Department for Environment Food & Rural Affairs

Department for Environment, Food and Rural Affairs

STATISTICAL RELEASE: 25 April 2019

- Urban background and roadside **particulate pollution (PM_{10})** has shown long-term improvement, with stable concentrations observed from 2015 to 2018 for both roadside and urban background sites. A substantial network for **fine particulate matter ($PM_{2.5}$)** has been operational since 2009 which shows a similar trend.

- The number of **hours of moderate or higher levels of particulate matter (PM_{10}/$PM_{2.5}$) pollution** has reduced in the long term, and a substantial decrease in number of hours of exceedance were recorded in 2018 compared with 2017 for $PM_{2.5}$ at both roadside and urban background sites.

- $PM_{2.5}$ pollution tends to **peak in the winter months and in the evening, although there are many pollution sources.** Burning of wood and coal by households in stoves and open fires is a large contributor to emissions of particulate matter both in the UK and across Europe, and is most common in winter months and during the evenings.

- Urban background and roadside **nitrogen dioxide (NO_2) pollution** has shown long-term improvement. In 2018 the lowest average annual mean concentrations since the start of the time series for both roadside and urban background monitoring sites were recorded.

- There were on average fewer **hours of moderate or higher levels of nitrogen dioxide pollution** in 2018 compared with 2017 at roadside sites. This continues a trend for reduction in short-term moderate or high NO_2 pollution since 2007, mainly due to reductions in this measure at monitoring sites in London.

- In 2018, NO_2 pollution tended to **peak in the rush hours and during weekdays; particularly for roadside sites.** Concentrations at roadside sites were 20 percent greater during the working week compared to the weekend. This pattern of concentrations follows the daily and hourly trends in road traffic.

Enquiries to Environment Statistics, Defra, Seacole Building, 2 Marsham Street, London, SW1P 4DF. enviro.statistics@defra.gsi.gov.uk, Public enquiries: 03459 335577 or Press enquiries: 020 8225 7317

- Urban background **ozone (O_3) pollution** has remained fairly stable between 2003 and 2018, although daily maximum eight-hour mean concentrations have shown a long-term increase since monitoring began. Rural background ozone pollution has shown no clear long-term trend. Concentrations increased from 2017 to 2018 at both rural and urban locations; reflecting the prolonged hot and sunny conditions in summer 2018.

- There were on average greater **hours of moderate or higher levels of ozone pollution** in 2018 compared with 2017 at both rural and urban background sites. This measure can vary greatly from year-to-year, and the hot summer in 2018 contributed to the high incidence of moderate or higher ozone pollution. 2018 had the greatest number of hours for this measure since 2006 for rural background sites, and since 2008 for urban background sites.

- In 2018, O_3 pollution tended to **peak in the spring and summer months.** Concentrations at rural background sites built up over the first few months of 2018, peaking in May before reducing to a stable level from August to the end of the year.

- There was on average a greater number of **days of moderate or higher pollution** at **urban** pollution monitoring sites in 2018 compared with 2017. This goes against the established trend of an ongoing decline in days of moderate or higher pollution at urban sites.

- There was on average a greater number of **days of moderate or higher pollution** at **rural** pollution monitoring sites in 2018 compared with 2017. There is no long term trend in this metric.

- The main drivers of the average number of days when air pollution is Moderate or higher are particulate matter and ozone, for urban and rural pollution monitoring sites in the UK respectively. In 2018, ozone was responsible for a large proportion of the moderate or higher pollution days. This was due to the prolonged hot and sunny conditions experienced in the UK in summer 2018.

Air quality statistics in the UK 1987 to 2018

NATIONAL STATISTICS STATUS

National Statistics status means that our statistics meet the highest standards of trustworthiness, quality and public value, and it is our responsibility to maintain compliance with these standards.

The continued designation of these statistics as National Statistics was confirmed in February 2012 following an assessment by the UK Statistics Authority (now the Office for Statistics Regulation) against the Code of Practice for Statistics. The Office for Statistics Regulation is currently carrying out a full assessment of these statistics and the related statistics “Emissions of Air Pollutants in the UK” against the Code of Practice for Statistics, and a public report is due in summer 2019.

Air Quality Statistics in the UK is an annual publication that provides an overview of the concentrations of air pollutants (measured using the national monitoring network: the Automatic Urban and Rural Network) considered most damaging to human health and the environment. Since the last assessment of these statistics in 2012, we have continued to comply with the Code of Practice for Statistics, and have made improvements including:

- Reporting a wider range of pollutants for annual summary statistics – in addition to PM_{10} and ozone, the publication also covers trends in annual mean $PM_{2.5}$ and nitrogen dioxide and urban background and roadside monitoring stations. This reflects the growth in the profile of these pollutants.
- Analysing trends in the average hours per year spent in the moderate or higher pollution categories of the Daily Air Quality Index (DAQI; see Table 5) for PM_{10}, $PM_{2.5}$, ozone and nitrogen dioxide. This provides more information on the duration of short-term pollution events.
- Reporting variation in concentrations by hour of the day, day of the week or month of the year where significant variation is present.
- Annual mean concentrations for each monitoring site in the accompanying set of tables to enable users to construct time series for long-running sites.

Defra keep all National Statistics under review and seek to make changes periodically to meet the needs of users. We welcome feedback and any thoughts to improve the publication further. Please can you send your feedback to Enviro.Statistics@defra.gov.uk. Some example questions are given below to help you structure your feedback but all feedback is welcome:

- How relevant is the current content of the publication to your needs as a user? What purpose do you require the data for?
- What data related to air quality would you find most useful for the Government to provide in a statistical publication?
- Is there any content that you did not find useful?
- Do you have any further suggestions for further development of this release; including what is should cover and opportunities for further innovation in analysis and presentation?

Background

Why do we measure air quality?

Air pollution is a local, regional and international problem caused by the emission of pollutants, which either directly or through chemical reactions in the atmosphere lead to negative impacts on human health and ecosystems. There are many sources of air pollution, including power stations, traffic, household heating, agriculture and industrial processes.

There have been significant reductions in recent decades of emissions of air pollutants from the above mentioned sources. However, the relationship between emissions and ambient air quality is not straightforward. It is strongly affected by weather; for example, the gas ozone (O_3) is not emitted directly in significant quantities, but is created in the air through chemical reactions between other pollutants in sunlight, with more being created on hot, still, sunny days.

Day-to-day changes in weather also have a great influence on air quality. Levels of pollutants that are relatively high on a still day when dispersion is limited can be much lower the next day or even the next hour if wind direction changes or wind speeds increase. In addition UK air quality can be affected by pollutants blown across from mainland Europe. For example, UK emissions of the pollutants that lead to ozone formation have reduced substantially, but this is not reflected in the long-term trend in ozone concentrations. This is partly explained by a proportion of the ozone experienced in the UK originating from air pollutant emissions from mainland Europe and beyond.[1] It follows that air pollutant emissions reductions do not always produce a corresponding drop in atmospheric concentrations in the UK. Therefore it is important to measure ambient air quality as well as emissions. The statistics presented in this release provide an important overview of air quality in the UK.

In order to monitor air quality and help assess the risks to people's health and to the environment, the concentrations of key pollutants are measured via a national network of monitoring sites, the Automatic Urban and Rural Network (AURN), which continuously captures ambient concentrations of selected pollutants throughout the UK. Monitoring data

[1] UNECE, 2010, Hemispheric Transport of Air Pollution 2010m Part D: Answers to Policy-Relevant Science Questions, Air Pollution Studies No. 20. ECE/EB.AIR/103, United Nations Economic Commission for Europe, Geneva.

is combined with modelled data for annual reporting of pollutant concentrations. The UK-AIR website provides further information and provides the most up-to-date data for all air pollutants measured by the Environment Agency on behalf of Defra.

In the UK, EU standards for air quality are set into English law through the Air Quality Standards Regulations (England) 2010[2] and equivalent regulations in Scotland, Wales and Northern Ireland. UK actions are informed by the statistics derived from air quality monitoring and modelling.

What does this National Statistics release report?

This statistical release covers concentrations in the UK of four pollutants thought to have the greatest health and environmental impacts resulting from exposure:

- Chronic exposure to particulate matter (PM_{10}/$PM_{2.5}$) contributes to the risk of developing cardiovascular and respiratory diseases, and there is increasing evidence suggesting that long-term and short-term exposure to particulate matter may have a significant effect on health. The annual average concentrations for particulate matter are considered a useful measure of overall long-term exposure to particulate matter. The number of hours per site per year that the 24-hour running mean concentration is greater than 35 µg/m^3 is a useful summary measure of the length of short-term events when particulate pollution had potential health impacts.

- The gas ozone (O_3) can affect people's health and can damage, for example, wild plants, crops and forests. Higher levels of ground level ozone can cause breathing problems, trigger symptoms of asthma, reduce lung function and cause lung diseases. Several European studies have reported that current ozone concentrations in Europe have health effects, especially in the summer, and that daily mortality rises with increases in ozone exposure[3]. The long-term ozone concentration reported in this release is the annual average of the maximum daily eight-hour running mean. The number of hours per site per year that the 8-hour running mean concentration is greater than 100 µg/m^3 is a useful summary measure of the length of short-term events when ozone pollution had potential health impacts.

- Short-term exposure to concentrations of NO_2 higher than 200µg/m^3 can cause inflammation of the airways. NO_2 can also increase susceptibility to respiratory infections and to allergens. The long-term NO_2 concentration reported in this release is the annual mean. The number of hours per site per year that the hourly mean concentration is greater than 200 µg/m^3 is a useful summary measure of the length of short-term events when NO_2 pollution had potential health impacts.

The statistical release also covers variation in concentrations of these pollutants by hour of the day, day of the week and month of the year where a notable trend exists.

[2] http://www.legislation.gov.uk/uksi/2010/1001/contents/made
[3] WHO, 2008, Air quality and health, Fact sheet no 313 (http://www.who.int/mediacentre/factsheets/fs313/en/).

The statistical release also covers **the number of days when air pollution was moderate or higher.** The indicator is intended to provide a summary measure of the main air pollutants that affect health due to short term exposure. The five pollutants included in the indicator are as follows:

- Particulate matter ($PM_{2.5}$)
- nitrogen dioxide (NO_2)
- ozone (O_3)
- Particulate matter (PM_{10})
- sulphur dioxide (SO_2)

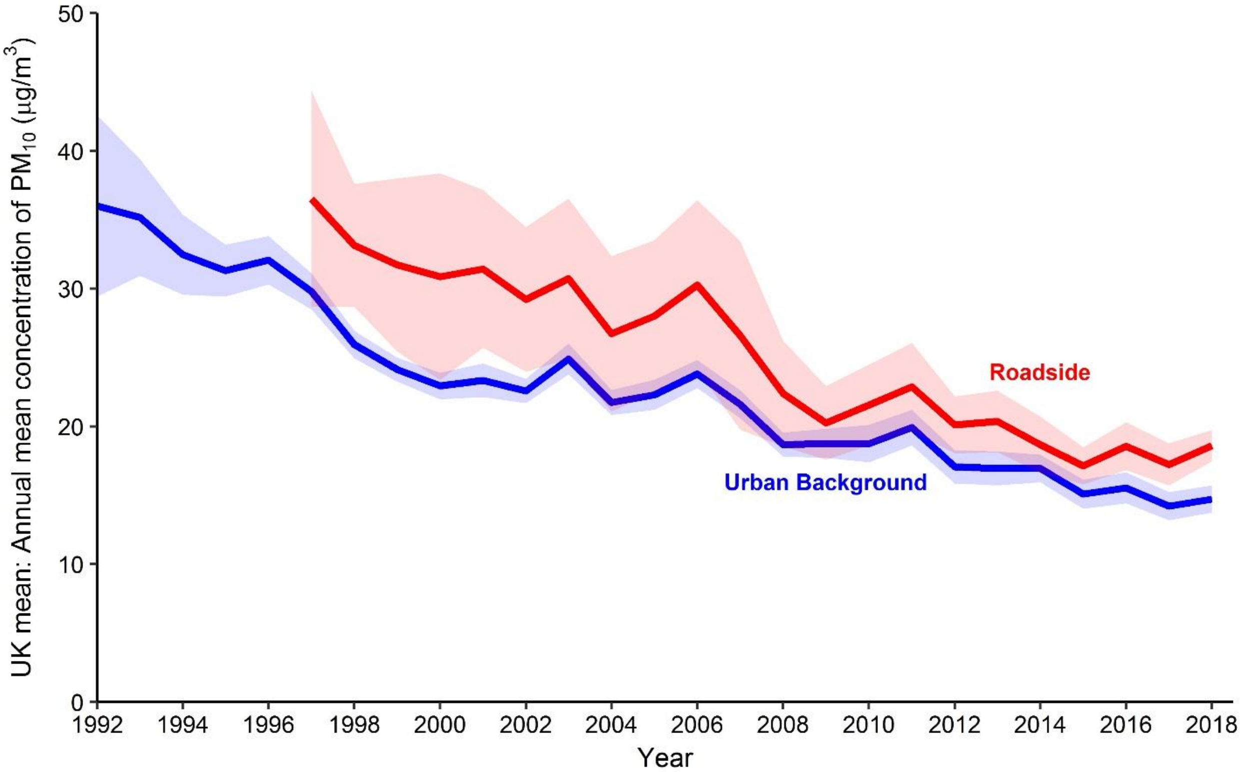
Defra's air pollution information service uses an index and banding system recommended by the Committee on Medical Effects of Air Pollutants (COMEAP)[4]. The system uses an index numbered 1-10, divided into four bands ("Low", "Moderate", "High" and "Very high") to provide more detail about air pollution levels in a simple way, similar to the sun index or pollen index. At the Moderate level, the effects of pollution may start to be noticeable to people with respiratory and other health problems, with greater risks to health at higher levels.

[4] https://uk-air.defra.gov.uk/air-pollution/daqi?view=more-info

Particulate Matter ($PM_{10}/PM_{2.5}$) concentrations

Annual Mean Concentrations of $PM_{10}/PM_{2.5}$

Figure 1: Annual concentrations of PM_{10} in the UK, 1992 to 2018



Source: Ricardo Energy & Environment

Notes:

The PM_{10} index shows the annual mean, averaged over all included sites that had annual data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the annual mean concentration for roadside sites (red) and urban background sites (blue). These intervals narrow over time because of an increase in the number of monitoring sites for both roadside and urban background sites; and a reduction in the variation between annual means for PM_{10} measured at roadside sites. Annual means for individual sites can be found in the PM_{10} tables that accompany this report.

- **Urban background PM_{10} pollution has reduced in the long-term and has been at a stable level since 2015**

  Average concentrations have decreased over the time series to 14.7 µg/m^3 in 2018, similar to 2017 (the increase between 2017 and 2018 is statistically insignificant). The annual mean concentration in 2017 (14.2 µg/m^3) was the lowest in the time series.

  Between 1992 and 2000 inclusive, the annual mean PM_{10} concentration at urban background sites reduced rapidly: by an average of 1.6 µg/m^3 each year. This reduction was observed at most monitoring sites across the UK; which could be a consequence of the large reduction in emissions of PM_{10} over the same period in the UK.

Between 2000 and 2006 the annual mean concentration fluctuated with no clear trend and this was observed at most monitoring sites across the UK. Emissions of PM_{10} in the UK and Europe were still decreasing over this period but the reductions were largely driven by changes to fuels used for energy generation; which may have a minimal impact on urban air quality.

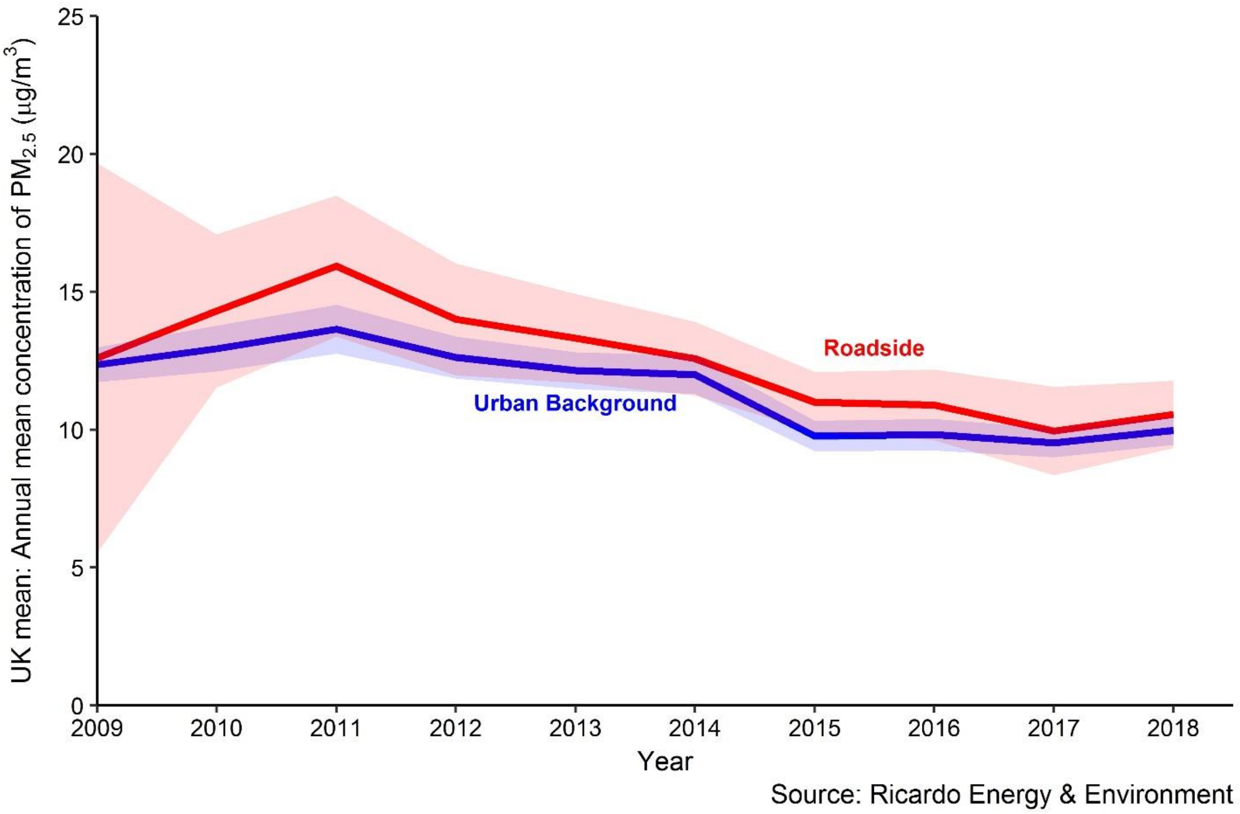
Between 2006 and 2015 inclusive, the annual mean PM_{10} concentration at urban background sites reduced by an average of 1.0 $\mu g/m^3$ each year, and concentrations have remained close to 2015 levels. Reductions in concentrations were observed at most monitoring sites across the UK.

- **Roadside PM_{10} pollution has reduced in the long-term and has been at a stable level since 2012**

Average concentrations steadily declined to 17.1 $\mu g/m^3$ in 2015, a low since monitoring began in 1997. The average concentration in 2018 was 18.6 $\mu g/m^3$; similar to concentrations recorded between 2012 and 2017. The annual mean PM_{10} concentration in 2018 is significantly greater at roadside sites compared to urban background sites; and there were 14 roadside monitoring sites with greater annual mean concentrations than the greatest mean concentration from an urban background site. This is most likely due to substantial PM_{10} emissions from road transport sources.

Between 1997 and 2012 inclusive, the annual mean PM_{10} concentration at roadside sites reduced by an average of 1.1 $\mu g/m^3$ each year. This reduction was observed at most long-running monitoring sites across the UK; which could be a consequence of the large reduction in emissions of PM_{10} over the same period in the UK, particularly from road transport sources. Since 2012 there has been no clear trend in the annual mean PM_{10} concentration at roadside sites.

Figure 2: Annual concentrations of $PM_{2.5}$ in the UK, 2009 to 2018



Notes:

The $PM_{2.5}$ index shows the annual mean, averaged over all included sites that had annual data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the annual mean concentration for roadside sites (red) and urban background sites (blue). The interval for roadside sites narrows over time because of an increase in the number of monitoring sites and a reduction in the variation between annual means for $PM_{2.5}$ measured at roadside sites. Annual means for individual sites can be found in the $PM_{2.5}$ tables that accompany this report.

- **Urban background $PM_{2.5}$ pollution has decreased gradually, but has remained at a stable level since 2015**

  Average concentrations have decreased over the time series to 10.0 µg/m^3 in 2018, similar to 2017 (the increase between 2017 and 2018 is statistically insignificant). The annual mean concentration in 2017 (9.5 µg/m^3) was the lowest in the time series.

  The decline in concentrations of $PM_{2.5}$ at urban background sites approximately follows the trends seen for PM_{10} ($PM_{2.5}$ is a subset of PM_{10}).

- **Roadside $PM_{2.5}$ pollution has decreased gradually, but has remained at a stable level since 2015**

  Average concentrations have decreased over the time series to 10.6 µg/m^3 in 2018, similar to 2017 (the increase between 2017 and 2018 is statistically insignificant). The annual mean concentration in 2017 (9.9 µg/m^3) was the lowest in the time series. The decline in concentrations of $PM_{2.5}$ at roadside sites approximately follows the trends seen for PM_{10} ($PM_{2.5}$ is a subset of PM_{10}).

Unlike for PM_{10}, the annual mean $PM_{2.5}$ concentrations for roadside and urban background sites in 2018 are not significantly different. This may be due to a smaller impact of particulate emissions from brake and tyre wear and road abrasion for $PM_{2.5}$ roadside concentrations relative to PM_{10} concentrations.

Concentrations of $PM_{2.5}$ tend to be greatest in urban environments in the southern and eastern areas of the UK due to greater exposure to pollution sources from mainland Europe; in 2018 6 of the top 7 sites in urban environments with the greatest annual mean concentration of $PM_{2.5}$ are located in the London, South East or East of England regions.

Average hours spent in 'Moderate' or higher PM_{10}/$PM_{2.5}$ pollution

This metric measures the annual trend in the number of hours on average that concentrations are recorded at levels that may have impacts on human health. For PM_{10}, 'moderate' air pollution (which requires action by citizens who are vulnerable to the health impacts of air pollution) is triggered when the latest 24-hour running mean concentration is greater than 50 µg/m^3. The coloured categories relate to the categories of the Daily Air Quality Index (see Table 5).

Figure 3: Annual mean hours when PM_{10} pollution was moderate or higher, for roadside sites, 1997 to 2018

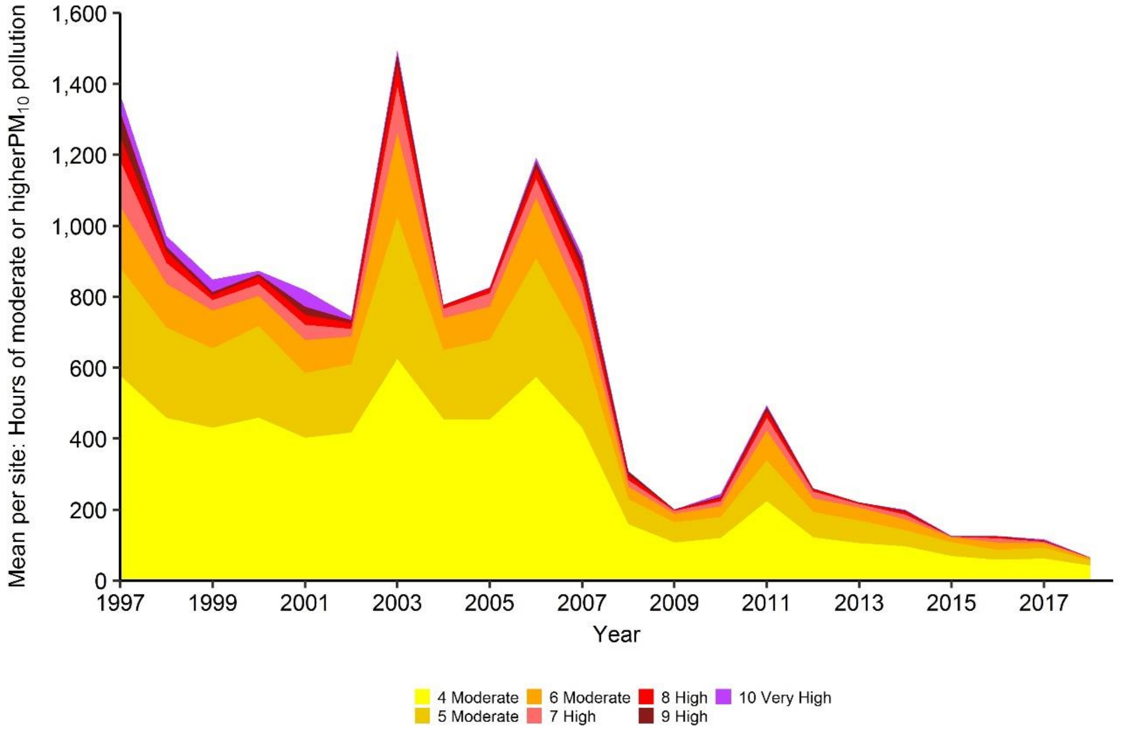
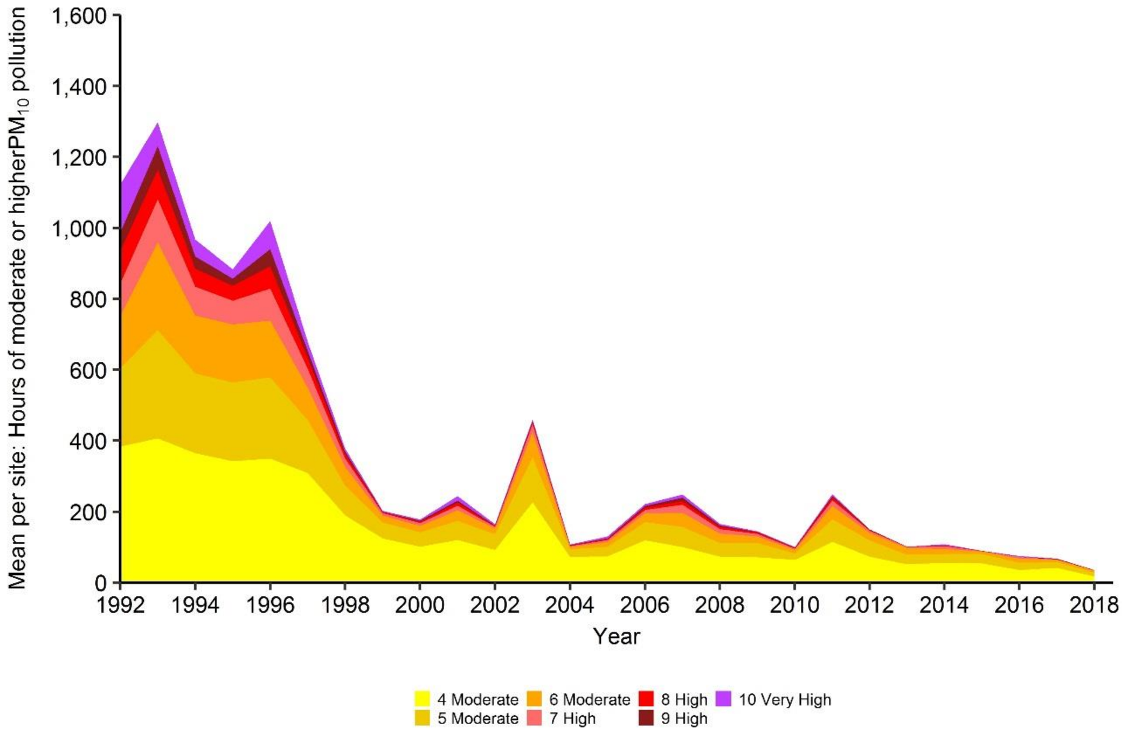


Figure 4: Annual mean hours per site when PM_{10} pollution was moderate or higher, for urban background sites, 1992 to 2018



- **Roadside and urban background monitoring sites have recorded fewer hours of 'moderate' or higher PM_{10} air pollution year-on-year in the long term**

At roadside and urban background sites the long-term trend has been a decline in the number of hours for which the mean PM_{10} concentration over the previous 24 hours exceeded 50 µg/m^3.

At the roadside the mean number of hours where PM_{10} concentrations exceeded this "moderate" threshold for a monitoring site decreased by 95 percent between 1997 and 2018 to the fewest hours in the time series (65 per site); an average decrease of 62 hours per year per site over the period.

At urban background sites the mean number of hours where PM_{10} concentrations exceeded the "moderate" threshold for a monitoring site decreased by 97 percent between 1992 and 2018 to the fewest hours in the time series (36 per site); an average decrease of 42 hours per year per site over the period. These statistics reflect the reduction in activity that cause short-term high concentrations of PM_{10} in the UK and Europe over time.

The downward trend in the time series has been interrupted in several years: most notably in 2003. In March and April 2003, meteorological analysis showed that concentrations at many monitoring sites were elevated due to primary emissions from Northern or Central Europe along with secondary particles caused by chemical reactions in the atmosphere. When cleaner Atlantic airflows became dominant in April 2003, pollution levels dropped drastically[5].

For $PM_{2.5}$, 'moderate' air pollution (which requires action by citizens who are vulnerable to the health impacts of air pollution) is triggered when the latest 24-hour running mean concentration is greater than 35 µg/m^3. The coloured categories relate to the categories of the Daily Air Quality Index (see Table 5).

[5] 'Air Pollution in the UK, 2003' https://uk-air.defra.gov.uk/assets/documents/reports/cat05/0502251134_Report_Air_Pollution_in_the_UK_Part_1_text.pdf

Figure 5: Annual mean hours when $PM_{2.5}$ pollution was moderate or higher for roadside sites, 2009 to 2018

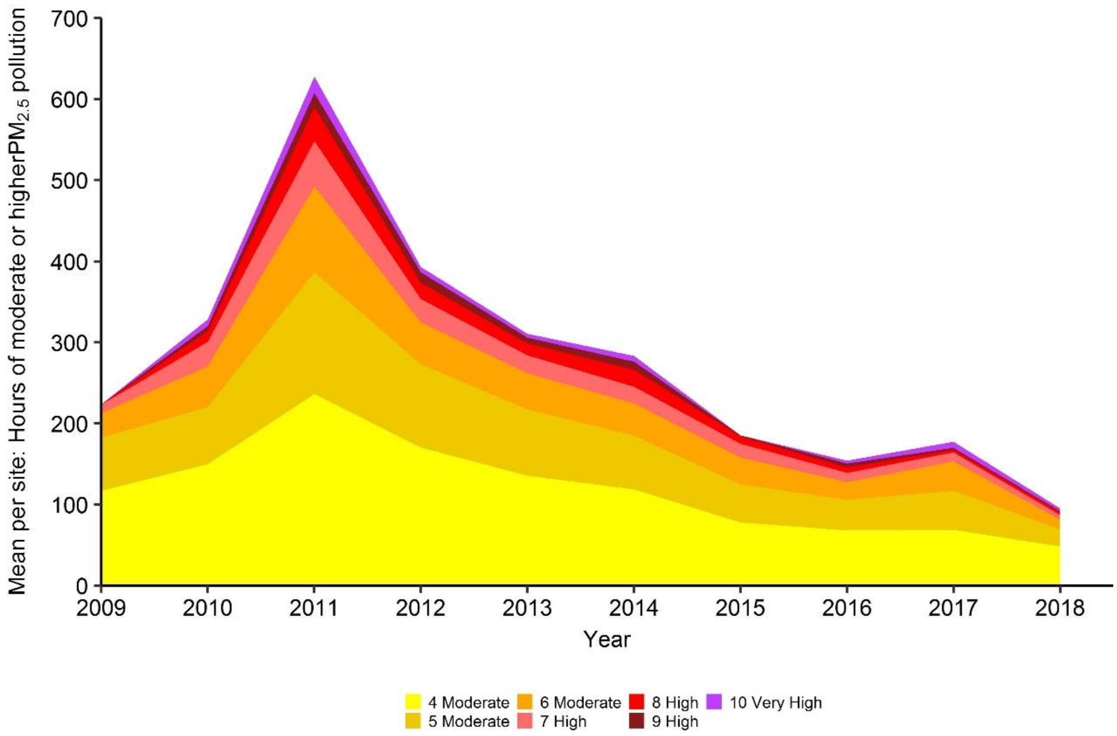
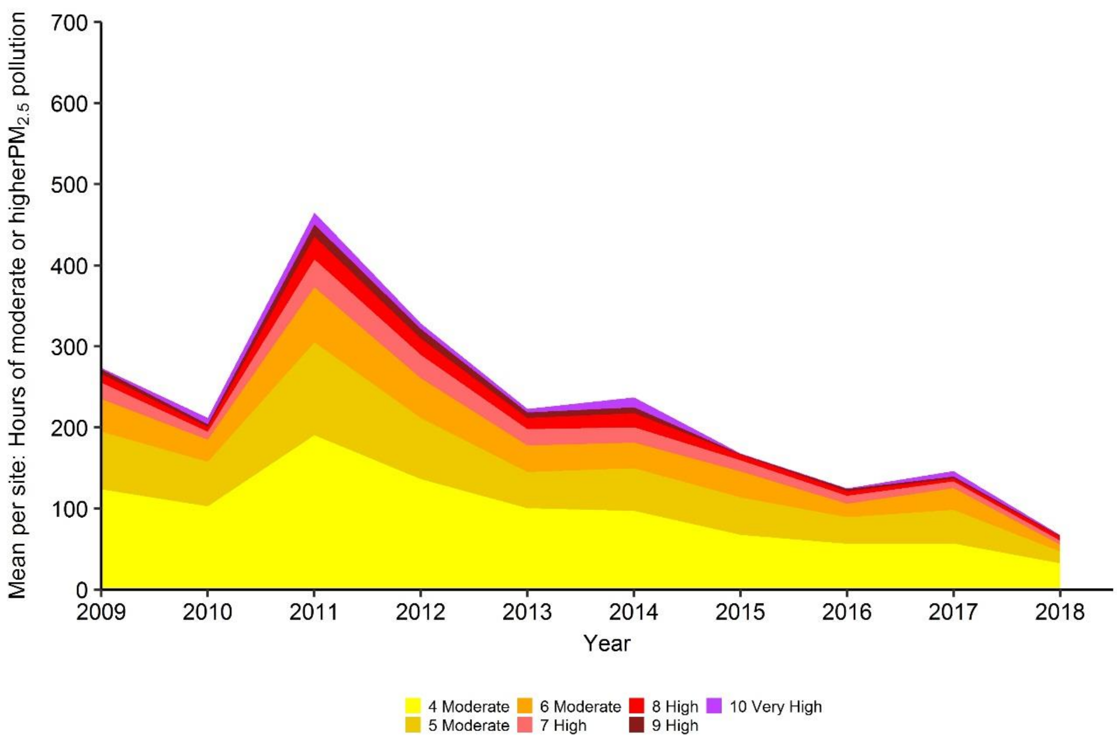


Figure 6: Annual mean hours when $PM_{2.5}$ pollution was moderate or higher for urban background sites, 2009 to 2018



- **Roadside and urban background monitoring sites have recorded a decreasing trend in hours of 'moderate' or higher $PM_{2.5}$ air pollution since the beginning of the time series.**

At roadside and urban background sites the trend since 2011 has been a decline in the number of hours for which the mean $PM_{2.5}$ concentration over the previous 24 hours exceeded 35 µg/m^3.

At the roadside the mean number of hours where $PM_{2.5}$ concentrations exceeded this "moderate" threshold for a monitoring site decreased by 85 percent between the peak year 2011 and 2018 to the fewest hours in the time series (95 per site); an average decrease of 76 hours per year per site over the period.

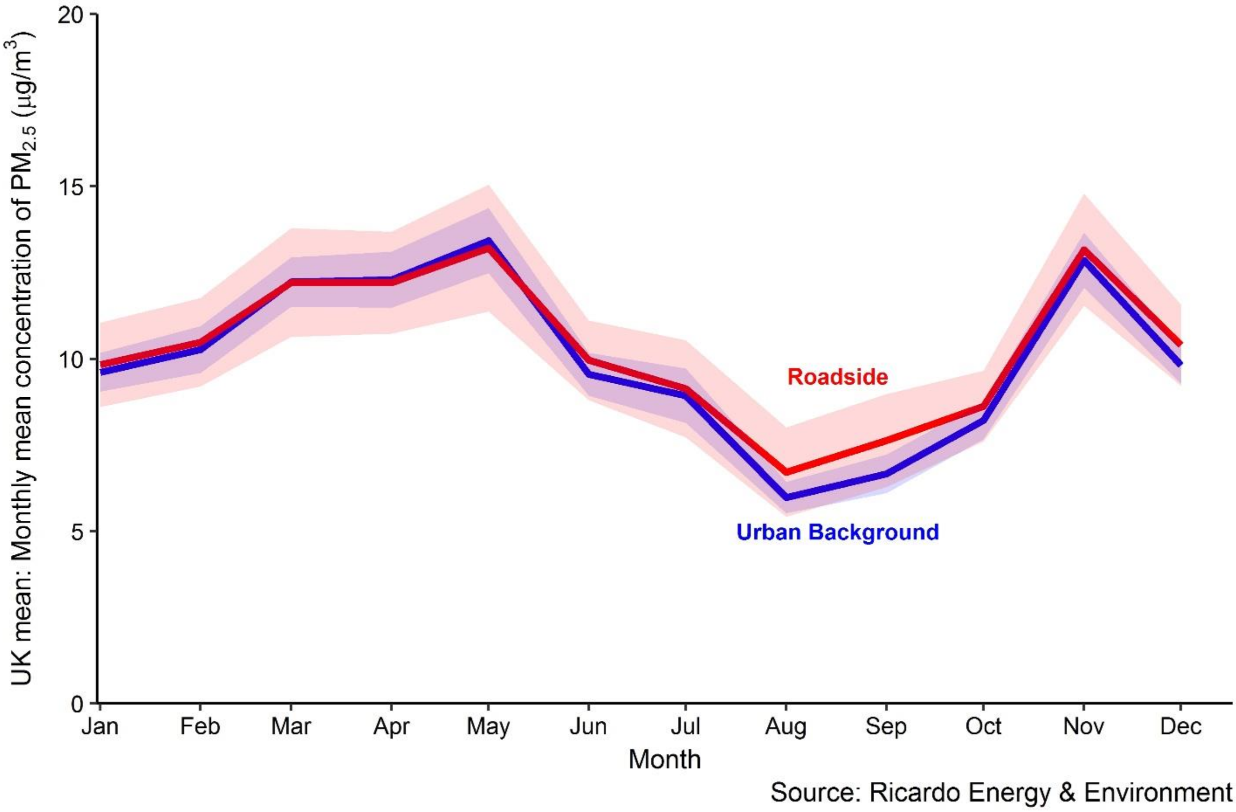
At urban background sites the mean number of hours where $PM_{2.5}$ concentrations exceeded the "moderate" threshold for a monitoring site decreased by 86 percent between the peak year 2011 and 2018 to the fewest hours in the time series (67 per site); an average decrease of 57 hours per year per site over the period.

Particulate pollution was particularly high in March and April 2011; due to a combination of secondary pollution being formed over mainland Europe and wind conditions carrying this pollution to the UK. A period of low wind conditions followed which allowed emissions from UK sources to build up in the atmosphere, leading to unusually high concentrations of particulate matter[6].

[6] 'Air Pollution in the UK 2011' https://uk-air.defra.gov.uk/library/annualreport/viewonline?year=2011_issue_2

Monthly variations in $PM_{2.5}$ concentrations

Figure 7: Monthly mean $PM_{2.5}$ concentration at roadside and urban background sites, 2018



Notes:

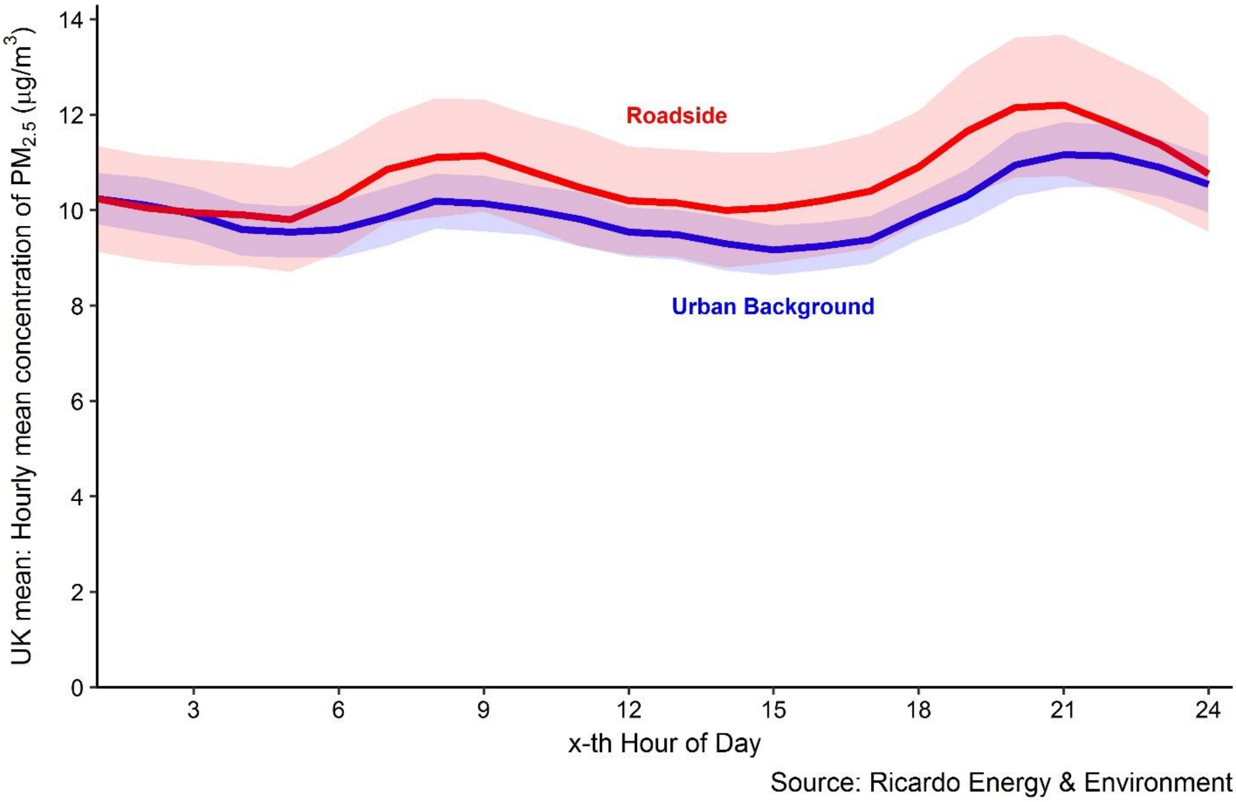
The $PM_{2.5}$ index shows the monthly mean, averaged over all included sites that had monthly data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the monthly mean concentration for roadside sites (red) and urban background sites (blue).

For $PM_{2.5}$ the highest concentrations in urban areas tended to occur during the winter and spring months in 2018. The greatest mean concentration in 2018 was in May (13.2 µg/m^3 for roadside sites and 13.4 µg/m^3 for urban background sites) and the greatest variation between sites was also in that month. Sites with relatively low annual mean $PM_{2.5}$ concentration have less monthly variation in concentrations than other sites.

Burning of wood and coal by households in stoves and open fires is a large contributor to emissions of particulate matter both in the UK and across Europe, and is more common in winter months. It should be noted that there are a large number of emission sources for particulate matter, and there may be other sources which contribute to this pattern. The contribution from sources originating outside of the UK can also be significant.

Hourly variations in $PM_{2.5}$ concentrations

Figure 8: Hourly mean $PM_{2.5}$ concentration at roadside and urban background sites, 2018



Notes:

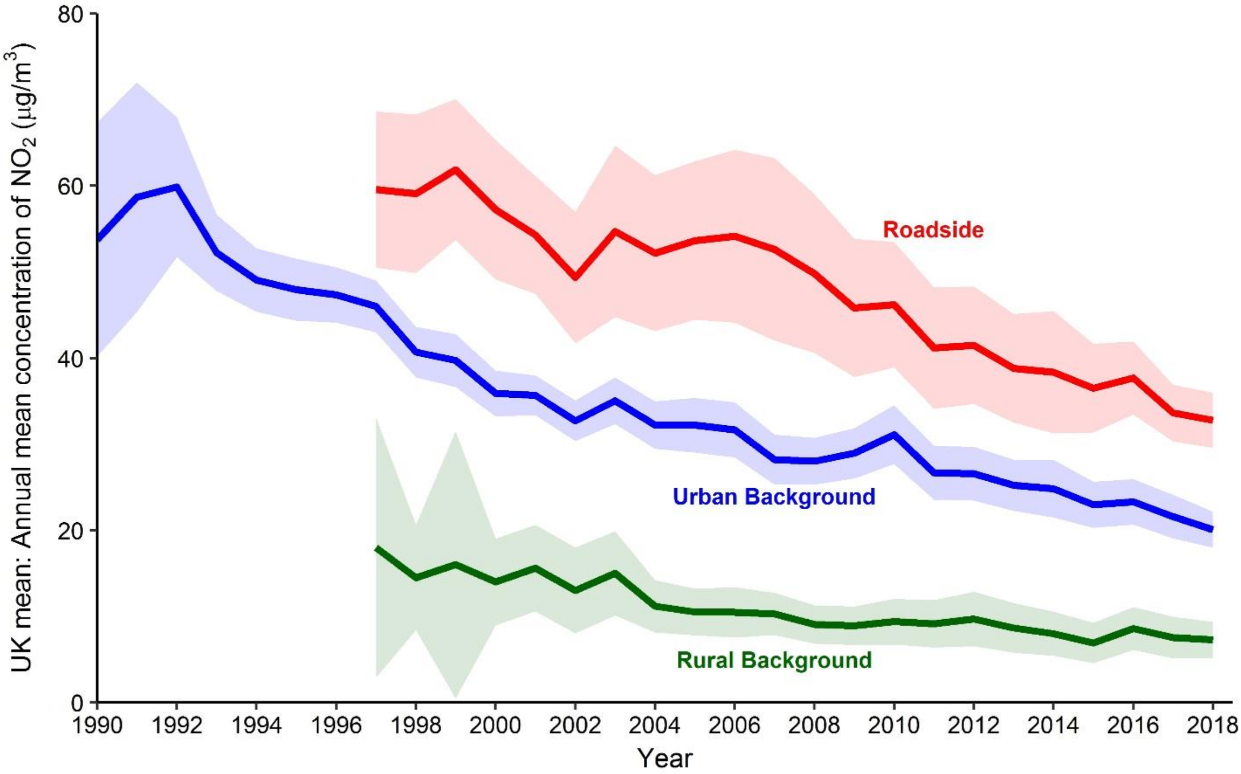
The $PM_{2.5}$ index shows the hourly mean, averaged over all included sites that had hourly data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the hourly mean concentration for roadside sites (red) and urban background sites (blue).

$PM_{2.5}$ concentrations tend to greater in the evening compared to other times of the day; in 2018 the greatest mean concentrations were between 8pm and 9pm (12.2 µg/m^3 for roadside sites and 11.2 µg/m^3 for urban background sites). This is thought to be the result of households burning wood, coal or other solid fuels in stoves or open fires for heating in the evenings, particularly in winter months.

Nitrogen dioxide (NO_2) concentrations

Annual Mean Concentrations of NO_2

Figure 9: Annual mean concentrations of NO_2 in the UK, 1990 to 2018



Source: Ricardo Energy & Environment

Notes:

The NO_2 index shows the annual mean, averaged over all included sites that had annual data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the annual mean concentration for roadside sites (red), urban background sites (blue) and rural background sites (green). The intervals narrow over time because of an increase in the number of monitoring sites and a reduction in the variation between annual means at monitoring sites for NO_2. Annual means for individual sites can be found in the NO_2 tables which accompany this report.

- **Urban background NO_2 pollution has reduced both in the long-term and in recent years**

  Average annual mean concentrations have decreased over the time series to 20.1 µg/m^3 in 2018, a low since the start of the time series in 1990.

  Between 1992 and 2002 inclusive, the annual mean NO_2 concentration at urban background sites reduced rapidly: by an average of 2.7 µg/m^3 each year. This reduction was observed at most monitoring sites across the UK; which could be a consequence of the large reduction in emissions of nitrogen oxides over the same period in the UK and in Europe.

Between 2002 and 2006 the annual mean concentration fluctuated with no clear trend and this was observed at most monitoring sites across the UK. Emissions of nitrogen oxides in the UK and Europe were still decreasing over this period but these years also coincided with increased use of coal in power stations, and with the increasing popularity of new diesel cars (which produce greater nitrogen oxide emissions than petrol equivalents).

Between 2006 and 2018 inclusive, the annual mean NO_2 concentration at urban background sites reduced by an average of 1.0 µg/m^3 each year. Reductions in concentrations were observed at most monitoring sites across the UK. Emissions of NO_2 in the UK and Europe have continued to decrease as newer road vehicles subject to stricter emission standards enter the fleet and power generation moves away from the use of coal, particularly in the UK.

- **Roadside NO_2 pollution has reduced in the long-term and in recent years, having been stable for most of the 2000s**

  Average concentrations have decreased over the time series to 32.8 µg/m^3 in 2018, a low since the start of the time series in 1997. The annual mean NO_2 concentration in 2018 is significantly greater at roadside sites compared to urban background sites. This is most likely due to substantial NO_2 emissions from road transport sources, as around 80 percent of concentrations at the roadside come from local transport sources.

  For most of the 2000s, the annual mean NO_2 concentration was stable, likely as a result of the increased ownership of diesel-fuelled vehicles which historically emitted far more nitrogen oxides compared to equivalent petrol-fuelled vehicles. This may have offset the impact of reduced emissions from other sources.

  Between 2007 and 2018 inclusive, the annual mean NO_2 concentration at roadside sites reduced by an average of 1.8 µg/m^3 each year. This reduction was observed at most long-running monitoring sites across the UK; which could be a consequence of the large reduction in road transport emissions of NO_2 over the same period in the UK, as newer vehicles subject to stricter emissions standards enter the transport fleet.

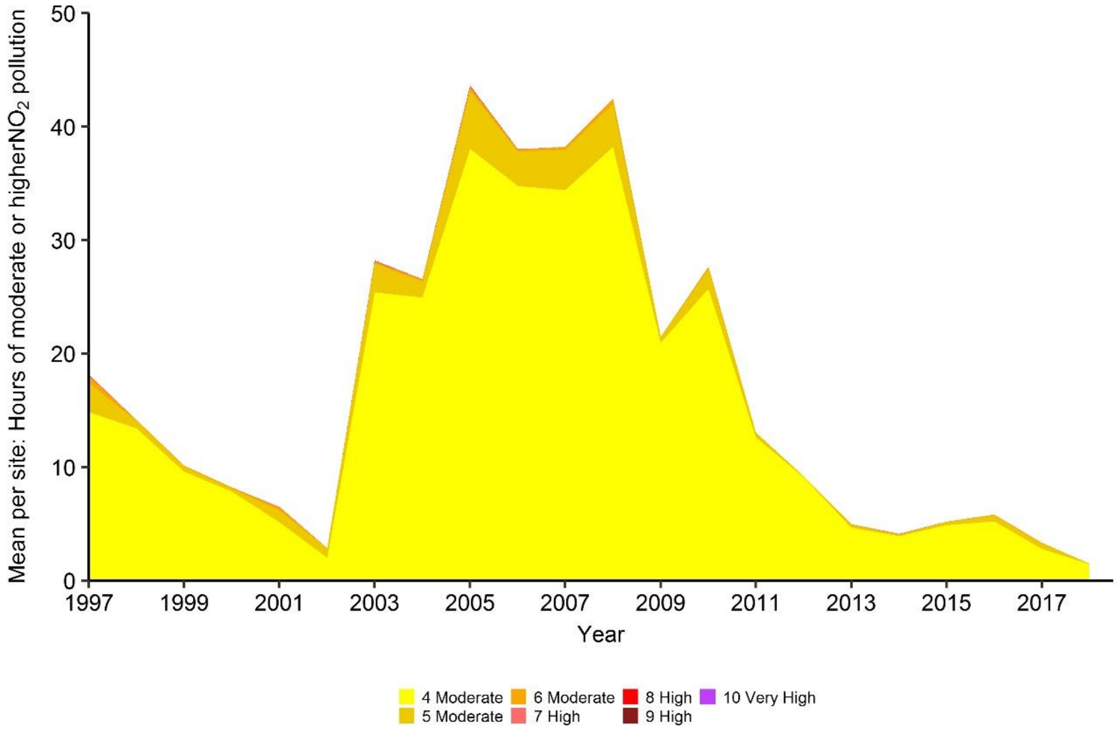
- **Rural background NO_2 pollution has reduced at a gradual rate over time; and is at low concentrations generally**

  Average concentrations have decreased over the time series to 7.3 µg/m^3 in 2018, similar to the time series low of 6.9 µg/m^3 in 2015. Since the start of the time series in 1997, the annual mean NO_2 concentration at rural background sites has reduced rapidly: by an average of 0.5 µg/m^3 each year. This reduction was observed at most monitoring sites across the UK; which could be a consequence of the large reduction in emissions of nitrogen oxides over the same period in the UK and in Europe.

Average hours spent in 'Moderate' or higher NO_2 pollution

This metric measures the annual trend in the number of hours on average that concentrations are recorded at levels that may have impacts on human health. For NO_2, 'moderate' air pollution (which requires action by citizens who are vulnerable to the health impacts of air pollution) is triggered when the latest hourly mean concentration is greater than 200 µg/m^3. The coloured categories relate to the categories of the Daily Air Quality Index (see Table 5).

Figure 10: Mean hours when NO_2 pollution is moderate or higher for roadside sites, 1997 to 2018



- **Roadside monitoring sites have recorded a decreasing trend in hours of 'moderate' air pollution due to NO_2 since 2008. 2018 had the fewest hours of 'moderate' air pollution per site due to NO_2 since the beginning of the time series.**

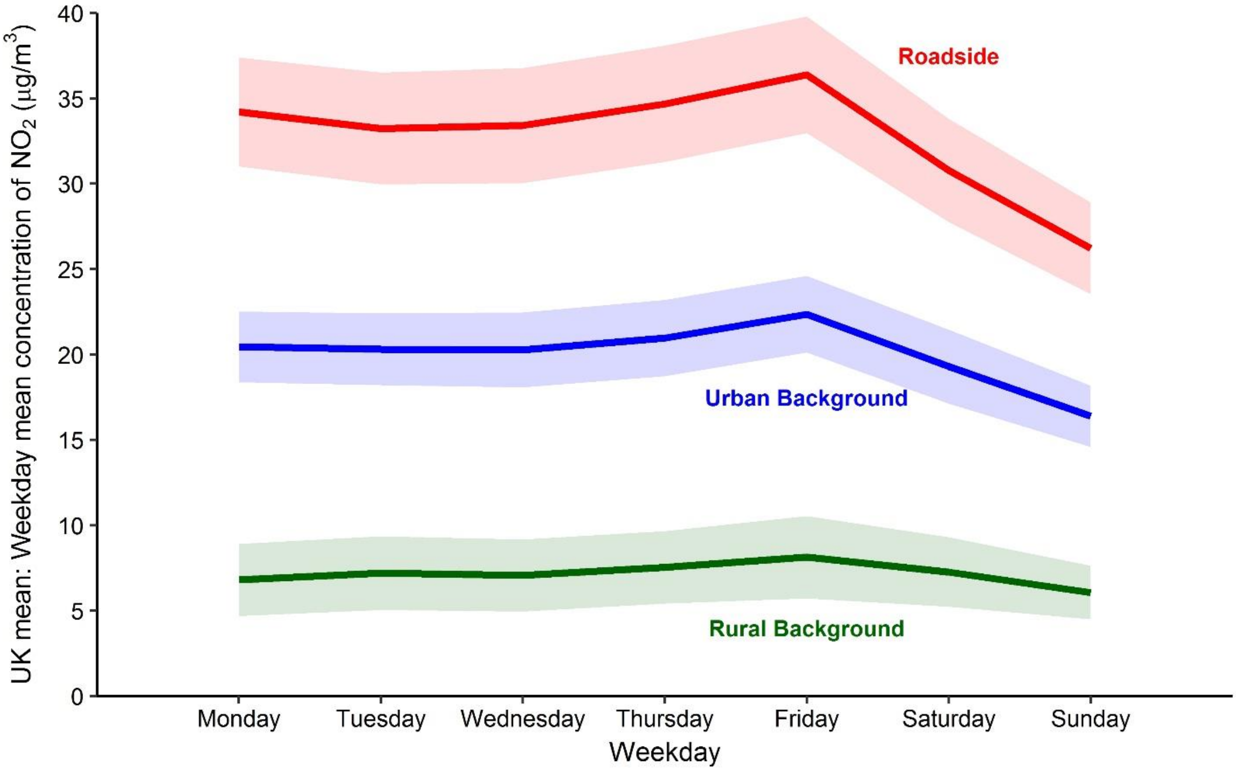
At roadside sites between 2017 and 2018 there was a decrease in the number of hours for which the mean NO_2 concentration over the previous hour exceeded 200 µg/m^3; from 3.3 hours to 1.5 hours per site. Urban background sites rarely record concentrations at these levels: less than 0.1 hours per site in 2018.

For PM_{10} and $PM_{2.5}$ moderate and high air pollution has historically been experienced at many monitoring sites across the UK; but for NO_2 moderate air pollution has been experienced by only a few particular sites. The overall trend follows the same trend as the London Marylebone Road site which recorded a peak of 853 hours in the 'moderate' category in 2005 and has reduced to 29 hours in this category in 2018. The other main site contributing to ‘moderate’ NO_2 pollution in 2018 was the Hafod-yr-ynys Roadside site in South Wales (54 hours in the ‘moderate’ category).

Moderate NO_2 pollution at the roadside is usually the consequence of a build-up of emissions of nitrogen oxides from transport sources, and the street canyon or wind conditions preventing dispersion of pollutants. For example, the London Marylebone Road site is on a six-lane congested road surrounded by high-rise buildings in central London.

Weekday variations in NO_2 concentrations

Figure 11: Weekday mean NO_2 concentration at roadside, urban background and rural background sites, 2018



Source: Ricardo Energy & Environment

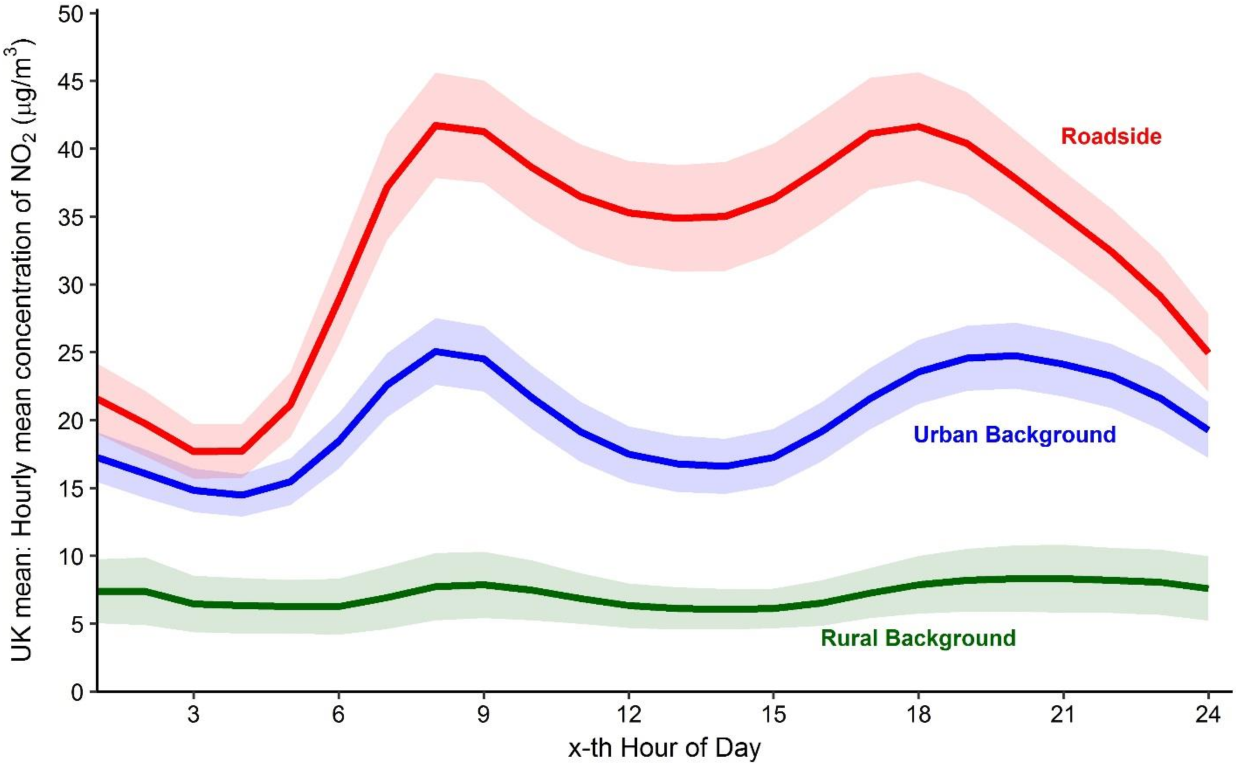
Notes:

The NO_2 index shows the weekday mean, averaged over all included sites that had weekday data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the weekday mean concentration for roadside sites (red), urban background sites (blue) and rural background sites (green).

NO_2 concentrations tend to be much lower at the weekend compared to during weekdays; particularly for roadside sites. This is likely to be primarily driven by far less road traffic at the weekends. In 2018, the Monday-to-Friday mean concentration at roadside sites was 34.4 µg/m^3; significantly greater than the mean concentration at the weekend (28.6 µg/m^3).

Hourly variations in NO_2 concentrations

Figure 12: Hourly mean NO_2 concentration at roadside, urban background and rural background sites, 2018



Source: Ricardo Energy & Environment

Notes:

The NO_2 index shows the hourly mean, averaged over all included sites that had hourly data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the hourly mean concentration for roadside sites (red), urban background sites (blue) and rural background sites (green).

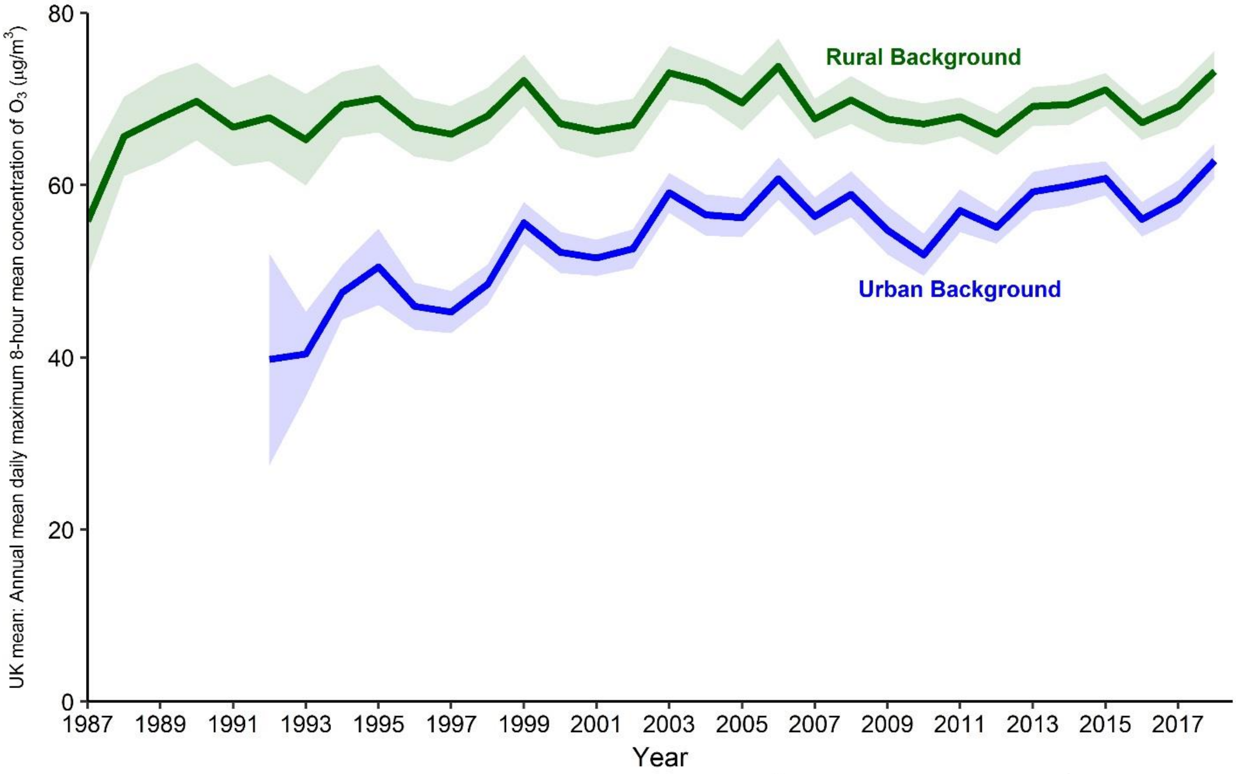
NO_2 concentrations tend to be much greater during the morning and evening rush hour compared to other times of the day, for roadside and urban background sites. This is most likely due to commuter traffic during the working week; as this observation does not apply to Saturdays and Sundays. This pattern of concentrations follows the distribution of road traffic by time of day[7].

[7] Road traffic estimates in Great Britain, 2017 https://www.gov.uk/government/statistics/road-traffic-estimates-in-great-britain-2017

Ozone (O_3) concentrations

Annual Mean Concentrations of O_3

Figure 13: Annual mean daily maximum 8-hour mean concentrations of O_3 in the UK, 1987 to 2018



Source: Ricardo Energy & Environment

Notes:

The O_3 index shows the annual mean of the daily maximum 8-hour mean, averaged over all sites that had annual data capture greater than or equal to 75%. The shaded areas represent the 95% confidence interval for the annual mean concentration for urban background sites (blue) and rural background sites (green). Annual means for individual sites can be found in the O_3 tables which accompany this report.

- **Urban background ozone pollution has shown a long-term increase but has been stable for the last decade**

  The average daily maximum eight hour mean concentration has increased since 1992 and was 62.8 µg/m^3 in 2018; a significant increase compared to 2017 (58.3 µg/m^3). Concentrations have fluctuated since the mid-2000s. Some variance from year-to-year is expected due to fluctuations in the occurrence of hot summer weather conditions which are associated with high ozone concentrations.

  From the start of the time series in 1992 to the mid-2000s, urban background ozone concentrations were increasing. This may have been due to the reduction in emissions of nitrogen oxides in the UK and Europe, which can inhibit the formation of ozone in urban areas.

- **Rural background ozone pollution has shown no clear long-term trend**

The average daily maximum eight hour mean concentration has fluctuated since the start of the time series in 1987 and was 73.2 µg/m^3 in 2018; a significant increase in concentration compared to 2017 (69.1 µg/m^3). Some variance from year-to-year is expected due to fluctuations in the occurrence of hot summer weather conditions which are associated with high ozone concentrations. The future trend in concentrations may be dependent on global emissions of ozone precursor substances.

Average hours spent in 'Moderate' or higher O_3 pollution

This metric measures the annual trend in the number of hours on average that concentrations are recorded at levels that may have impacts on human health. For O_3, 'moderate' air pollution (which requires action by citizens who are vulnerable to the health impacts of air pollution) is triggered when the latest 8-hour running mean concentration is greater than 100 µg/m^3. The coloured categories relate to the categories of the Daily Air Quality Index (see Table 5).

Figure 14: Mean hours when O_3 pollution is moderate or higher for rural background sites, 1987 to 2018

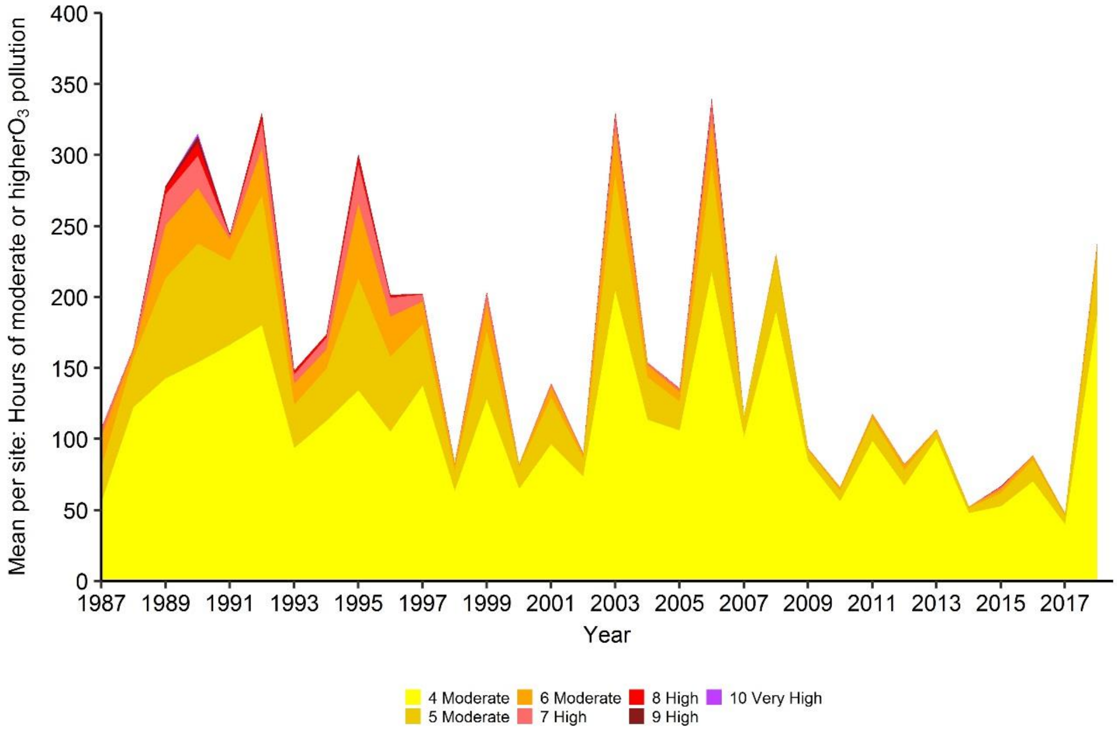
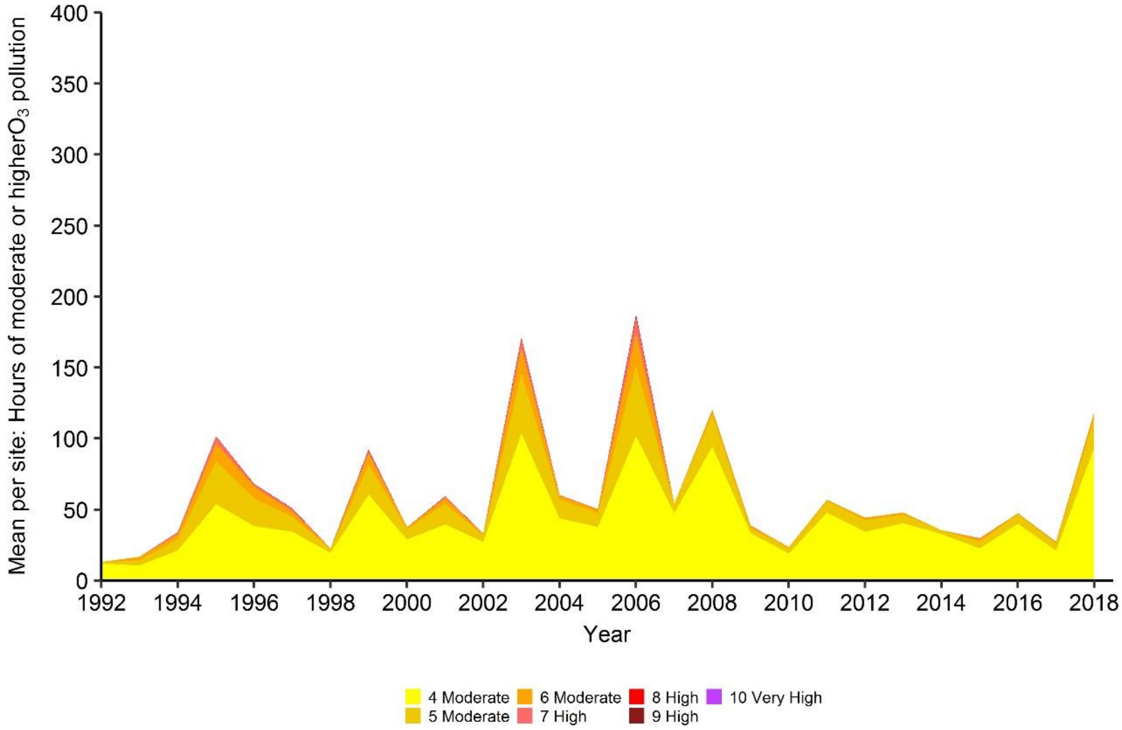


Figure 15: Mean hours when O_3 pollution is moderate or higher for urban background sites, 1992 to 2018



- **Rural and urban background monitoring sites have recorded greater hours of 'moderate' or higher O_3 air pollution in 2018 compared to 2017; though overall the time series is volatile.**

At rural and urban background sites between 2017 and 2018 there was an increase in the number of hours for which the mean O_3 concentration over the previous 8 hours exceeded 100 µg/m^3.

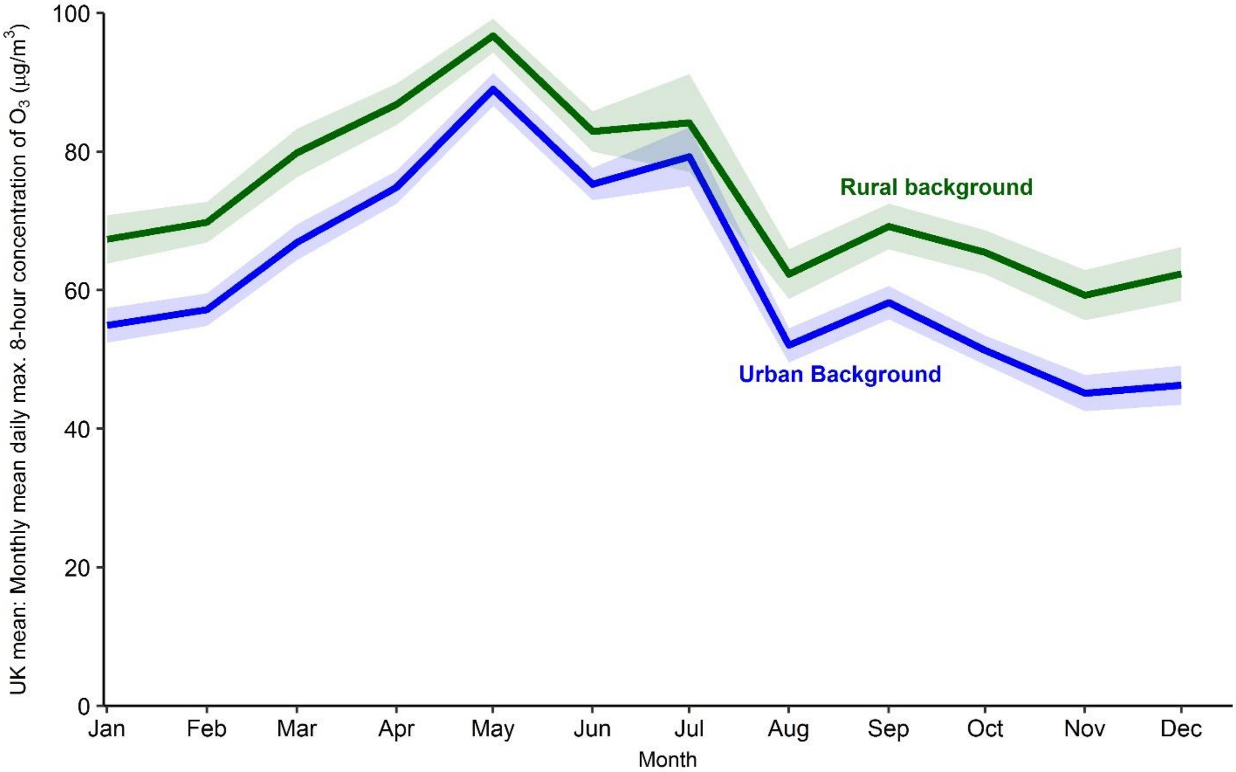
At rural sites the mean number of hours where O_3 concentrations exceeded this threshold for a monitoring site in 2018 was 239 compared with 48 in 2017. The comparable figures for urban background sites were 119 hours in 2018 compared with 27 hours in 2017. For both rural and urban background sites this was the greatest number of hours of moderate or higher ozone pollution since 2008.

The overall trend in the rural indicator is a long-term decrease interrupted by several years where moderate pollution was more common; and the same is true for the urban background indicator but to a lesser extent. The long-term decrease and the recent reduction in volatility is likely driven by reductions in global emissions of substances that lead to the formation of ozone such as nitrogen oxides and volatile organic compounds.

Ozone concentrations are strongly influenced by weather, which contributes to the high variability over time and peaks such as in the hot summers of 2003, 2006 and 2018. This means that long time series are required to distinguish between weather effects and the effect of changes in pollutant emissions.

Monthly variations in O_3 concentrations

Figure 16: Monthly mean daily maximum 8-hour mean concentrations of O_3 in the UK, 2018

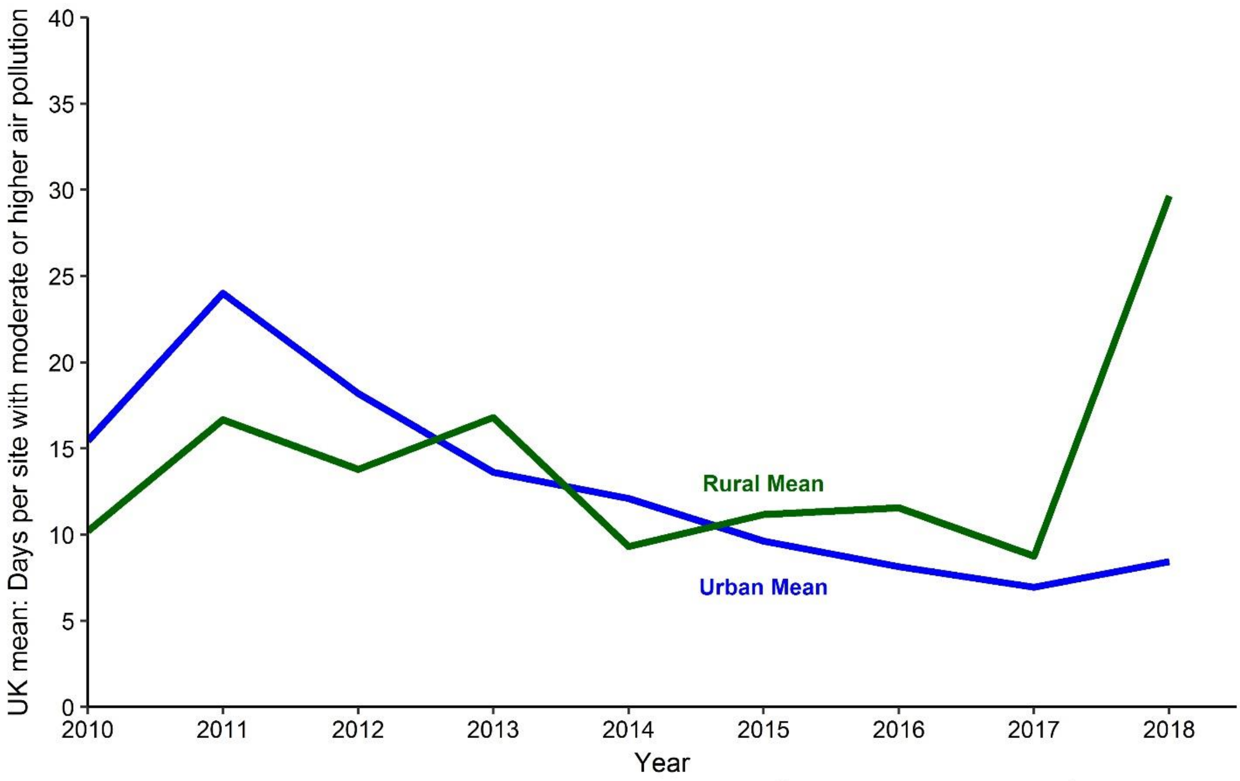


Source: Ricardo Energy & Environment

For O_3 the greatest average concentrations tend to occur during the spring and summer months. In 2018 the month that had the greatest ozone concentrations was May for both rural and urban monitoring sites (with monthly mean concentrations of 96.7 µg/m^3 and 89.0 µg/m^3 respectively).

Days with moderate or higher air pollution

Figure 17: Mean number of days per site when air pollution is moderate or higher in the UK, 2010 to 2018



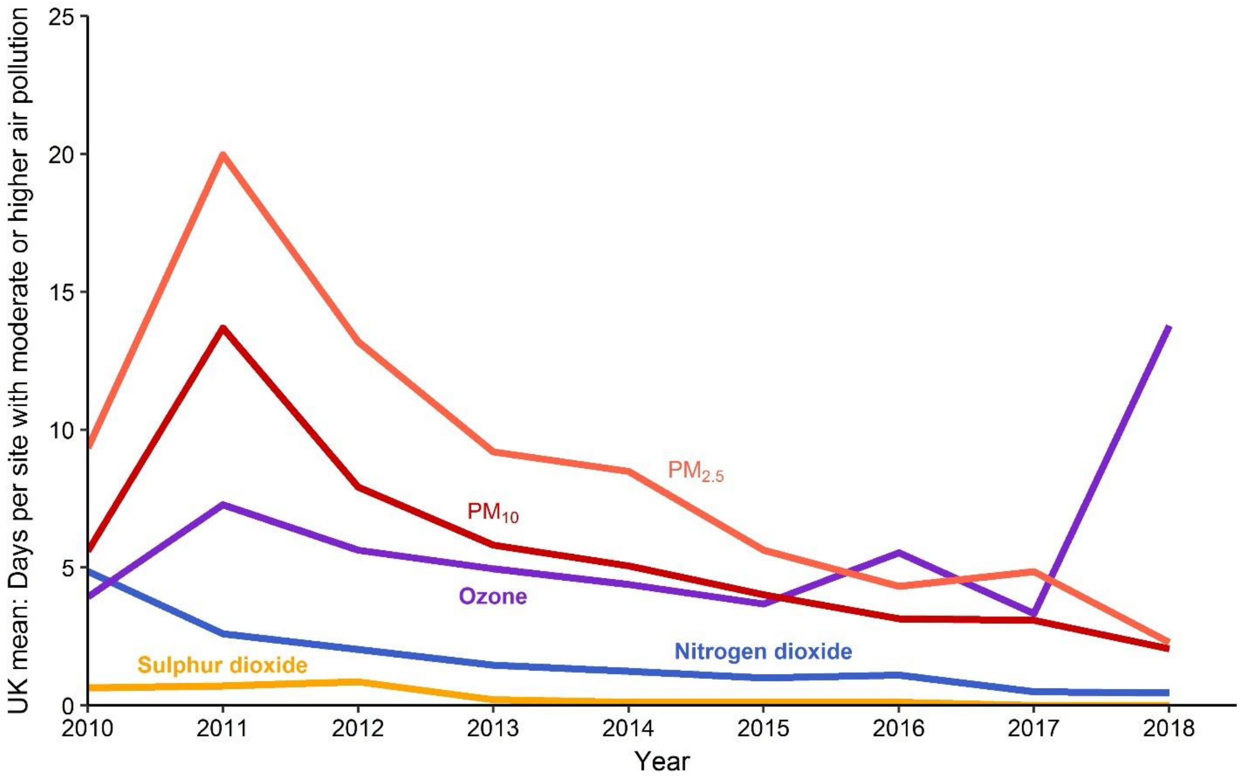
Source: Ricardo Energy & Environment

Figure 17 illustrates that:

- **There were on average a similar days of moderate or higher pollution at urban monitoring sites in 2018 compared with recent years; following a significant decrease between 2011 and 2015**: the average number of pollution days declined from 24.0 days in 2011 to 8.4 days in 2018. This is not significantly different from the lowest value in the time series: 7.0 days in 2017.

- **There is no clear trend in the number of days of moderate or higher air pollution at rural sites, but the number of days of moderate or higher air pollution increased to the highest value in the time series in 2018:** the average number of days increased from 8.8 days in 2017 to 29.7 days in 2018. Moderate and higher pollution days coincided with the prolonged hot and sunny conditions in spring and summer 2018.

Figure 18: Average number of days when levels of ozone, particulate matter, nitrogen dioxide and sulphur dioxide were moderate or higher at urban sites in the UK, 2010 to 2018



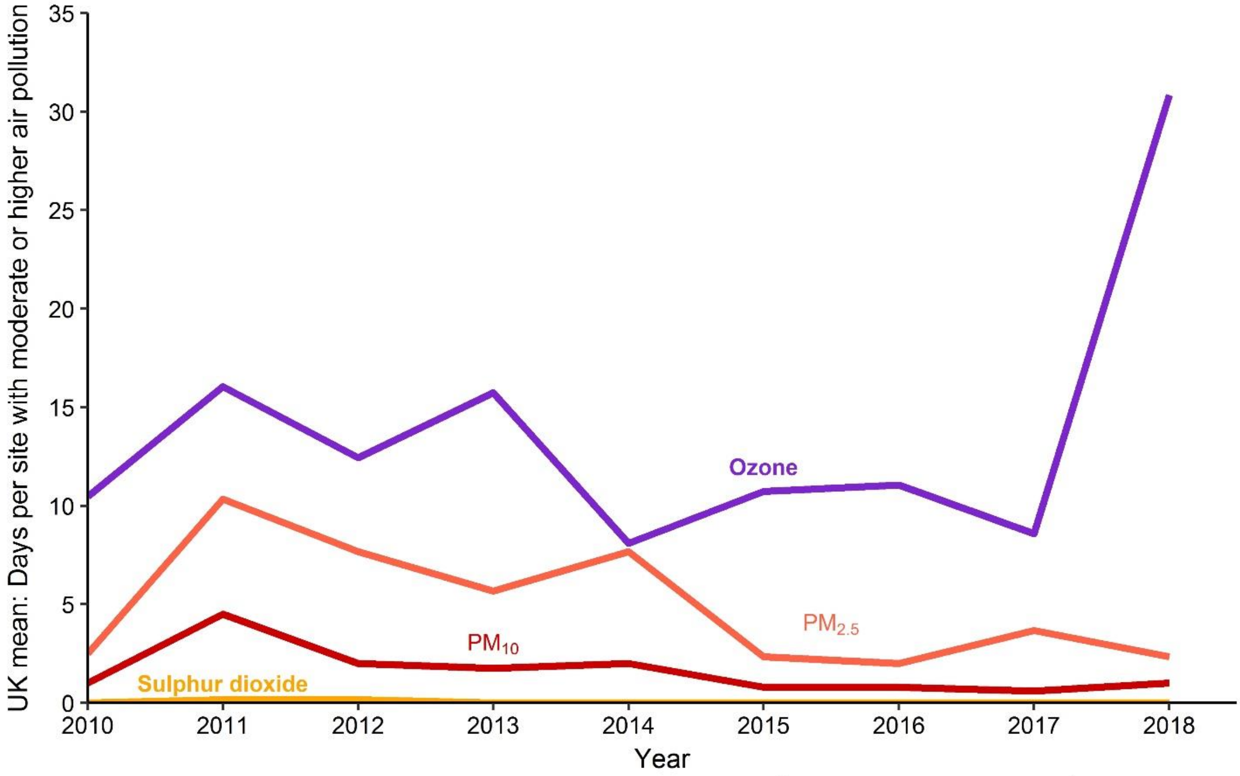
Source: Ricardo Energy & Environment

Note: for the purposes of this chart, where more than one pollutant exceeds the moderate threshold on any given day, it is counted for each pollutant i.e. there is double counting.

Figure 18 illustrates that:

- At urban sites the average number of days above the moderate threshold has decreased for PM_{10} year-on-year since the peak in 2011. In 2018, both PM_{10} and $PM_{2.5}$ had the lowest number of days with moderate or higher air pollution in the time series.
- Prior to 2018, there was no trend in days of moderate or higher ozone pollution. There was a large increase in moderate or higher air pollution days attributable to ozone pollution between 2017 (3.3 days per site) and 2018 (13.8 days per site), due to the prolonged hot and sunny conditions in spring and summer 2018.
- Nitrogen dioxide has caused on average 0.5 days of moderate or higher pollution in urban areas during 2018; a new low for the time series. This represents a decline since 2010 which had 4.9 days per site of moderate or higher nitrogen dioxide pollution.
- Sulphur dioxide did not cause any moderate or higher pollution days in 2018. This reflects the large reductions in emissions from the early 1990s.

Figure 19: Average number of days when levels of ozone, particulate matter, and sulphur dioxide were moderate or higher at rural sites in the UK, 2010 to 2018



Source: Ricardo Energy & Environment

Note: for the purposes of this chart, where more than one pollutant exceeds the moderate threshold on any given day, it is counted for each pollutant i.e. there is double counting. There were no days when levels of nitrogen dioxide were moderate or higher at rural sites in the UK between 2010 and 2018; hence data for this pollutant are not shown.

Figure 19 illustrates that:

- At rural sites in 2018 ozone was the main cause of moderate or higher pollution days, with a significant increase from 8.6 days in 2017 to 30.8 days in 2018. Sulphur dioxide and nitrogen dioxide did not directly contribute to the moderate or higher pollution days at rural sites, with no days of moderate or higher pollution attributed to these sources at any of the rural monitoring sites in 2018.

- PM_{10}, $PM_{2.5}$ and ozone caused all of the moderate or higher pollution days at rural sites in 2018, either separately or in combination with each other. Levels of these pollutants are particularly influenced by weather, which contributes to the variability over time.

A National Statistics publication

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Responsible Defra statistician: Philip Taylor

Main notes

1. The banding system used to determine moderate or higher air pollution is that of the UK Daily Air Quality Index. The version which has been used for this statistical release is displayed in Table 5 of the Annex.
2. More detailed data, site metadata and information are published on the UK-AIR website.
3. Further information on air quality policy is available from the Defra website.
4. Further details and data relating to UK air quality are available on Defra's Air Quality Statistics website.

Annex

Table 1: Annual average levels of PM_{10}, $PM_{2.5}$, NO_2 and O_3 ($\mu g\ m^{-3}$), 1987 to 2018

Year	PM_{10}		$PM_{2.5}$		NO_2			O_3	
	Roadside	Urban background	Roadside	Urban background	Roadside	Urban background	Rural background	Urban background	Rural background
1987									56
1988									66
1989									68
1990						54			70
1991						59			67
1992		36				60		40	68
1993		35				52		40	65
1994		32				49		48	69
1995		31				48		51	70
1996		32				47		46	67
1997	37	30			60	46	18	45	66
1998	33	26			59	41	15	48	68
1999	32	24			62	40	16	56	72
2000	31	23			57	36	14	52	67
2001	31	23			54	36	16	52	66
2002	29	23			49	33	13	53	67
2003	31	25			55	35	15	59	73
2004	27	22			52	32	11	57	72
2005	28	22			54	32	11	56	70
2006	30	24			54	32	10	61	74
2007	27	22			53	28	10	56	68
2008	22	19			50	28	9	59	70
2009	20	19	13	12	46	29	9	55	68
2010	22	19	14	13	46	31	9	52	67
2011	23	20	16	14	41	27	9	57	68
2012	20	17	14	13	41	27	10	55	66
2013	20	17	13	12	39	25	9	59	69
2014	19	17	13	12	38	25	8	60	69
2015	17	15	11	10	37	23	7	61	71
2016	19	16	11	10	38	23	9	56	67
2017	17	14	10	10	34	22	8	58	69
2018	19	15	11	10	33	20	7	63	73

Notes:

1. Each time series has been revised to reflect that sites can only contribute to the annual mean if they had at least 75% data capture.
2. PM_{10}, $PM_{2.5}$, NO_2: annual mean, averaged across all included sites.
3. Ozone: annual mean of the daily maximum 8 hour running mean: average across all included sites

Table 2: Average number of days of moderate or higher air pollution per site, 2010 to 2018

Year	Rural mean	Urban mean
2010	10.2	15.4
2011	16.7	24.0
2012	13.8	18.2
2013	16.8	13.6
2014	9.3	12.1
2015	11.2	9.6
2016	11.6	8.1
2017	8.8	7.0
2018	29.7	8.4

Notes:

Not every site in the automatic monitoring network is included. Sites must also meet certain data capture targets to be used in the index. Urban sites are required to monitor PM_{10} and rural sites are required to monitor ozone. For the required pollutants data capture should be more than or equal to 75% of the year. For ozone this applies to both the full year and the summer period in isolation.

Table 3: Average number of days of moderate or higher air pollution at urban sites caused by each of the basket of 5 pollutants, 2010 to 2018

Year	O_3	NO_2	SO_2	PM_{10}	$PM_{2.5}$
2010	3.9	4.9	0.6	5.6	9.3
2011	7.3	2.6	0.7	13.7	20.0
2012	5.6	2.0	0.9	7.9	13.2
2013	5.0	1.5	0.2	5.8	9.2
2014	4.4	1.2	0.1	5.1	8.5
2015	3.7	1.0	0.1	4.0	5.6
2016	5.5	1.1	0.1	3.1	4.3
2017	3.3	0.5	0.0	3.1	4.9
2018	13.8	0.5	0.0	2.1	2.3

Notes:

Not every site in the automatic monitoring network is included. Sites must also meet certain data capture targets to be used in the index. Urban sites are required to monitor PM_{10} and rural sites are required to monitor ozone. For the required pollutants data capture should be more than or equal to 75% of the year. For ozone this applies to both the full year and the summer period in isolation.

Table 4: Average number of days of moderate or higher air pollution at rural sites caused by the each of the basket of 5 pollutants, 2010 to 2018

Year	O_3	NO_2	SO_2	PM_{10}	$PM_{2.5}$
2010	10.5	0.0	0.0	1.0	2.5
2011	16.1	0.0	0.2	4.5	10.3
2012	12.4	0.0	0.2	2.0	7.7
2013	15.7	0.0	0.0	1.8	5.7
2014 (r)	8.1	0.0	0.0	2.0	7.7
2015 (r)	10.7	0.0	0.0	0.8	2.3
2016 (r)	11.1	0.0	0.0	0.8	2.0
2017 (r)	8.6	0.0	0.0	0.6	3.7
2018	30.8	0.0	0.0	1.0	2.3

Notes:

Not every site in the automatic monitoring network is included. Sites must also meet certain data capture targets to be used in the index. Urban sites are required to monitor PM_{10} and rural sites are required to monitor ozone. For the required pollutants data capture should be more than or equal to 75% of the year. For ozone this applies to both the full year and the summer period in isolation.

(r) Revised figures

Table 5: Daily Air Quality Index, updated April 2013

Band	Index	Ozone	Nitrogen Dioxide	Sulphur Dioxide	$PM_{2.5}$ Particles	PM_{10} Particles
		Running 8 hourly mean	hourly mean	15 minute mean	24 hour mean	24 hour mean
		µgm^{-3}	µgm^{-3}	µgm^{-3}	µgm^{-3}	µgm^{-3}
LOW						
	1	0-33	0-67	0-88	0-11	0-16
	2	34-66	68-134	89-177	12-23	17-33
	3	67-100	135-200	178-266	24-35	34-50
MODERATE						
	4	101-120	201-267	267-354	36-41	51-58
	5	121-140	268-334	355-443	42-47	59-66
	6	141-160	335-400	444-532	48-53	67-75
HIGH						
	7	161-187	401-467	533-710	54-58	76-83
	8	188-213	468-534	711-887	59-64	84-91
	9	214-240	535-600	888-1064	65-70	92-100
VERY HIGH						
	10	241 or more	601 or more	1065 or more	71 or more	101 or more