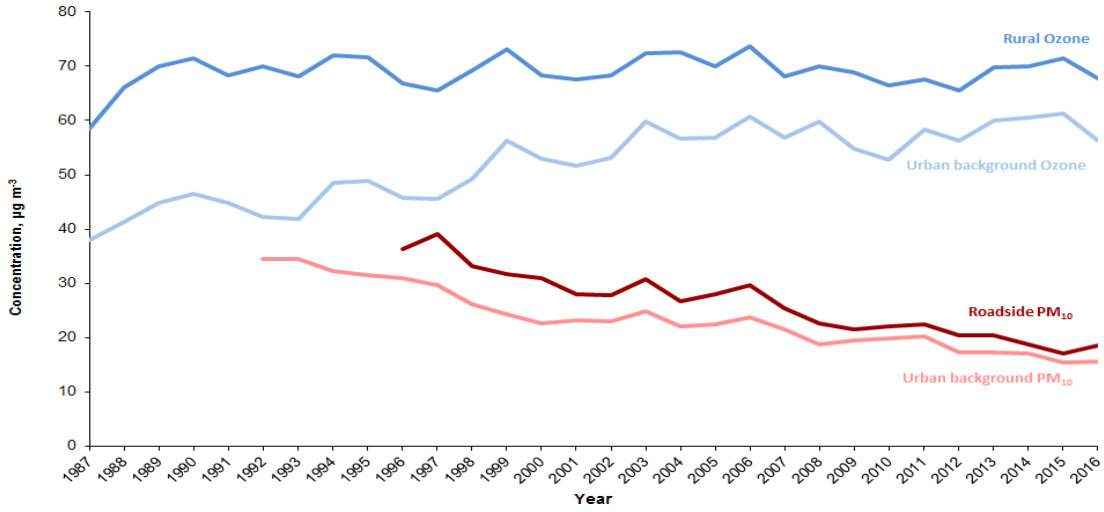
Department for Environment Food & Rural Affairs

Department for Environment, Food and Rural Affairs

STATISTICAL RELEASE: 27 April 2017

- **Urban background and roadside particulate pollution has shown long-term improvement however small increases in concentration are observed from 2015 to 2016 for roadside sites. There is some year-on-year variability with a long-term downward trend in urban background and roadside particulate pollution. For background sites the concentration of particulate pollution was similar in 2015 and 2016.**
- **There were on average fewer days of moderate or higher pollution at urban pollution monitoring sites in 2016 compared with 2015. There is an ongoing decline in days of moderate or higher pollution at urban sites.**
- **There were on average more days of moderate or higher pollution at rural pollution monitoring sites in 2016 compared with 2015. However, there is a great deal of year-on-year variability and there is no clear long-term trend.**
- **Urban background ozone pollution has remained fairly stable between 2003 and 2016, although concentrations have shown a long-term increase since monitoring began. Rural background ozone pollution has shown no clear long-term trend. Both these indicators decreased slightly from 2015 to 2016.**
- **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.**

Annual levels of PM_{10} and Ozone in the UK, 1987 to 2016



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Air quality statistics in the UK 1987 to 2016

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 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.

[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.

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 annual average concentrations in the UK of two pollutants thought to have the greatest health and environmental impacts due to longer term exposure (annual mean)[3]:

- Chronic exposure to particulate matter (PM_{10}) contributes to the risk of developing cardiovascular and respiratory diseases, and there is increasing evidence suggesting that long-term exposure to even low levels of particulate matter may have a significant effect on health. The annual average concentrations for particulate matter are considered a useful measure of overall exposure to particulate matter at all concentrations.

- 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[4]. The ozone concentration reported in this release is the annual average of the maximum daily eight-hour running mean.

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 air pollutants that affect health due to short term exposure (daily mean). The five pollutants included in the indicator from the 1st January 2012 are as follows:

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

Short term exposure to these five pollutants can have harmful effects on human health[5]. These pollutants are principally the products of combustion from space heating, power generation or from motor vehicle traffic. Fine particles ($PM_{2.5}$) can be carried deep into the lungs where they can cause inflammation and a worsening of heart and lung

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

diseases. The gases irritate the airways of the lungs, increasing the symptoms of those suffering from conditions such as lung diseases.

Defra's air pollution information service uses an index and banding system recommended by the Committee on Medical Effects of Air Pollutants (COMEAP)[6]. 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.

Methodological changes

"Annual levels of PM_{10} and Ozone in the UK" indicator

Changes have been made in recent years to the methodology used to calculate the "Annual levels of PM_{10} and Ozone in the UK" indicator. The data are now extracted from UK-AIR, which automatically applies a minimum annual data capture requirement of 75% for these annual statistics[7]. From a scientific point of view this is a better approach: it has therefore been adopted for the annual PM_{10} and ozone indicator statistics as of 2013. For previous years, comparing the statistics produced with and without the 75% minimum data capture requirement showed that its use had minimal effect on the indicator statistics. Typically the difference was within 1 µg m^{-3} except in some cases for earlier years when there were fewer sites. For this reason, the statistics for years up to 2012 inclusive have not been changed. This change only affects the annual PM_{10} and ozone indicator statistics (Figure 1 and Annex Table 1): for the other statistics, those based on days with Moderate or higher pollution, a 75% minimum data capture requirement has been in use throughout the presented time-series.

"Number of days with Moderate or higher air pollution" indicator

A change in methodology for the "number of days with Moderate or higher air pollution" indicator was introduced in 2013, as described in the Pre-Release Announcement on Methodological Changes issued in February 2013[8]. As explained in the announcement, the following changes have previously been made:

1. The pollutants included; and
2. The thresholds and in some cases, time periods used for the air pollution bandings.

[6] https://uk-air.defra.gov.uk/air-pollution/daqi?view=more-info&pollutant=pm25

[7] That is, if a specific monitoring station does not have data for 75% (or greater) of the year then it is excluded from the statistic calculations for the relevant pollutant.

[8] http://webarchive.nationalarchives.gov.uk/20130123162956/http:/www.defra.gov.uk/statistics/files/AQS-pre-release-statement-feb13.pdf

The change to the pollutants was the replacement of carbon monoxide (CO) by fine particulate matter ($PM_{2.5}$), as recommended by COMEAP. All other pollutants are still included.

These changes, made in order to ensure statistical alignment with calculation methods for EU Limit Values, have in most cases made the index more stringent. For nitrogen dioxide and PM_{10} the lower threshold of the Moderate band has been reduced, with the new threshold now consistent with the limit values set by the European Union Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe. The April 2013 update additionally increases the Moderate band for sulphur dioxide by 1µg m^{-3} to align it with the UK 15 minute objective set out in the 2007 Air Quality Strategy.

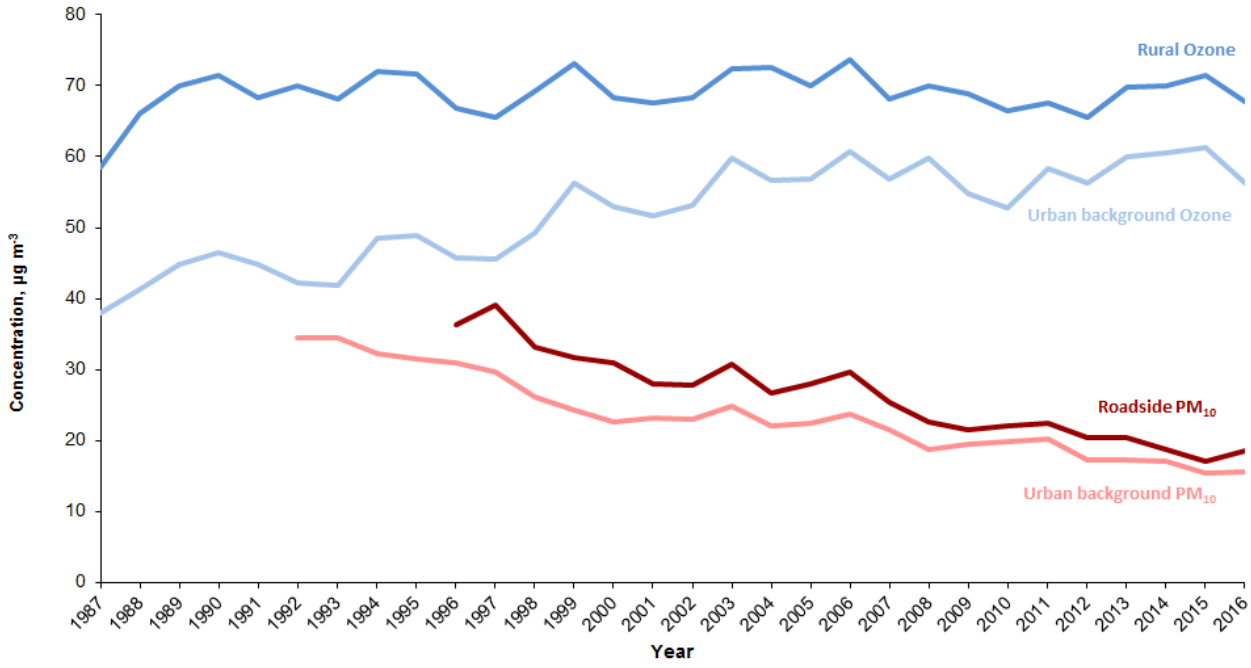
For some pollutants, the definition of the air quality bandings has also changed since January 2012. The air quality bandings for PM_{10} (and $PM_{2.5}$) now refer to the daily mean, while those for ozone now refer to the maximum daily eight-hour running mean instead of being based on either the maximum daily eight-hour or one-hour mean.

This statistical release has been undertaken using the updated April 2013 version which is set out in Table 6. These changes, together with an update on implementation of the index are provided in more detail on UK-AIR[9]. Annual figures on average days per site with Moderate or higher air pollution are presented from 2010 as the methodological changes described above were retrospectively applied to the previous two year's data (2010 and 2011) for the 2013 publication of this release. Up until 2015 the data produced using the outdated methodology was also presented. However, there is now a sufficient time series with the updated methodology to enable trends to be observed without reference to the previous methodology.

[9] http://uk-air.defra.gov.uk/library/reports?report_id=750

Particulate (PM_{10}) and Ozone concentrations

Figure 1: Annual concentrations of PM_{10} and Ozone in the UK, 1987 to 2016 (No data capture threshold pre-2013, 75% from 2013 onwards)



Notes:

The ozone index shows the annual average of the maximum daily eight-hour running mean, averaged over all included sites. The PM_{10} index shows the annual mean, averaged over all included sites.

Figure 1 illustrates that:

- **Urban background PM_{10} pollution has shown long-term improvement but the rate of change has reduced in recent years:** average concentrations have gone down fairly consistently throughout the time series to 15.5 µg m^{-3} in 2015, a low since monitoring began in 1992. The average concentration in 2016 was 15.6 µg m^{-3}; similar to 2015.

- **Roadside PM_{10} pollution has shown long-term improvement but the rate of change has reduced in recent years:** average concentrations steadily declined to 17.1 µg m^{-3} in 2015, a new low since monitoring began in 1996. The average concentration in 2016 was 18.6 µg m^{-3}; a small increase compared to 2015.

- **Urban background ozone pollution has shown a long-term increase:** the average maximum daily eight hour mean concentration has increased since 1987 and was 56.3 µg m^{-3} in 2016; a decrease in concentration compared to 2015 (61.3 µg m^{-3}). This ends the sequence of year-on-year increases between 2012 and 2015.

- **Rural background ozone pollution has shown no clear long-term trend:** average concentrations increased since 1987 to 67.7 µg m^{-3} in 2016. This was a decrease compared to 2015.

The data are presented in Table 1 of the Annex at the end of this statistical release. Statistics for 2015 have been re-calculated as there were some minor changes to the dataset since last year's Statistical Release was produced.

Trends in particulate matter concentrations are driven by changes in emissions of PM_{10}, which steadily declined until around a decade ago[10] when the rate of decline decreased. The steady decline was attributable to a move away from coal to gas in both electricity generation and domestic and commercial combustion; and also the introduction of emission standards for road vehicles.

Both particulate and 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 and 2006. This means that long time series are required to distinguish between weather effects and the effect of changes in pollutant emissions.

Emissions of the pollutants that are the main precursors to ozone (including nitrogen oxides (NO_x) and volatile organic compounds (VOCs)) have reduced substantially, but this is not reflected in the long-term trend in ozone concentrations. This may be partly explained by a proportion of the ozone experienced in the UK originating from releases of precursor pollutants that are blown over from mainland Europe and trends in hemispheric background concentrations.

A similar lack of an apparent link between emissions and measured concentrations of ozone in the air is observed Europe wide. The European Environment Agency provides further analysis of European air quality.

[10] See Statistical release: Emissions of air pollutants in the UK, 1970-2015

Days with moderate or higher air pollution

Figure 2: Average number of days per site when air pollution is moderate or higher in the UK, 2010-2016

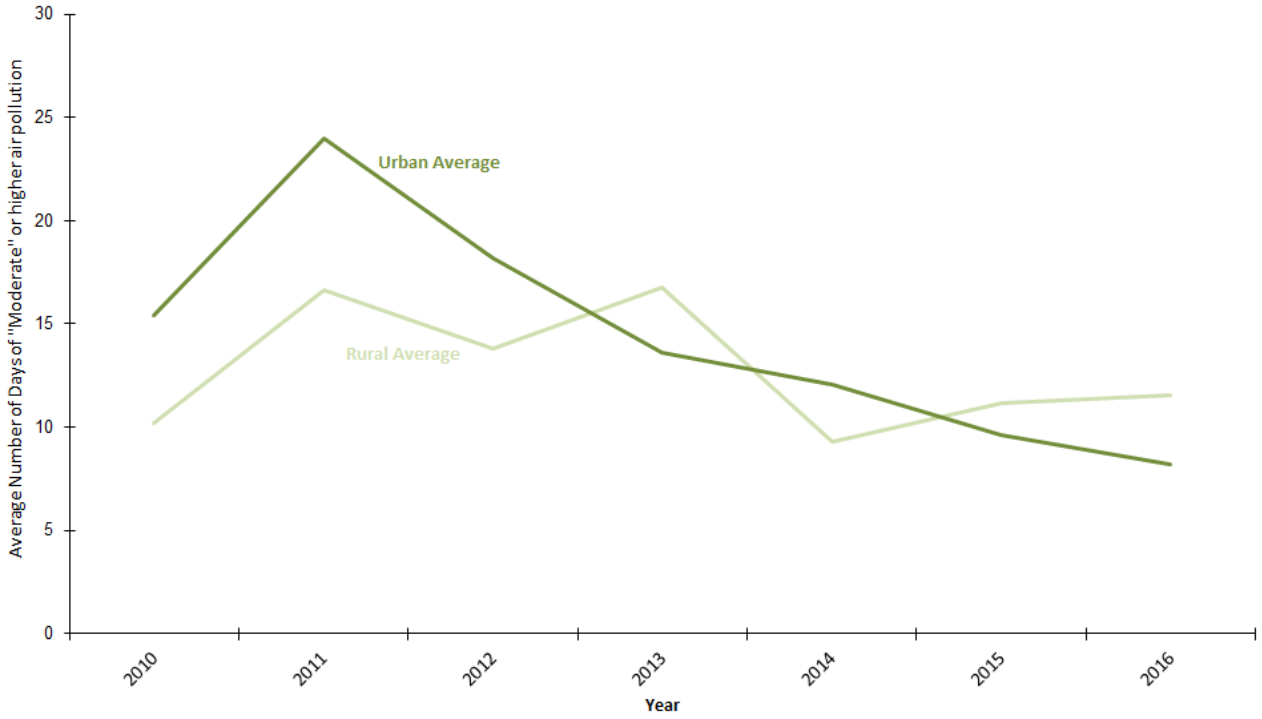


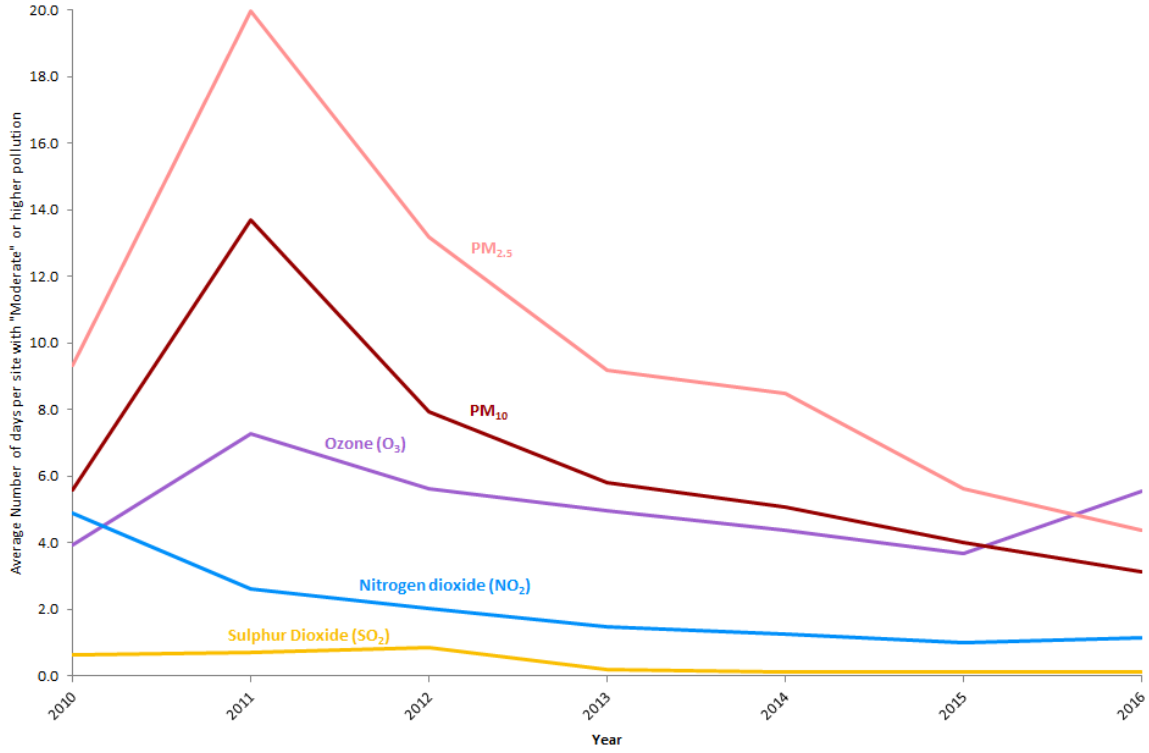
Figure 2 illustrates that:

- **There were on average fewer days of moderate or higher pollution at urban pollution monitoring sites in 2016 compared with any other year under the current methodology**: the average number of pollution days declined from 24.0 days in 2011 to 8.2 days in 2016, which is below the previous lowest point of 9.6 days of moderate or higher air pollution days in 2015.

- **There is no clear trend in the number of days of moderate or higher air pollution at rural sites:** the average number of days increased from 11.2 days in 2015 to 11.6 days in 2016.

The data are presented in Table 2 of the Annex at the end of this statistical release.

Figure 3: 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, 2010-2016



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.

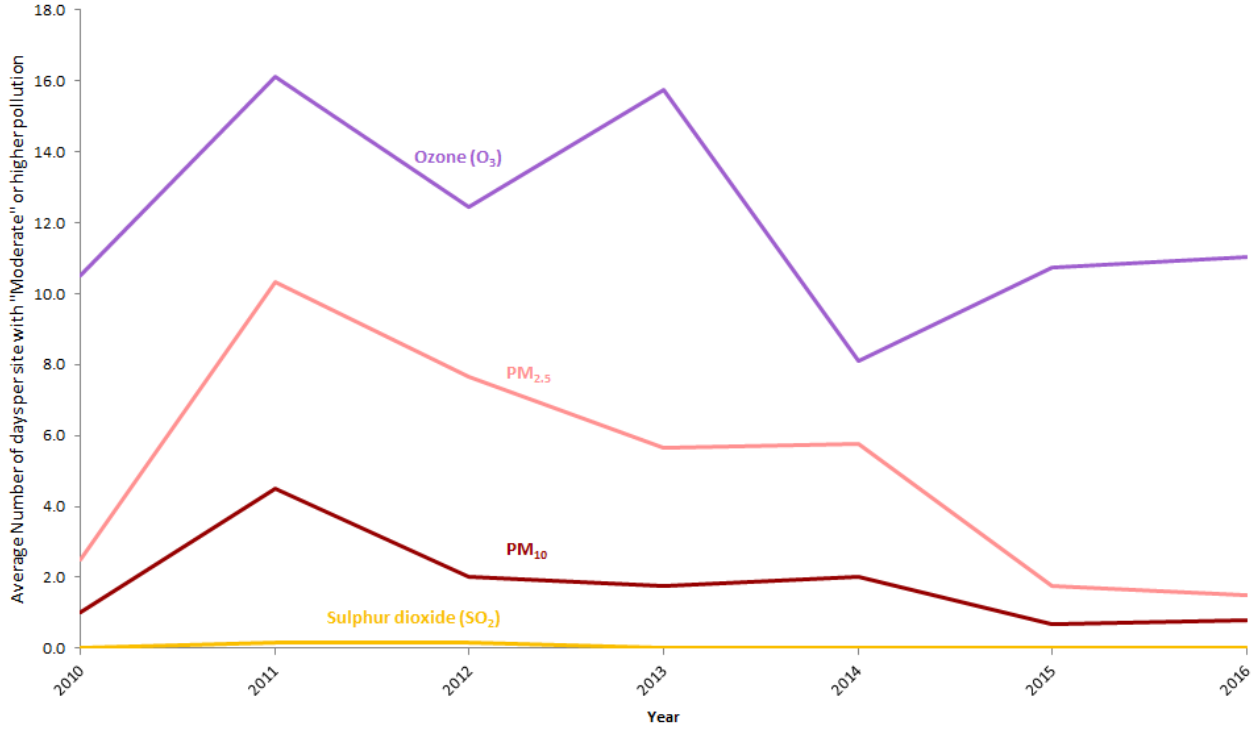
The data are presented in Table 3 of the Annex at the end of this statistical release

Figure 3 illustrates that:

- At urban sites the average number of days above the moderate threshold has decreased for particulate matter year-on-year since the peak in 2011.
- The ozone contribution has increased to over that of particulate matter, ending a sequence of year-on-year decreases in average number of days above the moderate threshold between 2011 and 2015. Levels of PM_{10}, $PM_{2.5}$ and ozone are particularly influenced by weather, which contributes to the variability over time.
- Nitrogen dioxide has caused on average 1.1 days of moderate or higher pollution in urban areas during 2016; similar to 2015. This represents a decline since 2010 which had 4.9 days of moderate or higher nitrogen dioxide pollution.
- Sulphur dioxide continues to cause less than one pollution day per site on average. This low number of pollution days reflects the large reductions in emissions from the early 1990s[11].

[11] See Statistical release: Emissions of air pollutants in the UK, 1970-2015

Figure 4: Average number of days when levels of ozone, particulate matter, and sulphur dioxide were moderate or higher at rural sites in the UK, 2010-2016



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 2016; hence data for this pollutant are not shown.

The data are presented in Table 4 of the Annex at the end of this statistical release

Figure 4 illustrates that:

- At rural sites in 2016 ozone was the main cause of moderate or higher pollution days, with an increase from 10.7 days in 2015 to 11.1 in 2016. 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 2016.

- PM_{10}, $PM_{2.5}$ and ozone caused the vast majority of the moderate or higher pollution days at rural sites in 2016, 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

National Statistics are produced to high professional standards set out in the Code of Practice for Official Statistics. They undergo regular quality assurance reviews to ensure they meet customer needs.

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 6 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 Environment Statistics website.

Annex

Table 1: Annual average levels of PM_{10} and Ozone (µg m^{-3}), 1987-2016, UK

Year	PM_{10}		Ozone	
	Roadside	Urban background	Rural	Urban background
1987	..	..	58	38
1988	..	..	66	41
1989	..	..	70	45
1990	..	..	72	46
1991	..	..	68	45
1992	..	35	70	42
1993	..	35	68	42
1994	..	32	72	49
1995	..	32	72	49
1996	36	31	67	46
1997	39	30	65	46
1998	33	26	69	49
1999	32	24	73	56
2000	31	23	68	53
2001	28	23	68	52
2002	28	23	68	53
2003	31	25	72	60
2004	27	22	73	57
2005	28	22	70	57
2006	30	24	74	61
2007	25	22	68	57
2008	23	19	70	60
2009	22 (19)1	19 (22)1	69	55
2010	22 (22)1	20	66	53
2011	23	20	68	58
2012	20	17	66	56
2013	20	17	70	60
2014	19	17	70	60
2015 (r)	17	15	72	61
2016	19	16	68	56

Notes:

1. Since 2008, upgrade of numerous PM_{10} monitoring instruments has enabled correction of measurements taken from sites using older equipment, by using the Volatile Correction Model (VCM). These results are shown in parentheses. Non-VCM corrected data for 2008 and 2009 are retained here for the purpose of year-on-year comparison. From 2011 all monitoring instruments had been upgraded so no correction is necessary.

2. PM_{10}: annual mean, averaged across all included sites.
3. Ozone: annual mean of the daily maximum 8 hour running mean: average across all included sites
4. .. not available because of insufficient data
5. (r) Revised figures
6. Not every site in the automatic monitoring network is included. Sites must also meet certain data capture targets to be used in the index. For both ozone and PM_{10}, from 2013 onwards data capture should be greater than or equal to 75% of the year.
7. Cardiff Centre and Manchester Piccadilly were excluded in 1994 and 2001 respectively, because stone cutting adjacent to sites caused unrepresentative results. Narberth was excluded in 2004 and 2007 due to incorrect measurements. Great Dun Fell was excluded until 2001 due to sample lines being frozen. Reading New Town was excluded in 2008 due to low data capture for PM_{10} caused by faulty new measuring instruments.

Table 2: Average number of days of moderate or higher air pollution per site, 2010-2016, UK

Year	Rural Average	Urban Average
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 (r)	11.2	9.6
2016	11.6	8.2

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 3: Average number of days of moderate or higher air pollution at urban sites caused by each of the basket of 5 pollutants, 2010-2016, UK

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 (r)	3.7	1.0	0.1	4.0	5.6
2016	5.5	1.1	0.1	3.1	4.4

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.

(r) Revised figures

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, 2010-2016, UK

	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	8.1	0.0	0.0	2.0	5.8
2015 (r)	10.7	0.0	0.0	0.7	1.8
2016	11.1	0.0	0.0	0.8	1.5

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: UK Air quality bandings applicable until 31st December 2011

Band	Index	Ozone		Nitrogen Dioxide		Sulphur Dioxide		Carbon Monoxide		PM_{10} Particles	
		Running 8 hourly or hourly mean*		hourly mean		15 minute mean		Running 8 hourly mean		Running 24 hour mean	
		µg m^{-3}	ppb	µg m^{-3}	ppb	µg m^{-3}	ppb	mg m^{-3}	ppm	µg m^{-3} (Grav. Equiv.)	µg m^{-3} (Ref. Equiv.)
Low											
	1	0-33	0-16	0-95	0-49	0-88	0-32	0-3.8	0.0-3.2	0-21	0-19
	2	34-65	17-32	96-190	50-99	89-176	33-66	3.9-7.6	3.3-6.6	22-42	20-40
	3	66-99	33-49	191-286	100-149	177-265	67-99	7.7-11.5	6.7-9.9	43-64	41-62
Moderate											
	4	100-125	50-62	287-381	150-199	266-354	100-132	11.6-13.4	10.0-11.5	65-74	63-72
	5	126-153	63-76	382-477	200-249	355-442	133-166	13.5-15.4	11.6-13.2	75-86	73-84
	6	154-179	77-89	478-572	250-299	443-531	167-199	15.5-17.3	13.3-14.9	87-96	85-94
High											
	7	180-239	90-119	573-635	300-332	532-708	200-266	17.4-19.2	15.0-16.5	97-107	95-105
	8	240-299	120-149	636-700	333-366	709-886	267-332	19.3-21.2	16.6-18.2	108-118	106-116
	9	300-359	150-179	701-763	367-399	887-1063	333-399	21.3-23.1	18.3-19.9	119-129	117-127
Very High											
	10	360 or more	180 or more	764 or more	400 or more	1064 or more	400 or more	23.2 or more	20 or more	130 or more	128 or more

* For ozone, the maximum of the 8 hourly and hourly mean was used to calculate the index value.

Table 6: Revised Daily Air Quality Index, updated April 2013

Band	Index	Ozone Running 8 hourly mean µgm^{-3}	Nitrogen Dioxide hourly mean µgm^{-3}	Sulphur Dioxide 15 minute mean µgm^{-3}	$PM_{2.5}$ Particles 24 hour mean µgm^{-3}	PM_{10} Particles 24 hour mean 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