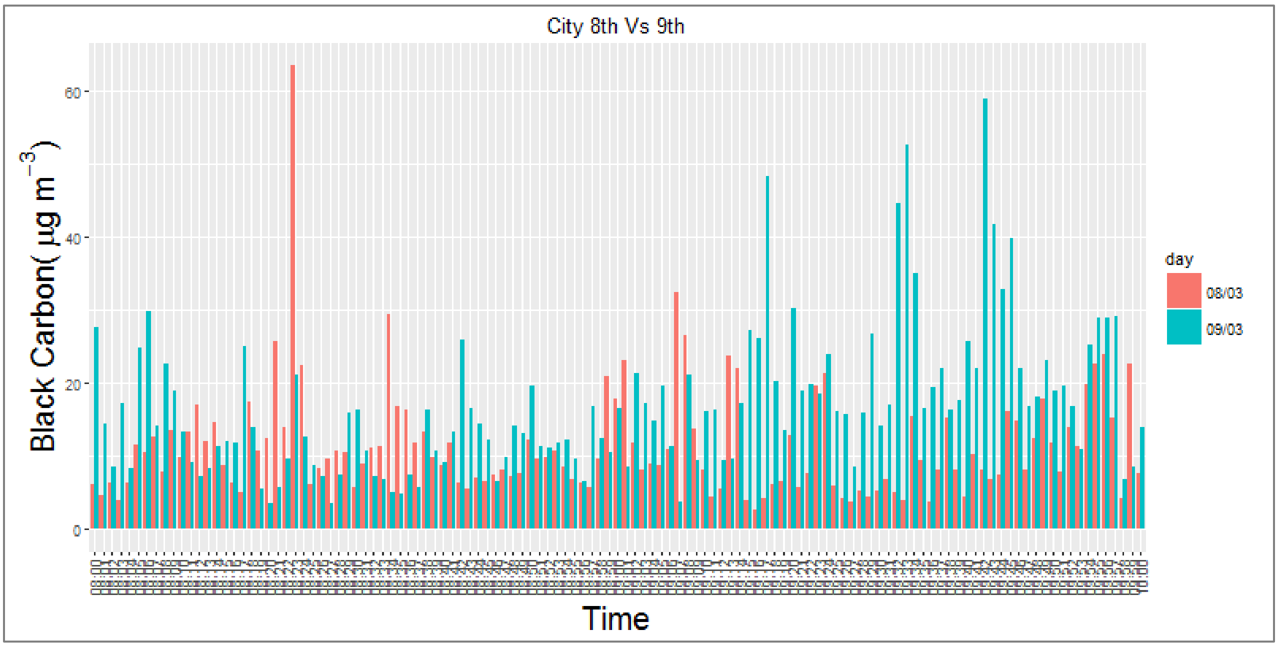


Figure 16 City of London time series 8th vs 9th



8.1.2 15th March (non-action day) vs 16th March (action day)

Figure 17 West End time series 15th vs 16th

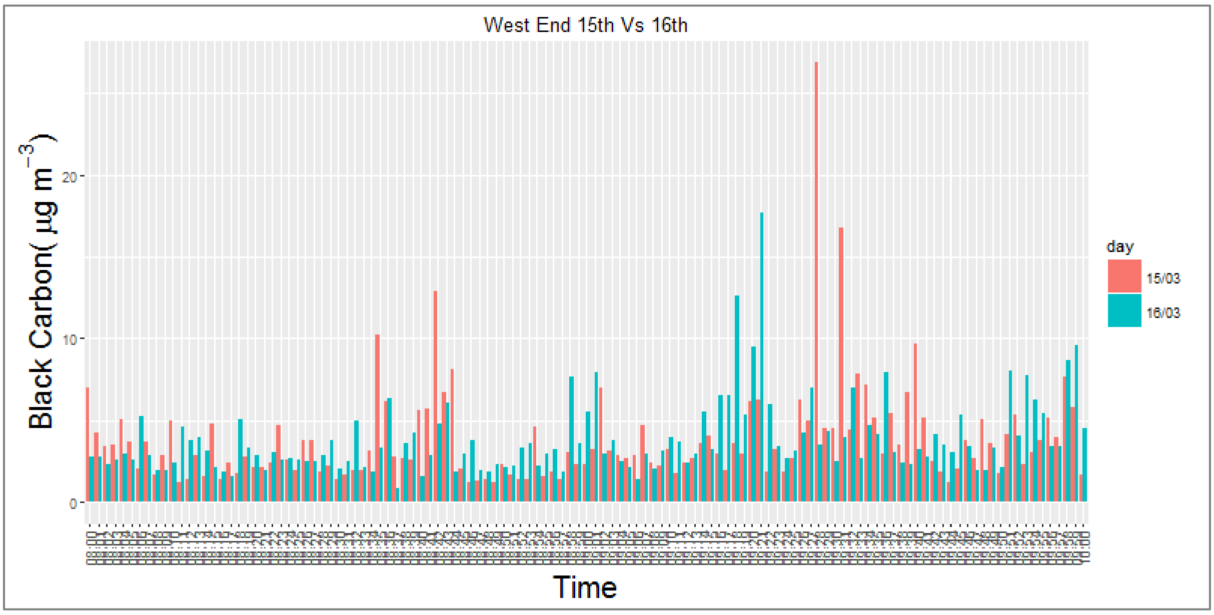


Figure 18 Waterloo time series 15th vs 16th

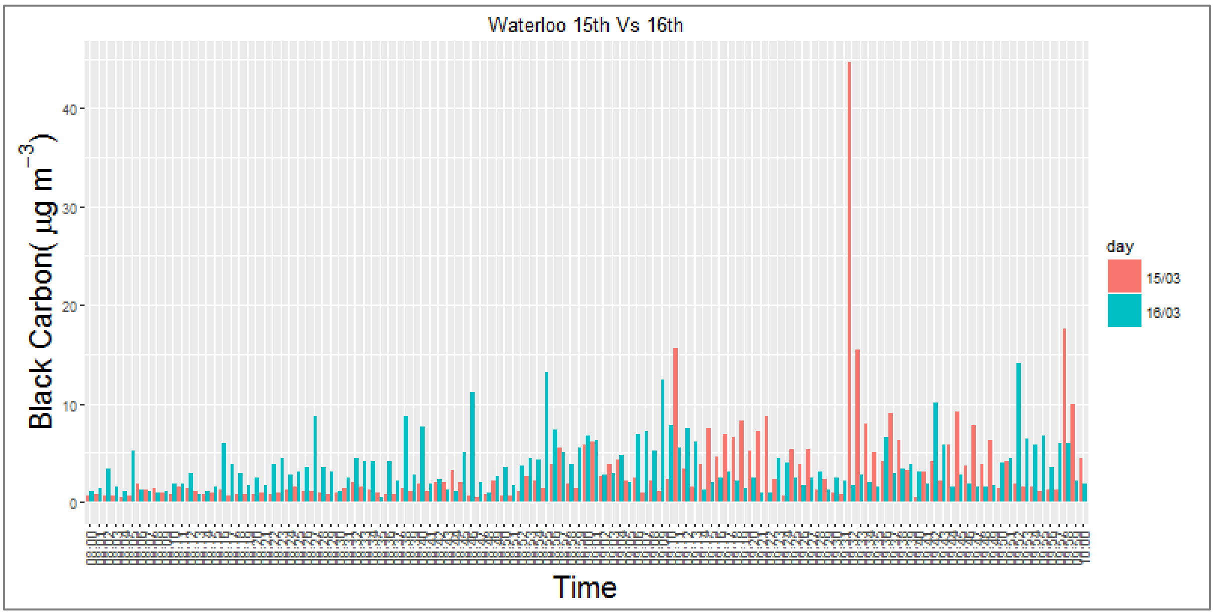


Figure 19 Wandsworth time series 15th vs 16th

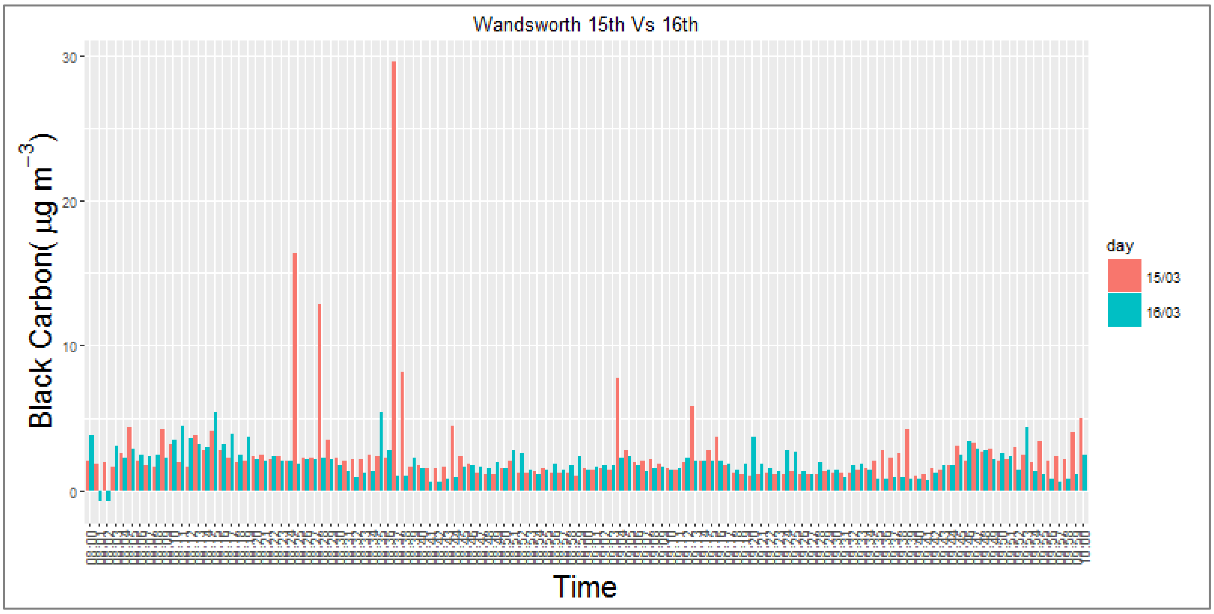
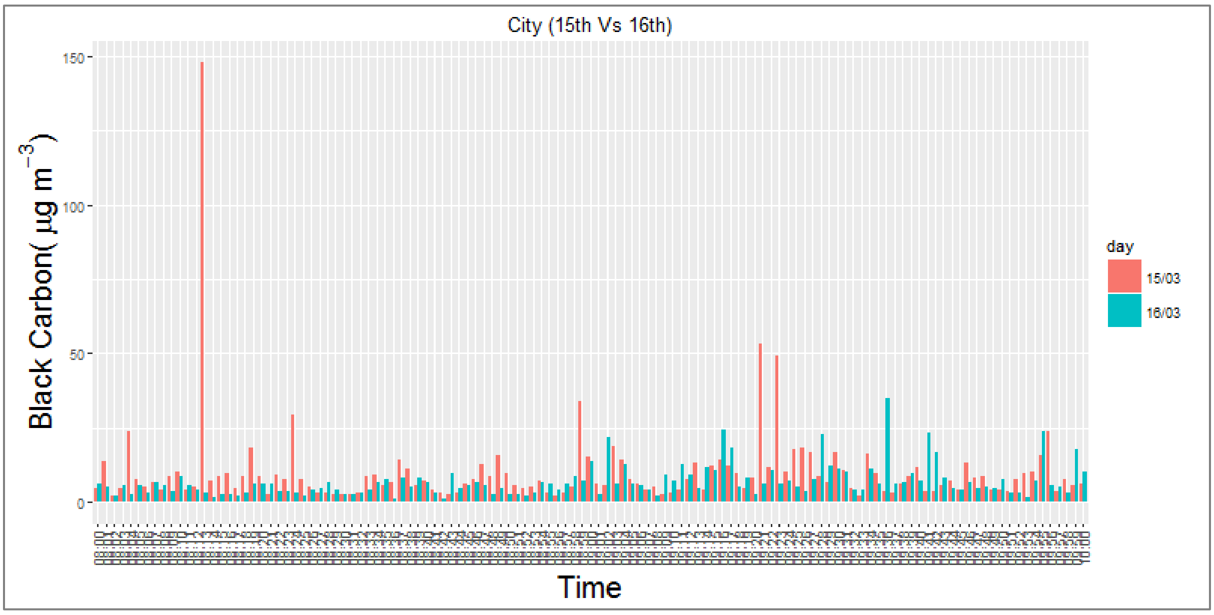


Figure 20 City time series 15th vs 16th



8.2 Density distribution

8.2.1 8th March (non-action day) vs 9th March (non-action day)

Figure 21 West End density distribution 8th vs 9th (log scale)

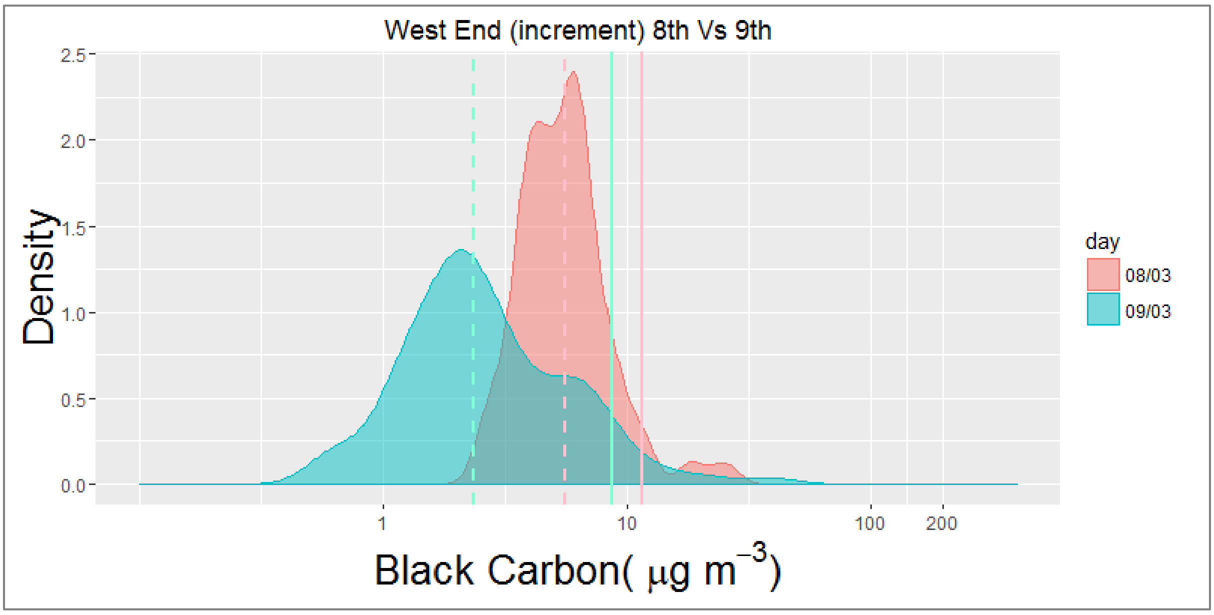


Figure 22 Waterloo density distribution 8th vs 9th (log scale)

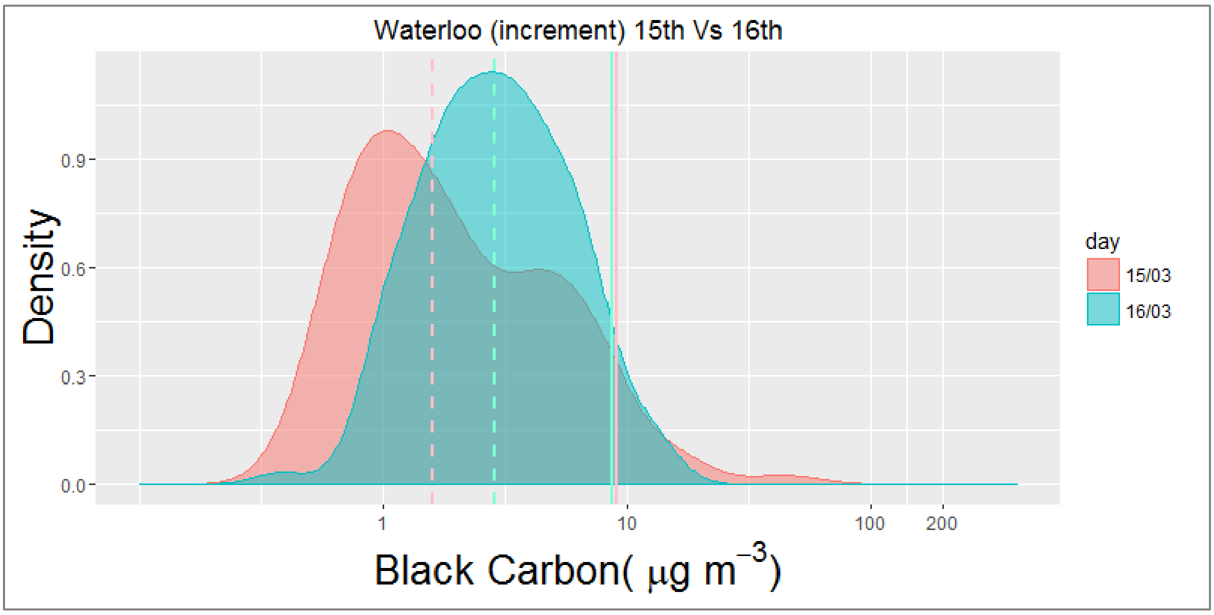


Figure 23 Wandsworth density distribution 8th vs 9th (log scale)

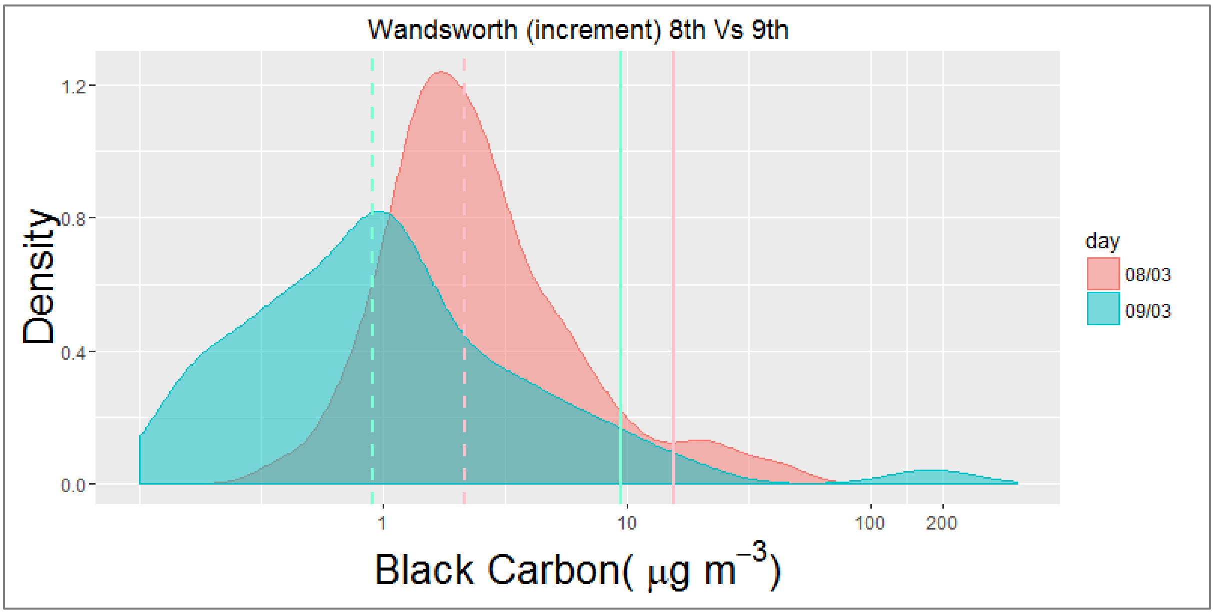
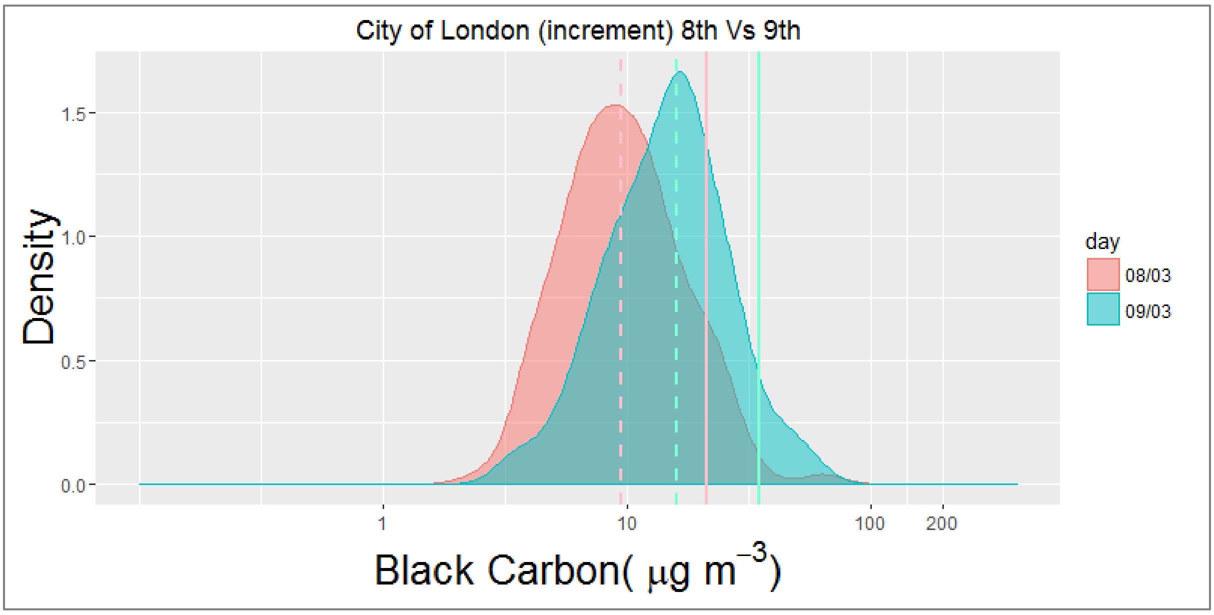


Figure 24 City of London density distribution 8th vs 9th (log scale)



8.2.2 15th March (non-action day) vs 16th March (action day)

Figure 25 West End density distribution 15th vs 16th (log scale)

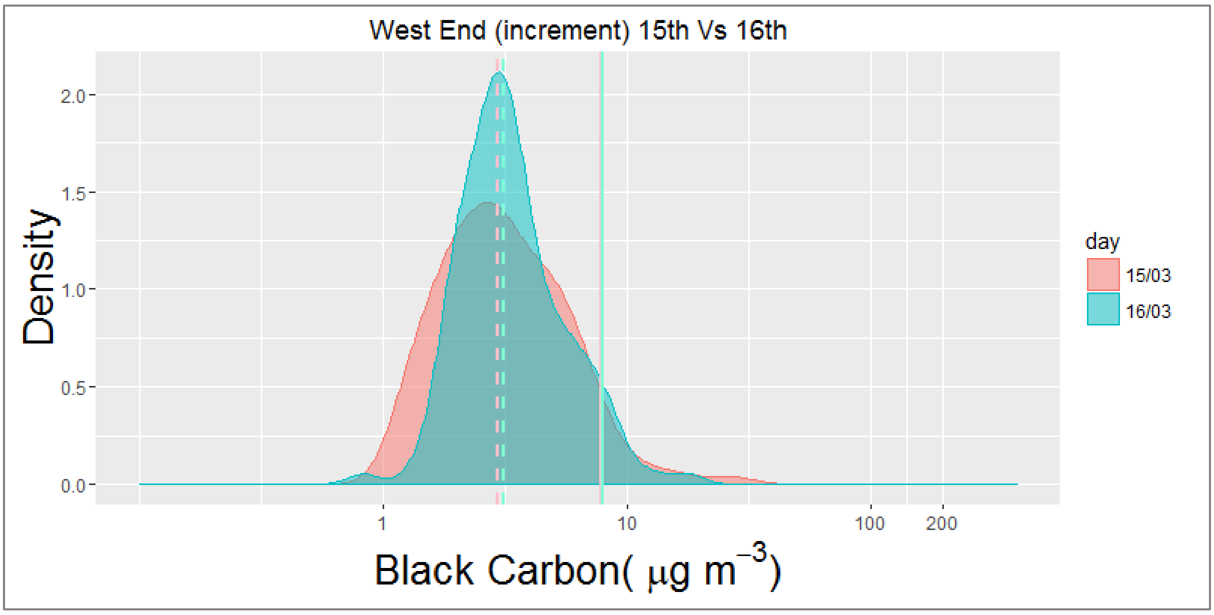


Figure 26 Waterloo density distribution 15th vs 16th (log scale)

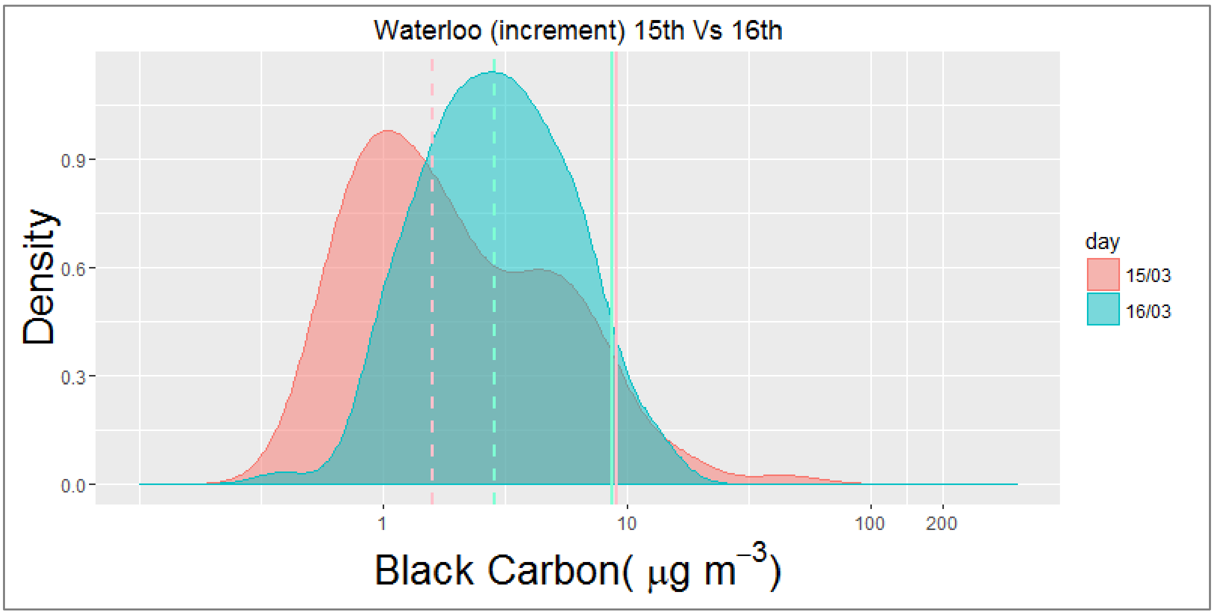


Figure 27 Wandsworth density distribution 15th vs 16th (log scale)

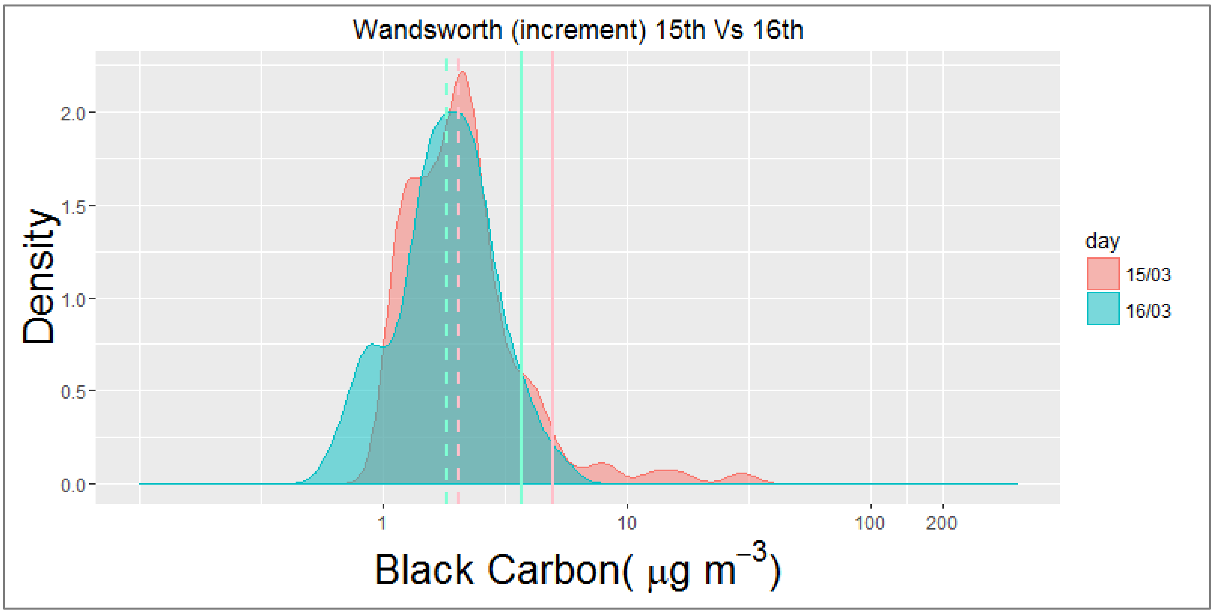


Figure 28 city of London density distribution 15th vs 16th (log scale)