



Environment Agency **UK Hydrocarbons Network**

Annual Report for 2025

21 July 2026



Document distribution

Environment Agency

UK Hydrocarbons Network

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21 July 2026

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- Environment Agency
- Department for Environment, Food and Rural Affairs
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Contents

1.	Executive summary	5
2.	Introduction	7
2.1	Sources of NMVOCs	7
2.2	Regulatory background	9
2.2.1	UK Air Quality Objectives	9
2.2.2	European Directive Limit Values	9
2.2.3	The European Monitoring and Evaluation Programme	10
2.3	Network background and methods	11
2.3.1	Non-Automatic Benzene Monitoring	11
2.3.2	Automatic Hydrocarbon Monitoring	11
3.	Site Management	14
3.1	Monitoring stations during 2025	14
3.2	Equipment Maintenance and Audits	15
4.	Data Quality	17
4.1	Estimation of Uncertainty	17
4.2	Determination of precision	18
4.3	Uncertainty calculations	18
4.4	Standard Methods	19
4.5	Limit of Detection	20
5.	Data Analysis	22
5.1	Comparison with Limit Values and Objectives	22
5.2	Instrumental Impacts on Data Capture	25
5.3	Long-term trend of benzene concentration	26
5.4	Impact of VOCs on regional O ₃ formation	29
5.4.1	Regional O ₃ increment	29
5.4.2	Photochemical ozone creation potential	31
5.5	Automatic Data Time Variations for Benzene	35
5.5.1	Auchencorth Moss	35
5.5.2	Chilbolton Observatory	36
5.5.3	Marylebone Road	37
5.5.4	London Honor Oak Park	38
5.6	Benzene Modelling	38
6.	Developments and recommendations	39

6.1	BS EN14662-1:2023	39
6.2	Standard method for ozone precursors	39
7.	Conclusions	40
8.	References	41
9.	Appendices	43

Tables

Table 2-1: UK Air Quality Objectives	9
Table 2-2: Benzene Limit Value and Assessment Thresholds	10
Table 2-3: Species measured by the automatic chromatographs. Note that m-xylene and p-xylene are reported as a single measurement	12
Table 4-1: Automatic analyser limit of detection	20
Table 9-1: Information of the monitoring stations in the automatic hydrocarbon network.	43
Table 9-2: Information of the monitoring stations in the non-automatic hydrocarbon network	43
Table 9-3: Summary statistics for all VOCs measured at the automatic monitoring sites in 2025	45

1. Executive summary

This report contains data and actions undertaken by Ricardo, however at the time of writing, the Ricardo business had been acquired by WSP UK Ltd¹. The UK Hydrocarbons Network comprises automatic and non-automatic systems to measure benzene in compliance with the European Directive 2008/50/EC (AQD) (EC, 2008).

In the UK, ambient (outdoor) air quality is regulated by the Air Quality Standards Regulations. These are as follows:

- The Air Quality Standards Regulations 2010 in England (UK Government, 2010), and their December 2016 (UK Government, 2016) and January 2019 (UK Government, 2019) amendments.
- The Air Quality Standards (Scotland) Regulations 2010 in Scotland (Scottish Government, 2010), and their December 2016 amendment (Scottish Government, 2016).
- The Air Quality Standards (Wales) Regulations 2010 in Wales (Welsh Government, 2010) and their February 2019 amendment (Welsh Government, 2019).
- The Air Quality Standards Regulations (Northern Ireland) 2010 (DAERA, 2010), and their December 2016 (DAERA, 2017), December 2018 (DAERA, 2018) and November 2020 (DAERA, 2020) amendments

Following the UK's exit from the EU, under retained EU law, the UK is required to continue to meet limit and target values for a range of air pollutants and other legal obligations covered by EU directives.

The AQD sets data capture requirements of 90% for benzene. The mean data capture for benzene measured at the non-automatic hydrocarbon monitoring stations in operation from January to December 2025 was 94%. The annual mean concentration across all non-automatic monitoring stations in the UK was 0.49 $\mu\text{g m}^{-3}$. All 34 monitoring stations used for non-automatic benzene measurements are situated in urban locations.

The AQD also requires the measurement of ozone precursor volatile organic compounds (VOCs). The UK Hydrocarbons Network measures 29 of the 31 listed substances (including 1,3-butadiene) using automatic analysers. There are 2 urban stations: an urban traffic station on the Marylebone Road, London and a suburban station in Eltham, Greenwich, the latter of which is currently closed due to building and development works.

Rural automatic stations at Chilbolton Observatory, Hampshire and Auchencorth Moss, Midlothian are used to support the European Monitoring and Evaluation Programme (EMEP) to Level 2 as well as the ACTRIS Network. EMEP is a scientifically based and policy driven programme under the Convention on Long-range Transboundary Air Pollution (CLRTAP) for international co-operation to solve transboundary

¹ <https://www.wsp.com/en-gb/news/2025/wsp-completes-acquisition-of-ricardo-plc-a-global-strategic-and-engineering-consultancy-firm>

air pollution problems. The station at Auchencorth Moss reports data to the Global Atmosphere Watch (GAW) programme, operated by the World Meteorological Organisation.

The mean data capture for benzene measured by the automatic hydrocarbon network in 2025 was 67%. The annual mean across all automatic monitoring stations in the UK was $0.43 \mu\text{g m}^{-3}$. When combined with the non-automatic network, the mean across the whole network is 93%.

The results for both automatic and non-automatic monitoring confirm no exceedances of EU or UK limit values and objectives at any of the Rural Background, Urban Traffic, and Urban Background locations during 2025.

This report also includes some more in-depth analysis of:

- Long-term trends in benzene concentrations;
- Ozone creation potential for different VOC species.

Key findings for 2025

- In 2025, none of the automatic or non-automatic monitoring stations in the UK exceeded the $5 \mu\text{g m}^{-3}$ annual mean Limit Value or the Upper Assessment Threshold of $3.5 \mu\text{g m}^{-3}$ for benzene set out in the AQD.
- The results confirm no exceedances of UK limit values and objectives at any of the Urban Background/Industrial, Urban Traffic and Rural Background monitoring stations during 2025.
- Measurements made at the Chilbolton observatory indicate that, of the 21 species measured, propane, butane, ethene and toluene are the largest contributors to regional O_3 increment during daylight hours in summer.

2. Introduction

This report provides a summary of the site management activities and data produced in 2025 by the UK Hydrocarbon monitoring network.

The network comprises automatic and non-automatic systems to measure benzene in compliance with the Air Quality Directive 2008/50/EC (AQD). The provisions of the AQD were transposed by the Air Quality Standards Regulations 2010 in England, the Air Quality Standards (Scotland) Regulations 2010 in Scotland, the Air Quality Standards (Wales) Regulations 2010 in Wales and the Air Quality Standards Regulations (Northern Ireland) 2010. Benzene is measured 34 urban traffic, urban background or urban industrial monitoring stations, with ozone precursors being measured at 2 suburban/urban locations in the UK. Up to 29 ozone precursor substances (including 1,3-butadiene) are measured using the automatic system at 4 sites, whereas a more cost effective non-automatic sampling system is used for more widespread benzene measurements. All hydrocarbon network instruments are co-located at AURN (Automatic Urban and Rural Network) monitoring stations.

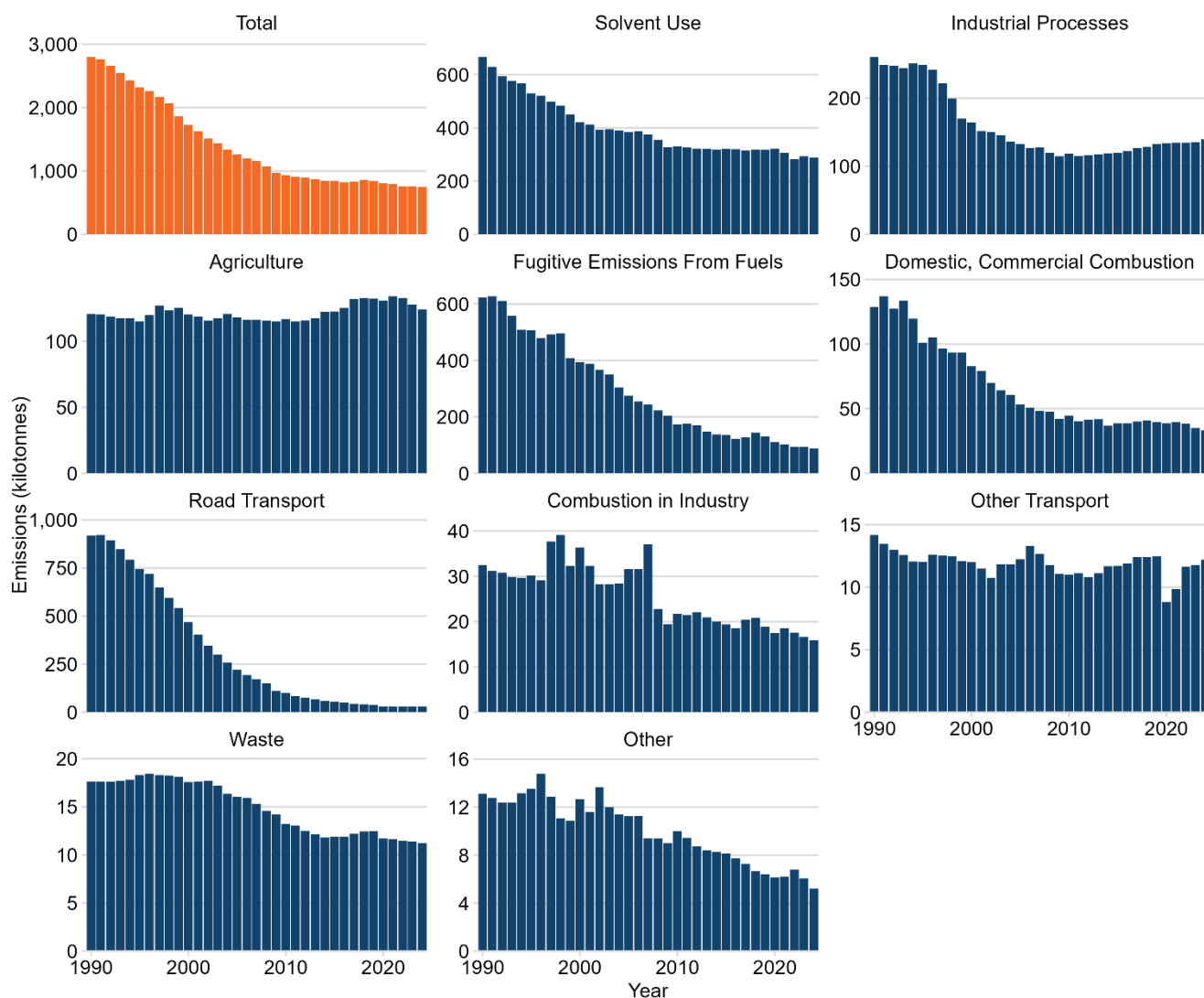
The number and location of sites in the network are based upon a Monitoring Regime Assessment required by the Air Quality Standards Regulations (UK Government, 2016, 2010) using modelled and measured evidence for 2016-2020.

The information and data presented in this report are correct at the time of publication, however, it is possible that data may be rescaled or deleted from the data set if future audits and calibrations identify a need to correct the data.

2.1 Sources of NMVOCs

Figure 1 shows source data from the National Atmospheric Emissions Inventory (NAEI) for Non-Methane Volatile Organic Compounds (NMVOCs) from 1990 to 2024, ordered by their 2024 values. At the time of writing, data are only available up to 2024. VOC emissions from road vehicles and fuel use predominated emissions until around 2001. However, the predominant source today is solvent use.

Figure 1: NAEI estimated NMVOCs emission from 1990.



There is a slight decrease between 2023 and 2024 following a notable reduction in NMVOC emission estimates from 2020 until 2022 before a slight increase in 2023. There is no single dominant factor behind the decrease in emissions, contributing sources to the trend include:

1. Reduced burning of coal in residential properties (-2 kt)
2. Reductions in oil loading in the North Sea (-2 kt)
3. Reduced emissions from refineries (-3 kt)
4. Reduced emissions from gas leakage (-2 kt)
5. Reductions in consumer product use, including screen wash and aerosols (-2 kt)
6. Decreasing emissions from adhesives due to a greater number of low-solvent products used (-3 kt)
7. Reduced emissions from manure spreading (-2 kt)

The main emission source counteracting this trend is an increase in emissions from the food and drink sector (+4 kt) resulting from the Scotch Whisky and animal feed sectors.

2.2 Regulatory background

2.2.1 UK Air Quality Objectives

The Air Quality Strategy for England (2023), Scotland, Wales and Northern Ireland (July 2007) sets out the UK Air Quality Objectives for benzene and 1,3-butadiene. These objectives are tabulated in Table 2-1.

Table 2-1: UK Air Quality Objectives.

Pollutant	Applicable to	Concentration ($\mu\text{g m}^{-3}$)	Measured As	To be achieved by
Benzene	All authorities	16.25	Running annual mean	31 December 2003
Benzene	England and Wales Only	5.00	Annual mean	31 December 2010
Benzene	Scotland and N. Ireland	3.25	Running annual mean	31 December 2010
1,3-Butadiene	All authorities	2.25	Running annual mean	31 December 2003

In addition to this, the growing evidence of harm that $\text{PM}_{2.5}$ can cause led the announcement of new annual mean limits, reducing them from 10 to 5 $\mu\text{g m}^{-3}$ (World Health Organization, 2021). Following this, two targets in England were established with both to be achieved by 2040 which are; achieve annual mean concentrations of $\text{PM}_{2.5}$ of 10 $\mu\text{g m}^{-3}$ or lower and for Population exposure to $\text{PM}_{2.5}$ to be reduced by 35% compared to 2018 levels.

2.2.2 European Directive Limit Values

The provisions of the Directive 2008/50/EC (AQD) were transposed by the Air Quality Standards Regulations 2010 in England, the Air Quality Standards (Scotland) Regulations 2010 in Scotland, the Air Quality Standards (Wales) Regulations 2010 in Wales and the Air Quality Standards Regulations (Northern Ireland) 2010. The AQSR2010 sets a limit value for annual mean benzene concentrations as well as lower and upper assessment thresholds, tabulated in Table 2.

Table 2-2: Benzene Limit Value and Assessment Thresholds.

Threshold	Concentration ($\mu\text{g m}^{-3}$)	Measured As
Limit Value	5.0	Annual mean
Upper assessment threshold	3.5	Annual mean
Lower assessment threshold	2.0	Annual mean

The limit value for the protection of human health for benzene is $5 \mu\text{g m}^{-3}$ as a calendar year mean, to be achieved by 1 January 2010. The upper and lower assessment thresholds, $3.5 \mu\text{g m}^{-3}$ (70% of limit value) and $2 \mu\text{g m}^{-3}$ (40% of limit value), are used to determine how many fixed sampling points are required. The UK uses a combination of monitoring and modelling to assess air quality and for compliance reporting. Where levels are assessed to be below the lower assessment threshold than modelling, objective estimation and indicative measurements are suitable for assessment and fixed monitoring is not required. Therefore, monitoring in the UK is primarily at locations where levels of benzene are modelled or measured to be above the LAT such as for assessment of emissions from industrial sources or from road transport.

The Data Quality Objective for benzene measurement uncertainty is $\pm 25\%$ with a minimum data capture of 90%. A further 5% of planned equipment maintenance and calibration time may be deducted from the data capture objective for automatic measurements during the ratification process. For the Hydrocarbon network, it is estimated that this is $<2\%$ based on a typical calibration regime. There is no planned downtime for the non-automatic measurements. The minimum time coverage is 35% (distributed over the year) for urban background and traffic sites and 90% for industrial sites.

Annex X of the AQD lists 31 other Volatile Organic Compounds (VOCs) which are ozone precursors and which must be measured in at least one urban or suburban area to support the understanding of ozone formation. With the exception of formaldehyde and total non-methane hydrocarbons, these VOCs are all measured by the current automatic hydrocarbon network instruments and are listed in Table 2-3. Neither data quality objectives nor limit values are given for measurement of these species, however, Defra have specified that all other VOC compounds have a minimum data capture target of 50%.

2.2.3 The European Monitoring and Evaluation Programme

The European Monitoring and Evaluation Programme (EMEP) is a scientifically based and policy driven programme under the Convention on Long-range Transboundary Air Pollution (CLRTAP) for international co-operation to solve transboundary air pollution problems. Defra have supported the programme, providing 2 sites to Level 2 status, which includes the measurement of ozone precursor measurements. The same system used to support the AQD is used at 2 rural locations; Chilbolton Observatory, Hampshire and Auchencorth Moss, Midlothian. In addition, data are also reported to and used by the Aerosol, Clouds and Trace Gases Research Infrastructure ([ACTRIS](#)) pan-European initiative to consolidate trace gas measurements. EMEP and ACTRIS data are both held within the EBAS database maintained by the Norwegian Institute for Air Research (NILU).

2.3 Network background and methods

The UK Hydrocarbon Network is one of several air quality monitoring networks operated by the Environment Agency on behalf of Defra to fulfil its statutory reporting requirements and policy needs. These include the Automatic Urban and Rural Network, which measures particulate matter, NO₂, CO, SO₂ and O₃, Heavy Metals Network and Polycyclic Aromatic Hydrocarbon Network, which meet the requirements of the AQD and Fourth Daughter Directive ([DD4](#)). Other monitoring programmes including the Particle Concentrations and Numbers Network, Black Carbon Network and UK Eutrophying and Acidifying Pollutants Network exist to meet other requirements.

2.3.1 Non-Automatic Benzene Monitoring

The Non-Automatic Hydrocarbon network started operation in 2001, measuring benzene and 1,3-butadiene. Benzene measurements are made using a dual sample tube-controlled flow pump unit described in EN 14662-1:2023, 'Ambient air quality – Standard method for measurement of benzene concentrations' using the sorbent carbopack-X and based on a study by Martin et al. (2003). This methodology currently produces measurements as nominal fortnightly averages at 34 stations.

The benzene monitoring method involves drawing ambient air at a controlled rate (nominally 15 ml/min) alternately through two tubes (A and B) containing a carbon-based sorbent (Carbopack X). Each tube samples at 15 ml/min for 8 minutes for a nominal two-week period. A designated local site operator manually changes the tubes and returns these to WSP, on completion of the sampling period. The tubes are then sent to our subcontractors' laboratory for subsequent analysis of benzene by gas chromatography-mass spectrometry. The sampling period and sample flow rate are important such that enough benzene is captured onto the sorbent to enable fully quantifiable analysis, but not too much that the analyte is able to travel through the sorbent and be lost causing 'sample breakthrough'.

Until 2007, passive diffusion tubes were also used to measure 1,3-butadiene in order to assess compliance with the UK Air Quality Strategy Objective (2.25 µg m⁻³ expressed as a running annual mean). However, the network was reviewed in 2007, and in view of the fact that:

- 1,3-butadiene levels at all the sites were well below the objective.
- Levels at half of the sites were at or below the detection limit for the method used.

Defra took the decision to discontinue monitoring 1,3-butadiene with passive diffusion tubes. Currently, 1,3 butadiene is only measured using the automatic method.

2.3.2 Automatic Hydrocarbon Monitoring

Automatic hourly measurements of speciated hydrocarbons, made using advanced automatic gas chromatography, started in the UK in 1991. By 1995, monitoring had expanded considerably with the formation of a 13-site dedicated network measuring 26 species continuously at urban, industrial and rural locations. Over the following years, the number of sites was reduced and from 2015 there were only 4 UK sites in operation to satisfy network requirements. The London Eltham site fulfils the UK requirement to monitor ozone precursors at an urban background location, Marylebone Road measurements are made to inform research undertaken at the site with regard to roadside emissions and the 2 rural background sites support the EMEP and ACTRIS programmes and provide information regarding

concentrations at rural locations in the UK. Since the London Eltham station is currently off-line for building and development works, data measured by the University of York at London Honor Oak Park has been provided since 2025 and ratified quarterly in arrears. Table 2-3 lists the 29 species currently measured by the automatic gas chromatographs. Table 2-3 also lists the photochemical ozone creation potential (POCP) for individual VOCs. These values are used to study the contribution of each VOC to the regional ozone formation in section 4.3.

The main sources for each VOC are taken from Malley et.al (2015). The “main source” column gives the Selected Nomenclature for Air Pollution (SNAP) sector with the largest contribution of that VOC to UK annual anthropogenic emissions in 2011, except for isoprene which is mainly of biogenic origin. The POCP values are taken from Derwent et al. (2007). The listed SNAP sectors are SNAP 2, non-industrial combustion plants; SNAP 4, production processes; SNAP 5, extraction and distribution of fossil fuels; SNAP 6, solvent use; SNAP 7, road transport; and SNAP 8, non-road transport.

Table 2-3: Species measured by the automatic chromatographs. Note that m-xylene and p-xylene are reported as a single measurement.

VOC	Class	Chemical formula	Main source	POCP
ethane	alkane	C ₂ H ₆	SNAP5 (65%)	8
propane	alkane	C ₃ H ₈	SNAP5 (36%)	14
n-butane	alkane	C ₄ H ₁₀	SNAP6 (44%)	31
isobutane	alkane	C ₄ H ₁₀	SNAP5 (61%)	28
n-pentane	alkane	C ₅ H ₁₂	SNAP5 (42%)	40
isopentane	alkane	C ₅ H ₁₂	SNAP5 (41%)	34
n-hexane	alkane	C ₆ H ₁₄	SNAP6 (42%)	40
2-methylpentane	alkane	C ₆ H ₁₄	SNAP6 (43%)	41
n-heptane	alkane	C ₇ H ₁₆	SNAP5 (43%)	35
n-octane	alkane	C ₈ H ₁₈	SNAP5 (64%)	34
isooctane	alkane	C ₈ H ₁₈	SNAP4 (100%)	25
ethene	alkene	C ₂ H ₄	SNAP8 (27%)	100
propene	alkene	C ₃ H ₆	SNAP4 (36%)	117
1-butene	alkene	C ₄ H ₈	SNAP7 (26%)	104
cis-2-butene	alkene	C ₄ H ₈	SNAP5 (87%)	113
trans-2-butene	alkene	C ₄ H ₈	SNAP5 (90%)	116
1,3-butadiene	alkene	C ₄ H ₆	SNAP8 (57%)	89
isoprene	alkene	C ₅ H ₈	Biogenic	114

VOC	Class	Chemical formula	Main source	POCP
ethyne	alkyne	C ₂ H ₂	SNAP7 (46%)	7
1-Pentene	alkyne	C ₅ H ₁₀	Undefined	95
trans-2-pentene	alkyne	C ₅ H ₁₀	Undefined	111
benzene	aromatic	C ₆ H ₆	SNAP2 (35%)	10
toluene	aromatic	C ₇ H ₈	SNAP6 (63%)	44
ethylbenzene	aromatic	C ₈ H ₁₀	SNAP6 (54%)	46
o-xylene	aromatic	C ₈ H ₁₀	SNAP6 (50%)	78
m-xylene	aromatic	C ₈ H ₁₀	SNAP6 (71%)	86
p-xylene	aromatic	C ₈ H ₁₀	SNAP6 (50%)	72
1,2,3-trimethylbenzene	aromatic	C ₉ H ₁₂	SNAP6 (79%)	105
1,2,4-trimethylbenzene	aromatic	C ₉ H ₁₂	SNAP6 (74%)	110
1,3,5-trimethylbenzene	aromatic	C ₉ H ₁₂	SNAP6 (71%)	107

There is no standard reference method for measuring ozone precursor substances in ambient air. Development of such a standard is currently being discussed within Technical Committee 264 under CEN Working Group 13. Since 2025, measurements of the butene, pentene and trimethylbenzene isomers have ceased at the rural stations, due to the measurements being consistently below the lower detection limit.

The analyser operated by the University of York also measures additional compounds, not measured by the UK network, including ethanol, acetone, nonane and cyclopentane.

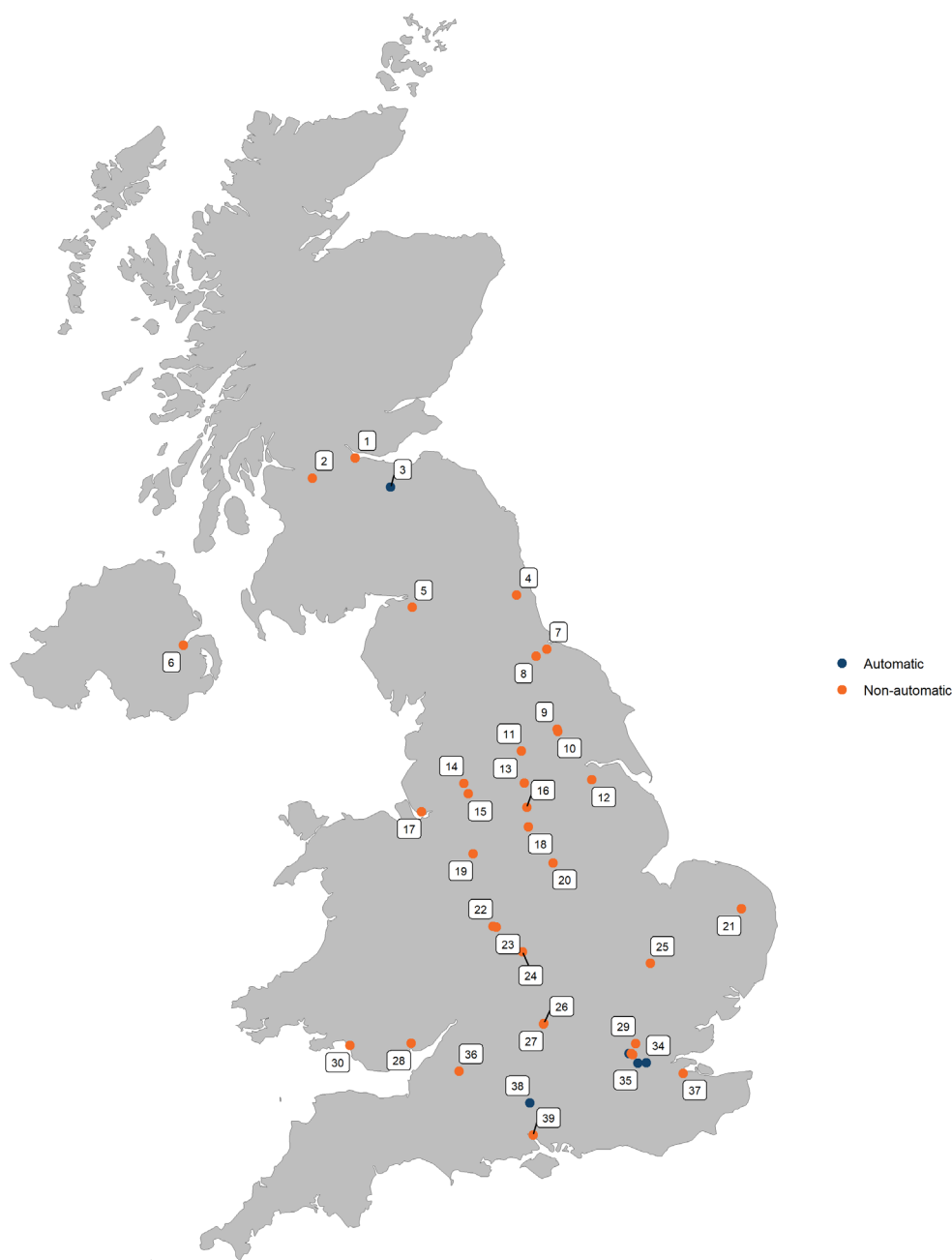
Automated thermal desorption within situ gas chromatography and flame ionisation detection (FID) is used to measure hourly hydrocarbon concentrations. During 2025, hydrocarbons at all AHN network sites were measured using automatic Perkin Elmer Ozone Precursor Analysers. The system at London Honor Oak Park is a bespoke thermal desorber system built by the University of York coupled with an Agilent Gas Chromatograph. A known volume of air (500 - 600 ml) is dried and drawn through a cold trap, which contains adsorbent material. The PerkinElmer cold trap is held at -30°C to ensure that all the ozone precursor target analytes are retained. At London Honor Oak Park, a stirling cooler is used to cool the trap to a much lower temperature using significantly less adsorbent. Following a 40-minute period of sampling, components are desorbed from the cold trap and are transferred to the capillary column where they are separated using gas-chromatography and subsequently detected by a flame ionising detector. The PerkinElmer analysers are calibrated using an on-site 30 component gas mixture. At London Honor Oak Park, the University of York produce secondary standard cylinders using a primary standard which is assessed against the primary standard routinely to assess the secondary cylinders efficacy.

3. Site Management

3.1 Monitoring stations during 2025

The monitoring stations operating in the UK Hydrocarbon Network during 2025 are shown in Figure 2. Full names of the monitoring stations and their coordinates can be found in Table 9-1 and Table 9-2.

Figure 2: Map of UK Hydrocarbon Monitoring stations in 2025.



3.2 Equipment Maintenance and Audits

All non-automatic benzene monitoring stations were visited by WSP field engineers in April and October 2025 in order to carry out site audits and to undertake routine maintenance of the equipment. The main functions of these visits are to:

- Carry out certified flow measurements and calibration using a low flow BIOS instrument (UKAS accredited)
- Ensure no blockages or leaks in the system
- Clean or replace dirty filters and inspect/replace the sample inlet
- Replace O-rings and leak test all connections
- Carry out electrical Portable Appliance Testing (annually)
- Review the site infrastructure and surroundings
- Review health and safety risks at the site
- Replace or refurbish non-automatic sampler pumps

Routine flow measurements have been used to calculate sample volumes for the 2025 data set by means of interpolation. The calibration data from these audits have been used to rescale the benzene concentrations during the ratification process.

The automatic monitoring stations are serviced annually by the Equipment Support Unit (Perkin Elmer) where the following routine tasks are undertaken.

Annual preventative maintenance visits:

- Leak check all pneumatic systems
- Replace all consumables such as filters, gaskets
- Replace the cold trap
- Check and condition columns, trimming or replacing as necessary
- Checking and replacing transfer line if necessary
- Checking and replacing fused silica lines if necessary
- Replacing the nafion dryer if necessary

The Central Management and Co-ordination Unit (WSP) provides an annual reference gas audit in addition to the automatic on site calibrations. These audits use the instrument sample port as opposed to the analyser calibration port. The sample line is inspected and cleaned/replaced annually.

The operational performance and stability of these types of automated chromatography systems can be affected for a period of time following ad-hoc repairs or power cuts. This means that an analyser that was only off for an hour might produce poor chromatography for a few days subsequent to that issue. Data obtained when the instrument is stabilising following repair will not be representative of ambient



concentrations at the monitoring location. The ratification team will remove any such erroneous data up until the period when the data demonstrates that the instrument has stabilised and is producing meaningful data.

Ancillary equipment failure is the cause of most prolonged downtime. A spare hydrogen generator, TOC zero air generator and air compressor is kept by the ESU such that equipment can be swapped quickly if necessary.

4. Data Quality

4.1 Estimation of Uncertainty

Calculated uncertainty for the Non-Automatic Hydrocarbon sites in 2025 for benzene is 15%, expressed at a 95% level of confidence. This includes contributions from WSP's flow measurements, desorption efficiency and analysis uncertainty. The measurement uncertainty calculations for the individual hourly measurements are as defined in the standard operating procedures adopted under the ACTRIS project.

The requirement for benzene measurement uncertainty from an automatic hydrocarbon analyser is 25%, expressed at 95% confidence limit. The Perkin-Elmer analyser used in the UK network has not been type tested, as there is no reference method comparator, so an estimate of the various contributions has been made to assess compliance with the DQO requirement. The main contributions are:

- Repeatability and lack of fit – derived if possible from the manufacturer's specifications
- Variation in sample gas pressures, surrounding temperature and electrical voltage – derived if possible from the manufacturers specifications
- Interference from ozone – derived if possible from the manufacturers specifications
- Memory effects – derived if possible from the manufacturers specifications
- Differences between the sample and calibration port – these differences are negligible; the sample and calibration port are in contact with 90% of the same valve. Removing the calibration cylinder to evaluate this will disturb the system and affect sample measurements for some considerable time afterwards.
- Uncertainty in calibration gas – from NPL cylinder certificate
- Reproducibility under field conditions – this could be estimated from the manufacturers specifications
- Long term drift – corrections are made such that this is not applicable to the expanded uncertainty.

The largest components in the uncertainty budget are lack of fit and calibration gas uncertainty, although the calibration gas used is of the highest available quality. In the absence of data from type testing, the maximum permissible values stated in the EN Standard have been used as a worst-case scenario. Using these values and the known values from the calibration cylinder the uncertainty budget has been calculated. The uncertainty of benzene measurements using a Perkin-Elmer analyser is estimated to be < 24%. Measurements reported to EMEP and ACTRIS are required to be reported with hourly uncertainty figures for each hour. The calculation used is provided in ACTRIS standard operating procedures:

$$\chi_{sample,i} = (A_{sample,i} - A_{blank,i}) / V_{sample} * f_{cal,i} \quad (1)$$

$$f_{cal,i} = (V_{cal,i} * \chi_{cal,i}) / (A_{cal,i} - A_{blank,i}) = 1 / (C_{num}^i * C_{resp,i}) \quad (2)$$

Where

- $A_{sample,i}$ = peak area of sample measurement of compound i
- $A_{cal,i}$ = peak area of calibration gas measurement of compound i
- $A_{blank,i}$ = possible blank value of compound i determined in zero gas measurements
- $\chi_{cal,i}$ = certified mole fraction of calibration gas standard
- V_{cal} = sample volume of calibration gas
- V_{sample} = sample volume of sample
- C_{num}^i = Number of C atoms in the molecule i (e.g. for i = n-Pentane, $C_{num} = 5$)
- $C_{resp,i}$ = mean C-response factor of compound i

4.2 Determination of precision

Precision covers random errors of peak integration, volume determination and blank variation.

Precision ($\delta_{\chi_{prec}}$) is determined as the standard deviation of a series of sample measurements ($\sigma_{\chi_{sample}}$)

$$\Delta_{\chi_{prec}} = \sigma_{\chi_{sample}} \quad (3)$$

This represents the instrument precision at the concentration level and complexity of the sample gas. Because the instrument is subjected to variable peak areas in ambient air, a more general description is applied:

$$\Delta_{\chi_{prec}} = \sqrt{(1/3DL)^2 + (\chi * \sigma^{rel} \chi_{sample})^2} \quad (4)$$

Where:

- DL = detection limit (described below)
- χ = mole fraction of the ambient peak
- $\sigma^{rel} \chi_{sample}$ = relative standard deviation of the sample (from the reference standard)

The detection limit is the dominant factor for small peaks, while reproducibility becomes more important for larger peaks.

4.3 Uncertainty calculations

The total uncertainty $\Delta_{\chi_{unc}}^2$ of a single measurement does not only include the random errors described by the precision but also systematic errors $\Delta_{\chi_{sys}}^2$ of the measurement.

$$\Delta_{\chi_{unc}}^2 = \Delta_{\chi_{prec}}^2 + \Delta_{\chi_{sys}}^2 \quad (5)$$

Errors included in the UK network calculations include:

- Uncertainty in the standard gas mole fraction $\delta_{\chi_{cal}}$
- Systematic errors (for example peak overlay/poor separation) $\delta_{A_{int}}$
- Sample volume error δv
- Other (system artefacts) $\delta_{\chi_{instrument}}$

The overall systematic error is described as:

$$\Delta_{\chi_{sys}}^2 = |\Delta_{\chi_{cal}}^2 + \Delta_{\delta_{int}}^2 + \Delta_{\chi_{vol}}^2 + \Delta_{\chi_{instrument}}^2| \quad (6)$$

Referring to [Equation 1](#) and [Equation 2](#), the single error contribution is determined for each measurement:

$$\Delta_{\chi_{cal}} = (A_{sample} * v_{cal}) / (v_{sample} * A_{cal}) * \delta_{\chi_{cal}} \quad (7)$$

Where $\delta_{\chi_{cal}}$ includes the certified relative uncertainty of the standard gas and possible drift.

$$\Delta_{\chi_{int}}^2 = (f_{cal} / v_{sample} * \delta_{A_{int.sample}})^2 + (A_{sample} * v_{cal} * \chi_{cal} / (v_{sample} * A_{cal}^2) * \delta_{A_{int.cal}})^2 \quad (8)$$

Where $\delta_{A_{int.cal}}$ represents the reference gas standard deviation and the $\delta_{A_{int.sample}}$ represents the sample gas standard deviation respectively.

Sample volume error cancels from [Equation 1](#) as sample and calibration volume are identical.

4.4 Standard Methods

The Air Quality Standards Regulations 2010 that refer out to the AQD states that automatic measurements of benzene should be compliant with Standard BS EN14662-3:2015 – Part 3 (CEN, 2015): Automated pumped sampling with in-situ gas chromatography which is determined as the Ambient Air Quality Standard method for the measurements of benzene concentrations. This Standard is for the determination of benzene in ambient air for the purpose of comparing measurement results with annual mean limit values. It describes guidelines for measurements with automated gas chromatographs, between 0 and 50 $\mu\text{g m}^{-3}$. Measurements undertaken by the Automatic Hydrocarbon Network are carried out in accordance with this Standard.

The Standard Method for measurement of benzene using an automatic analyser was completed by CEN Working Group 12 in 2023. The proposed revisions include a requirement for more rigorous linearity tests. The proposal states the linearity tests will be performed using at minimum the following concentrations: 0 %, 10 %, 50 % and 90 % of the maximum of the certification range of benzene or the user-defined range. At each concentration (including zero) at least 3 measurements shall be performed, the result of the first shall be discarded. The test shall be repeated at the following intervals:

- Within 1 year of the test at initial installation; subsequently:
- Within 1 year after test if the lack-of-fit is within 2.0 % to 5.0 %;
- Within 3 years if the lack of fit is ≤ 2.0 %;
- After repair

Currently the first 3 of these were already implemented on the UK network.

The AQD also states that non-automatic measurements of benzene should be compliant with Standard BS EN14662-1:2023 the Ambient Air Quality Standard method for measurement of benzene concentrations – Part 1: Pumped sampling followed by thermal desorption and gas chromatography. This Standard gives general guidance for the sampling and analysis of benzene in air by pumped sampling, thermal desorption and capillary gas chromatography. The pumped sampler was developed by the National Physical Laboratory in compliance with this standard. WSP contract SOCOTEC to analyse the samples in accordance with this standard. The non-automatic samplers were built specifically to meet the standard.

The AQD does not specify a standard method for the measurement of ozone pre-cursors (including formaldehyde), with the exception of benzene, as described above.

4.5 Limit of Detection

The Limit of Detection for the mass of benzene on a desorption tube from the Non-Automatic Hydrocarbon Network is approximately 5 ng. This is equivalent to about $0.05 \mu\text{g m}^{-3}$ from a 14-day sample period.

The Limit of Detection for each of the 29 species measured by the Perkin Elmer Ozone Precursor Analysers is 10 ppt. These are converted to $\mu\text{g m}^{-3}$ and shown in Table 4-1.

Table 4-1: Automatic analyser limit of detection.

VOC	Limit of detection (Perkin Elmer, $\mu\text{g m}^{-3}$)
Ethane	0.10
Ethene	0.01
Propane	0.02
Propene	0.02
Ethyne	0.01
i-Butane	0.02
n-Butane	0.02
trans-2-Butene	0.02
1-Butene	0.02
cis-2-Butene	0.02
i-Pentane	0.03
n-Pentane	0.03
1,3-Butadiene	0.02

VOC	Limit of detection (Perkin Elmer, $\mu\text{g m}^{-3}$)
trans-2-Pentene	0.03
1-Pentene	0.03
2-Methylpentane	0.04
Isoprene	0.03
n-Hexane	0.04
Benzene	0.03
i-Octane	0.05
n-Heptane	0.04
n-Octane	0.05
Toluene	0.04
Ethylbenzene	0.04
(m+p)-Xylene	0.04
o-Xylene	0.04
1,3,5-Trimethylbenzene	0.05
1,2,4-Trimethylbenzene	0.05
1,2,3-Trimethylbenzene	0.05

5. Data Analysis

5.1 Comparison with Limit Values and Objectives

The annual mean concentrations of benzene measured using non-automatic samplers over the calendar year 2025 are summarised in Figure 3, alongside the associated data capture rate. Figure 4 provides similar statistics for the automatic monitoring of benzene and 1,3-butadiene. Figure 5 shows the data capture rate for other automatically measured VOC species.

Summary statistics for other measured pollutants can be seen in Table 9-3.

Figure 3: Non-Automatic Benzene annual statistics for 2025. Range shows the annual minimum and maximum nominal fortnightly measurement.

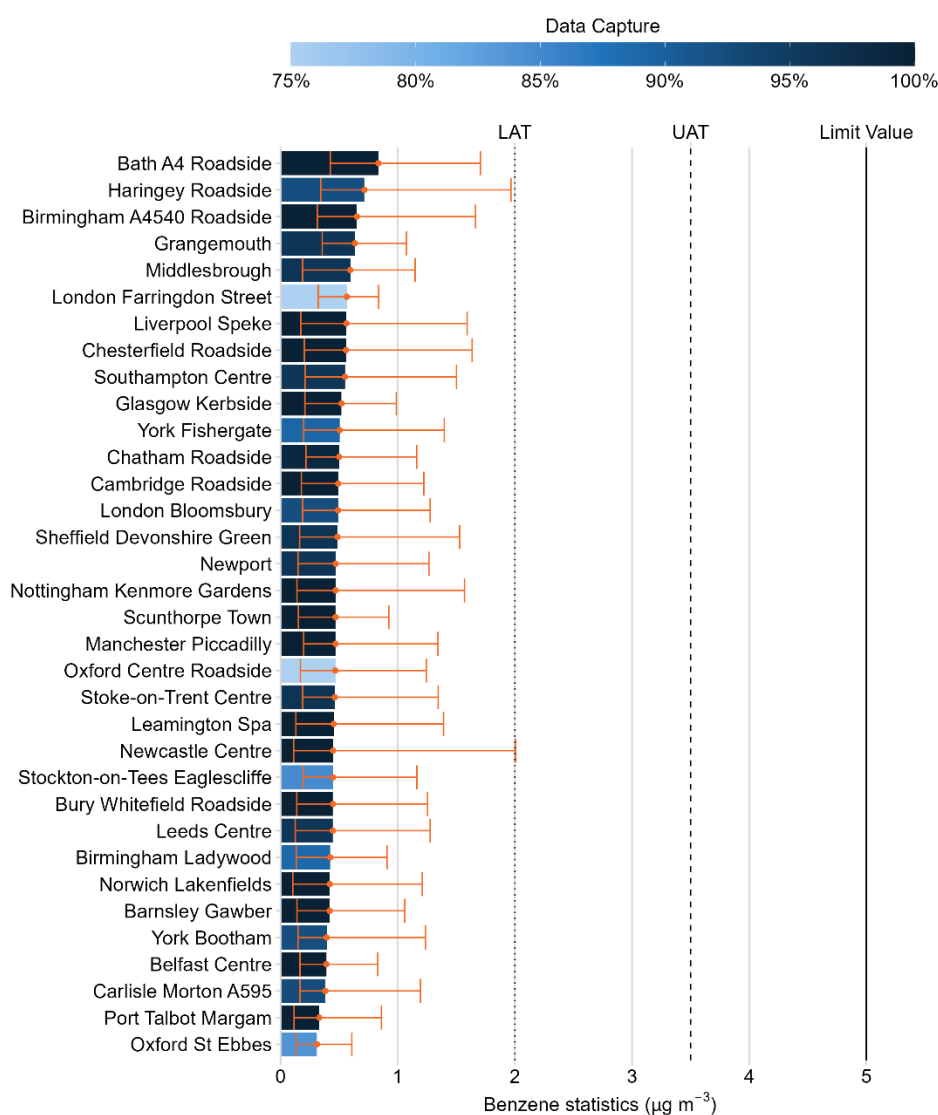


Figure 4: Automatic benzene and 1,3-butadiene annual statistics for 2025. Range shows the annual minimum and maximum hourly measurement.

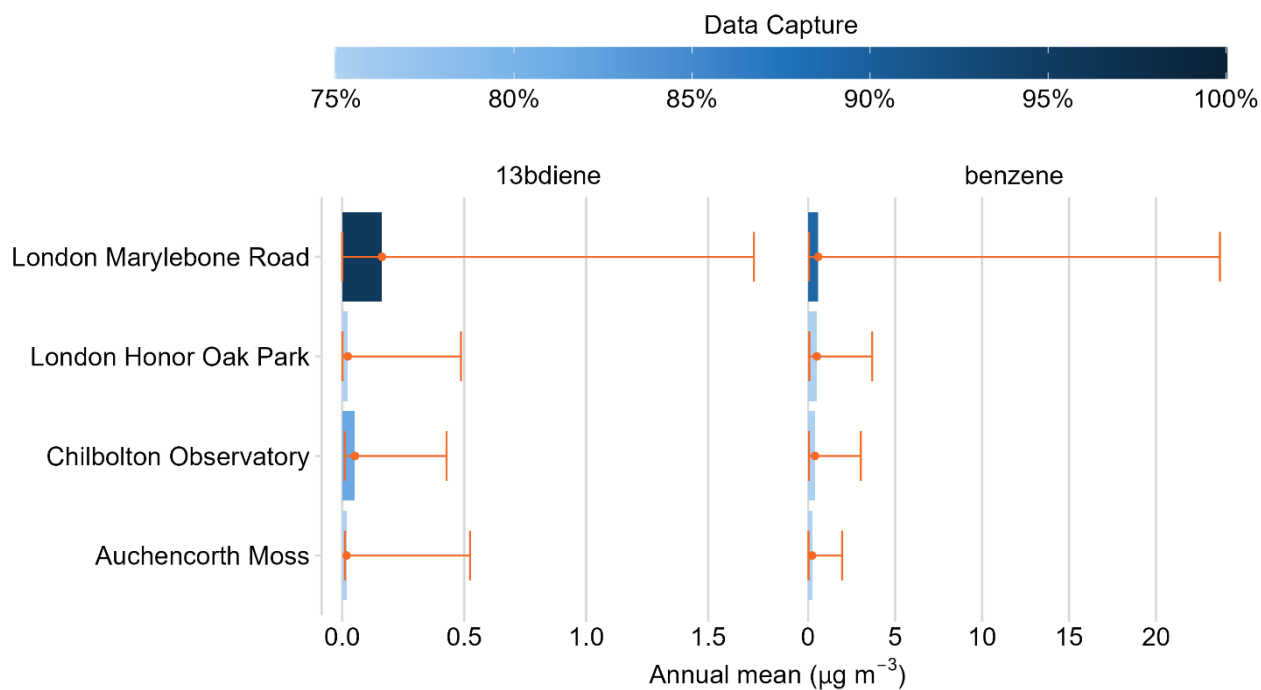
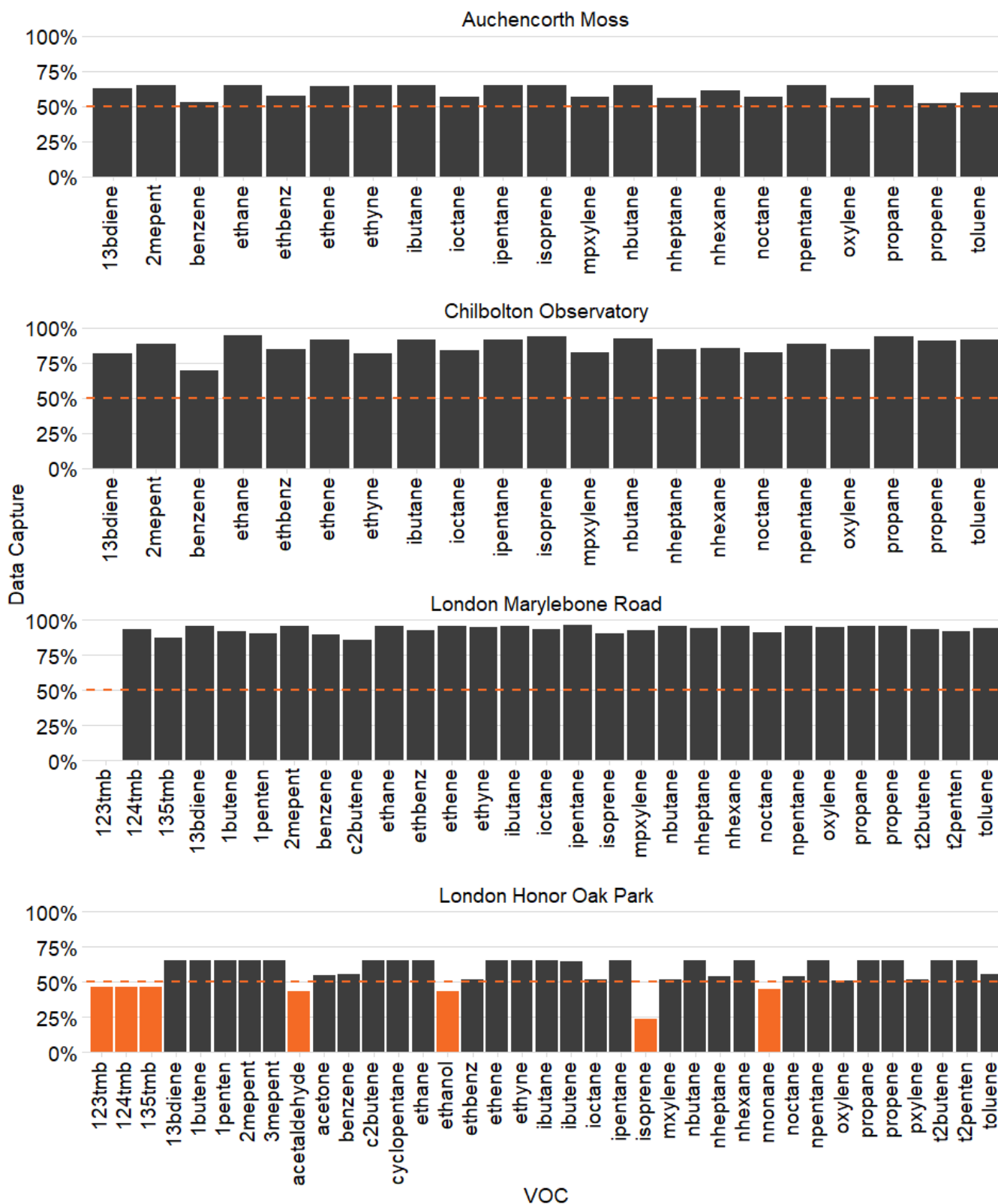


Figure 5: VOCs annual statistics for 2025. The dashed lines show the objective data capture rate; any VOC below the objective are highlighted in orange.



Annual time weighted mean concentrations at all monitoring stations were below the Limit Value of $5 \mu\text{g m}^{-3}$ for benzene set by the Air Quality Standards 2010 as well as the UK Air Quality Objectives as defined in the Air Quality Strategy 2007.

The 2011 Implementing Provisions Regulations (EC, 2011) has changed how the UK reports statutory air quality data to Europe. For VOCs, IPR requires measurements below the instruments limit of detection to be reported as half the limit of detection with a specific data flag. Data capture from 2013 onwards is calculated based on the number of valid data points in the year, including data below the limit of detection, recorded as half that of the limit. In previous years, flags recorded less than LoD were reported as 'not measured'.

These changes have increased data capture but introduced a small step change in long-term trends that is not representative of atmospheric conditions in the UK. The change from 2012 to 2013 is negligible in terms of absolute concentrations but significant in 2012/2013 ratio for components that were previously not measured as a result of measurements being below the detection limit. For example, using the new IPR flags, Trimethylbenzene measurements at Auchencorth Moss changed from no data capture to 90.24% data capture and a concentration of $0.12 \mu\text{g m}^{-3}$. These measurements will be reported with a '<' symbol to clarify this for data users. The revised data capture calculation also includes an allowance of 5% for planned maintenance and calibration. This decreases the data capture target for benzene from 90% to 85%.

The data flags used in the Implementing Provisions Regulations (IPR) are applied using a program, written by WSP.

5.2 Instrumental Impacts on Data Capture

The automatic system comprises several components listed below:

- Turbomatrix Thermal Desorber (TD)
- Sample vacuum pump
- Clarus 500 Gas Chromatograph (GC)
- Zero Air generator
- Air Compressor
- Hydrogen Generator
- High Volume Flow Inlet (including a fan)
- Site PC including Totalchrom software

These components are checked by local site operators on a fortnightly basis. The system manufacturer (PerkinElmer) carries out annual preventative maintenance. The data from the system is checked Monday to Friday by WSP's daily data checking team. If there is an instrument failure Perkin Elmer engineers are called out to the site to repair the problem. There are no hot spare Thermal Desorbers or Gas Chromatographs, so some considerable downtime is possible if the instrument fault cannot be diagnosed and/or repaired quickly.

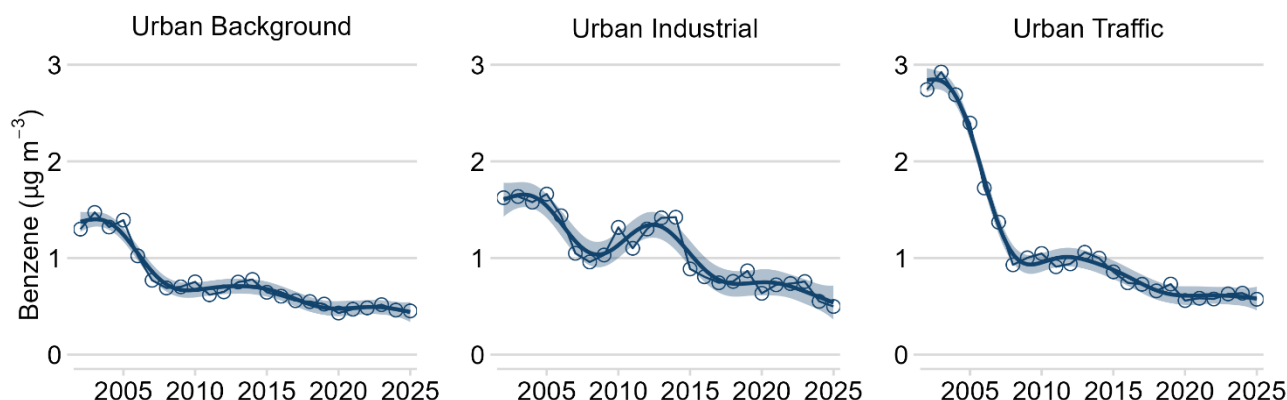
Further data loss is likely due to instrument detector stability following power cuts, preventative maintenance visits and instrument faults. It can take several days for the instrument to stabilise. This problem is unavoidable with chromatography, we ensure all faults are diagnosed within 48 hours (excluding weekends and public holidays), and all faults are repaired following diagnosis unless this is not possible, for example where a component has failed that needs to be ordered. In addition, specific peaks can be affected by co-elution with a system artefact or other unknown hydrocarbons resulting in reduced data capture for individual species.

5.3 Long-term trend of benzene concentration

Figure 6 shows the trends in benzene concentration averaged across 4 main site types with a smooth trend line fitted. The plot reveals that the highest concentrations were generally observed at roadside sites until 2008. Note that there are only 2 industrial sites, so these trends are noisier than for other site types. What is clear from the trend analysis is that concentrations of benzene decreased sharply from 2002 to 2008, which reflects better emissions control on vehicles (exhaust and evaporative emissions). For 2025, roadside concentrations are on average much closer to background concentrations than they were in the early 2000s. Annual concentrations at all 4 of the site types were seen to dip in 2020, likely owing to changes in human activity in the UK during the COVID-19 pandemic.

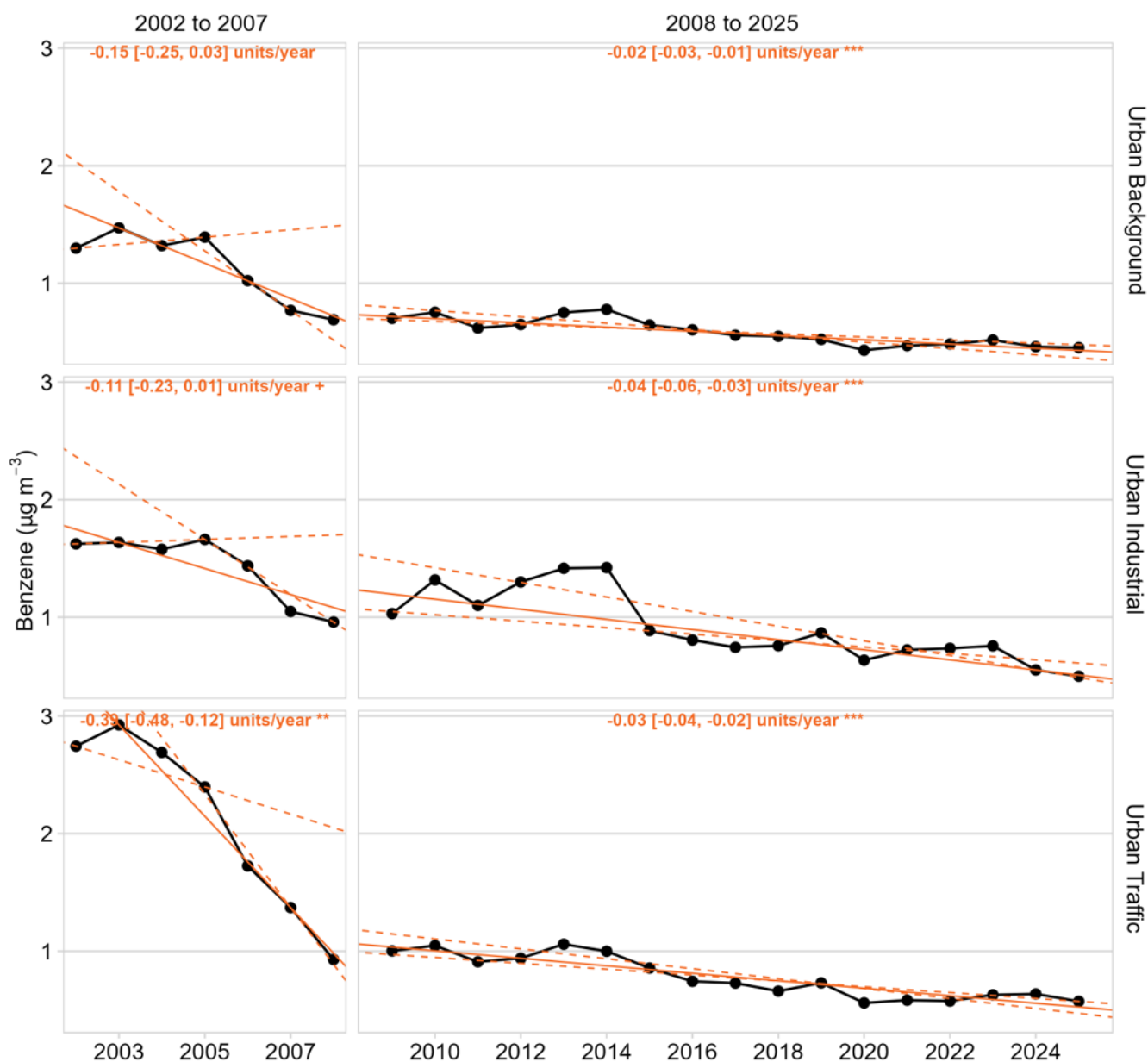
Concentrations at Industrial sites declined from 2023. This is likely due to reductions in operations at Port Talbot steel works in 2024, as well as further reductions since the decommissioning of the Grangemouth Oil refinery in April 2025.

Figure 6: Average Non-Automatic network benzene means by site type from 2002 to 2025.



Trend estimates using robust statistical techniques in openair provide a way of quantifying the trends over time as a percentage change in benzene concentration per year. The trends have generally shown 2 characteristics: a decrease from 2002 to 2008 and then a period of stabilisation from 2008 to 2025. Figure 7 separately considers the trends for these 2 periods. While the post-2008 trends are significant, the magnitude of their slopes are notably smaller than pre-2008, suggesting more stable benzene concentrations.

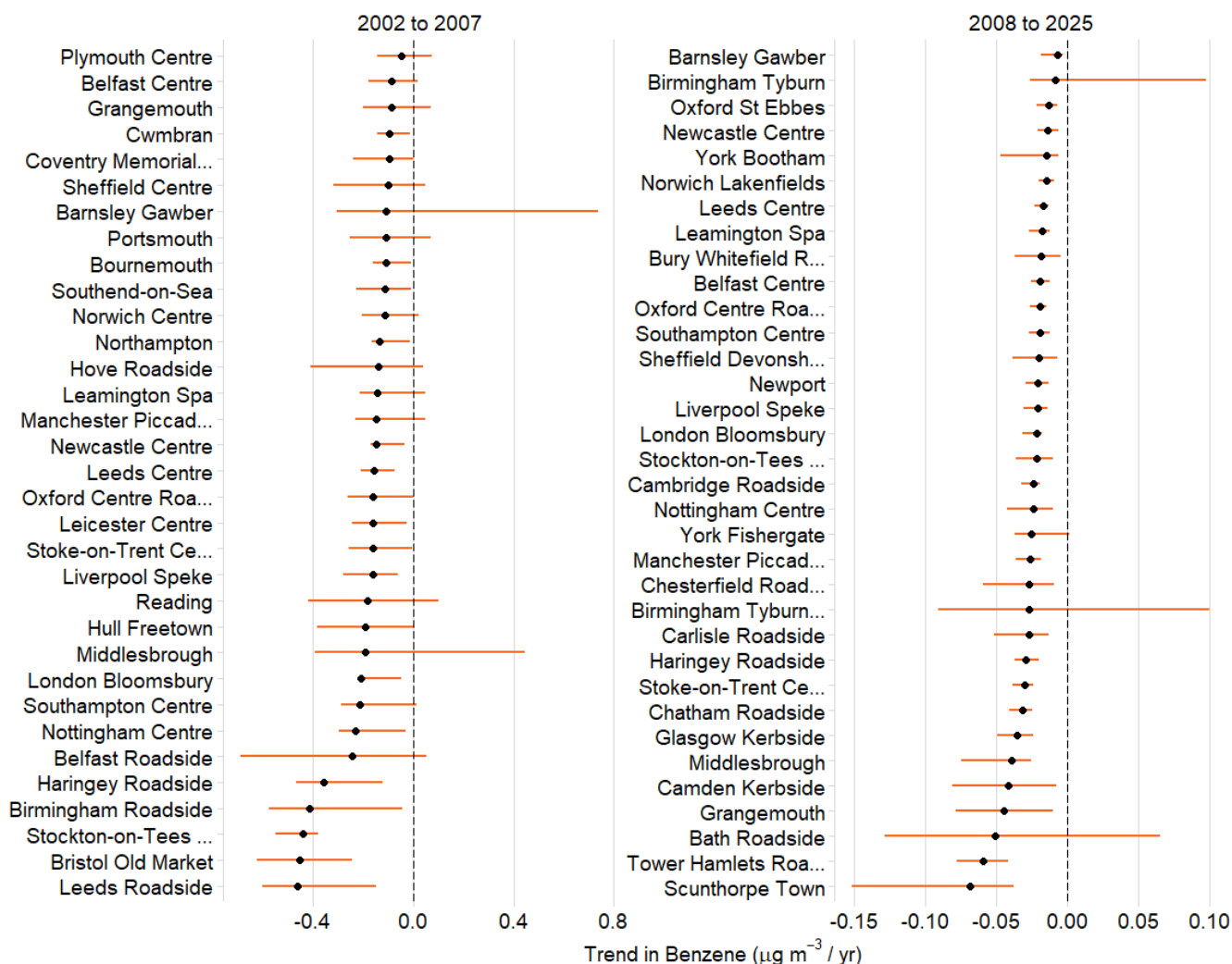
Figure 7: Non-automatic benzene rate of change for 2002-2007 and 2008-2025.



To compare trends in benzene concentrations across all measurement sites, Figure 8 shows the trend in annual average benzene concentrations at non-automatic monitoring sites from 2002 to 2025. To help with interpretation the trends are ordered, and a dashed line is shown for zero change.

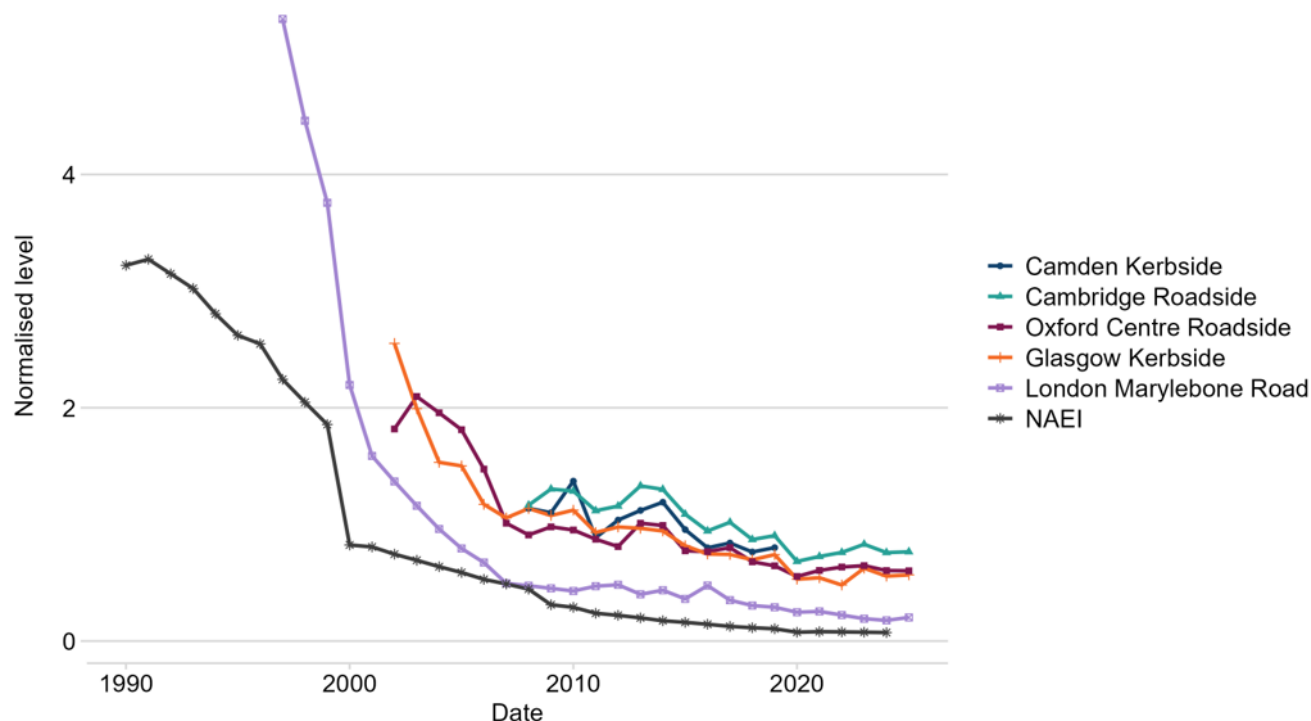
The plot below shows that all sites showed a decrease in benzene concentration over the period 2002 to 2025. The magnitude of the decrease is larger between 2002 and 2007 compared to more recent years. Note that the error bars relate to the 95% confidence intervals, which reveals that the trends at some sites are relatively uncertain.

Figure 8: Benzene concentration trend ($\mu\text{g m}^{-3} / \text{yr}$) at non-automatic sites from 2002 to 2025.



Data obtained from the National Atmospheric Emissions Inventory (NAEI) can be used to see if there is a long-term relationship between emissions and measurements. Figure 9 shows that the NAEI urban benzene emissions data agrees with the monitoring data, where a sharp decline can be seen from 1995 up to the year 2000 where petrol benzene additives were replaced by toluene for the purposes of maintaining the required octane value. The emissions data is steadily decreasing since 2000, but the monitoring data has stabilised, possibly due to additional urban sources of benzene such as use of wood burning appliances for domestic and commercial space and water heating. NAEI benzene data for 2025 is not yet available.

Figure 9: Normalised annual average benzene concentration and NAEI benzene emission estimate (1995 - 2025). Normalisation involved dividing the annual means by the mean value for the whole time series. Therefore, monitoring sites with only one annual mean are not shown.



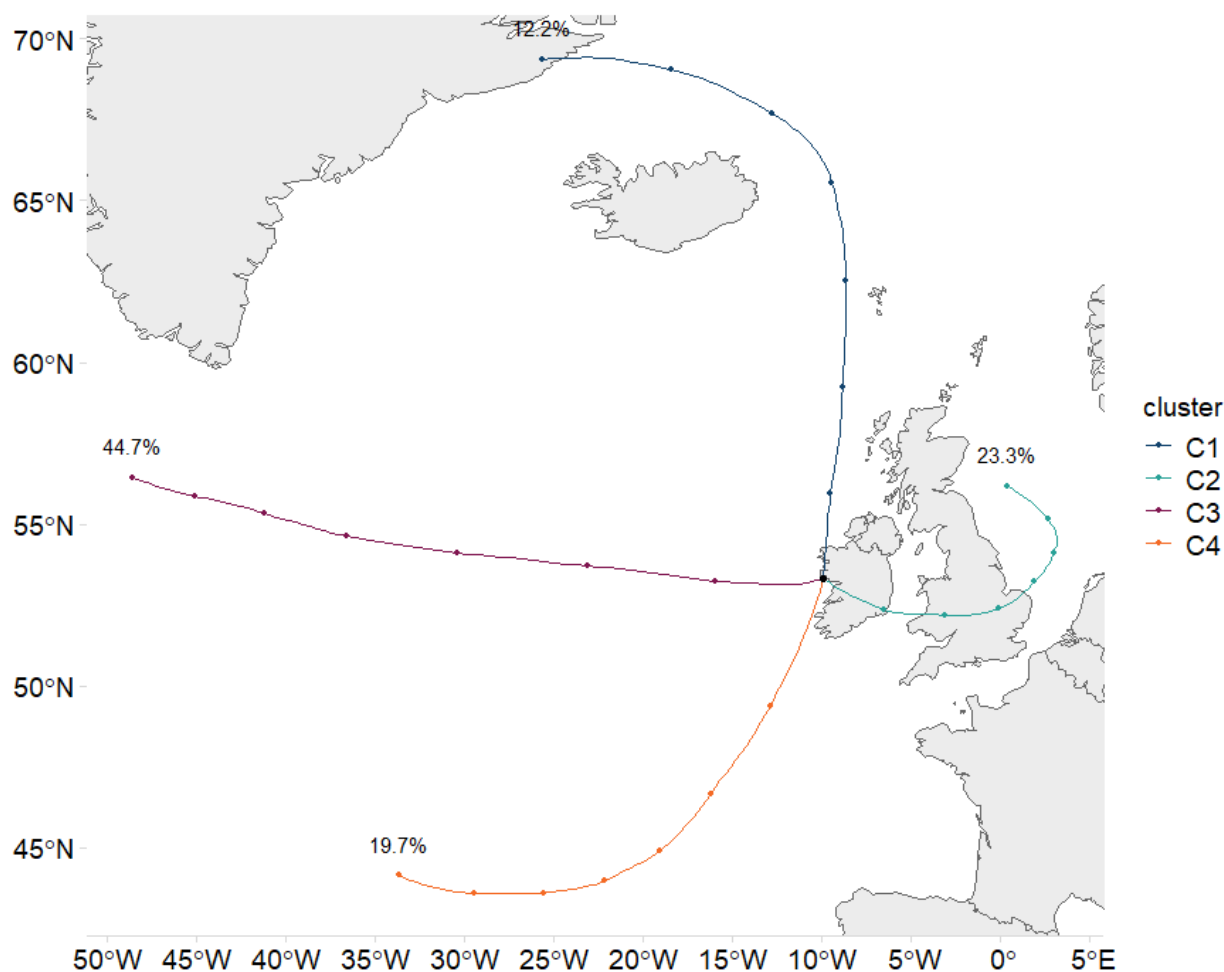
5.4 Impact of VOCs on regional O₃ formation

5.4.1 Regional O₃ increment

The UK measures different species of VOCs due to their ozone creation potential. To understand the contribution of individual VOCs to the O₃ production at the UK (regional) scale, we first need to quantify the O₃ increment at the UK level. This section presents evidence of the regional ozone formation and the relative contribution from each VOC. The methodology of the analysis in this section follows that set out by Malley et al. (2015).

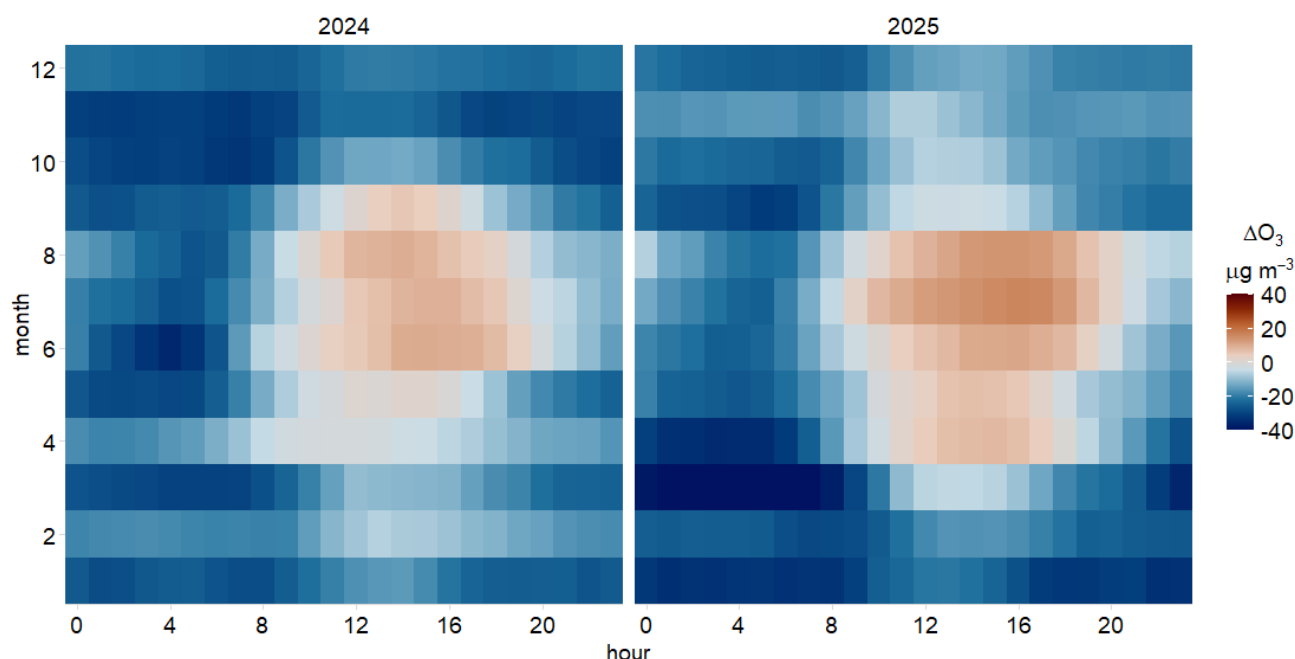
In this report, the regional O₃ production is defined as the O₃ concentration measured at Chilbolton minus the northern hemispheric background O₃ concentration. Chilbolton is a rural monitoring site generally representing the regional background O₃ in southern England. The hemispheric background O₃ concentrations were derived from measurements at Mace Head coupled with air-mass back trajectory analysis. 96h air-mass back trajectories arriving daily at Mace Head were modelled with the Hysplit model and were grouped into 4 clusters based on the similarity of the angle of each trajectory from the origin (Mace Head). These clusters are visualised in Figure 10. The hours corresponding to trajectory clusters from the west and southwest (C1 and C2) are considered to be “clean” air masses and therefore representing the hemispheric background O₃ concentration.

Figure 10: Air mass back trajectories arriving at Mace Head in 2025.



To quantify the regional O_3 increment, 288 month-hourly average O_3 concentrations were calculated at Chilbolton and for the “clean” air masses at Mace Head. The difference between them is shown in Figure 11. These plots show the average O_3 increment for each hour of each month. In general, we would expect higher concentrations for the hemispheric background O_3 , i.e. negative values in Figure 11. However, elevated regional background O_3 concentrations due to photochemical reactions were evident especially during the summer day hours. 2023 is seen to have higher average O_3 concentrations in June and September compared to 2024, whilst May and August 2024 are higher than 2023.

Figure 11: Month–hourly average differences between regional and hemispheric background O₃ in 2024 and 2025 at Chilbolton.



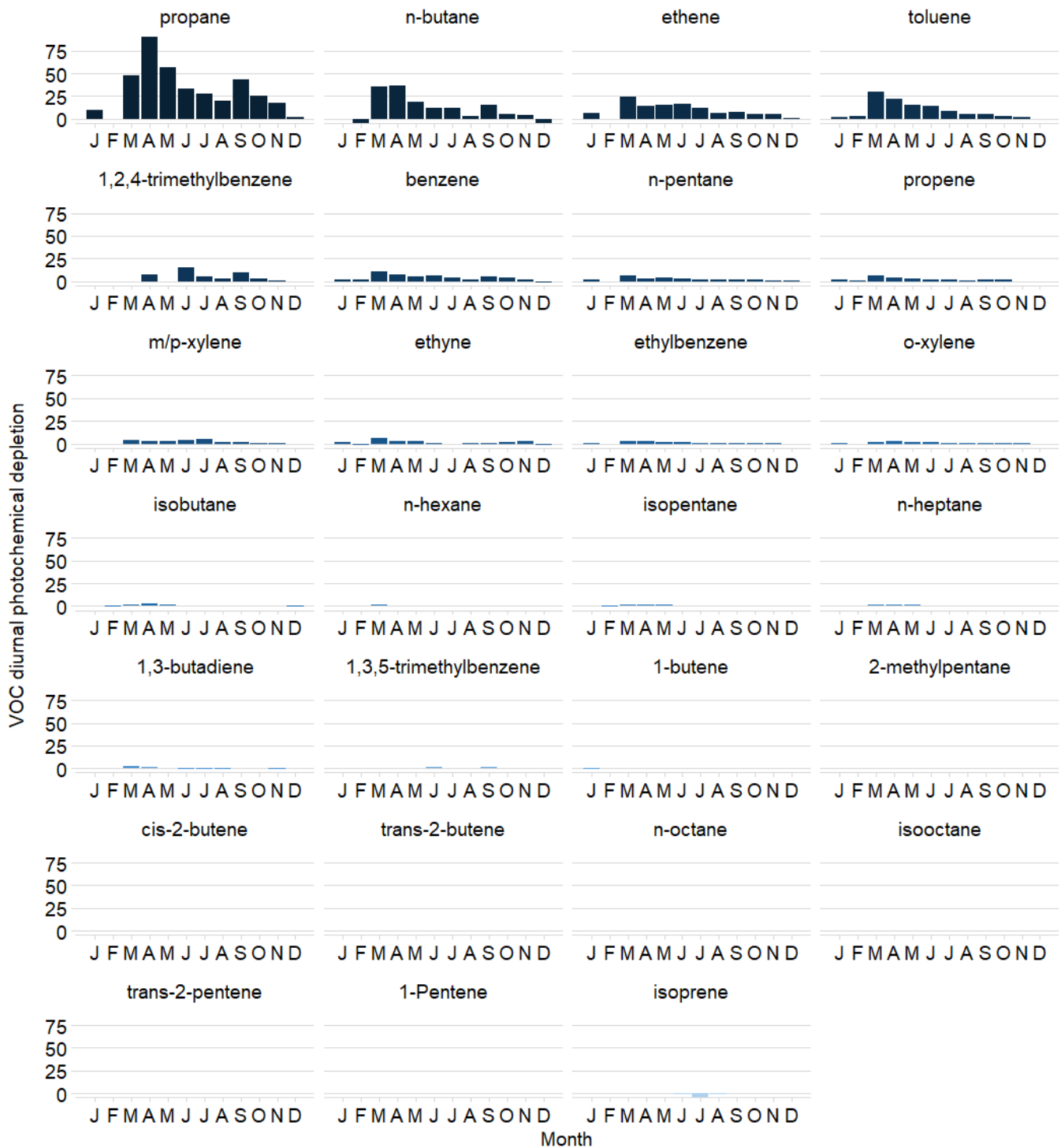
5.4.2 Photochemical ozone creation potential

Multiple studies have tried to quantify the propensity of each VOC to produce O₃ and derived the photochemical ozone creation potential (POCP) (Derwent et al., 2007; Hakami et al., 2004; Luecken and Mebust, 2008). The POCPs derived by Derwent et al. (2007) are used in this analysis as they were calculated under simulated north-western European conditions, which is most relevant in the UK context. In Derwent et al. (2007), a VOC POCP was defined as the ratio (multiplied by 100) of the increase in O₃ due to increased emissions of the VOC simulated in a Lagrangian model along a trajectory traversing from central Europe to the UK, relative to the modelled increase in O₃ from the same mass increase in emissions of ethene (the reference POCP VOC assigned a value of 100). Hourly VOC concentrations were multiplied by the corresponding POCPs to weight their potential to create O₃. Diurnal variation of the weighted VOC concentrations at Chilbolton represents the extent of photochemical depletion that occurred in the southern England, and in turn leads to the regional O₃ creation. It is acknowledged that part of the diurnal variation in VOC concentrations is due to changes in the boundary layer mixing depth. To eliminate this effect, hourly POCP-weighted VOC concentrations were normalised by the corresponding POCP-weighted ethane concentrations. Ethane was chosen because it has the second smallest POCP of the measured VOCs (see Table 2-3) and has previously been used to estimate photochemical loss of VOCs (Malley et al., 2015; Yates et al., 2010). The VOC diurnal photochemical depletion is then calculated as the difference between the average POCP-weighted VOC/ethane ratio at night (00:00 – 04:00) and in the afternoon (12:00 – 16:00). A positive value indicates daytime photochemical depletion of the VOC relative to ethane.

The median of the VOC diurnal photochemical depletion for each month is summarised in Figure 12. The seasonal pattern of VOC diurnal photochemical depletion matches the seasonal pattern of regional O₃ increment as observed in Figure 13, i.e., largest VOC diurnal photochemical depletion and regional O₃ increment in the summer months. The magnitude of the VOC diurnal photochemical depletion indicates

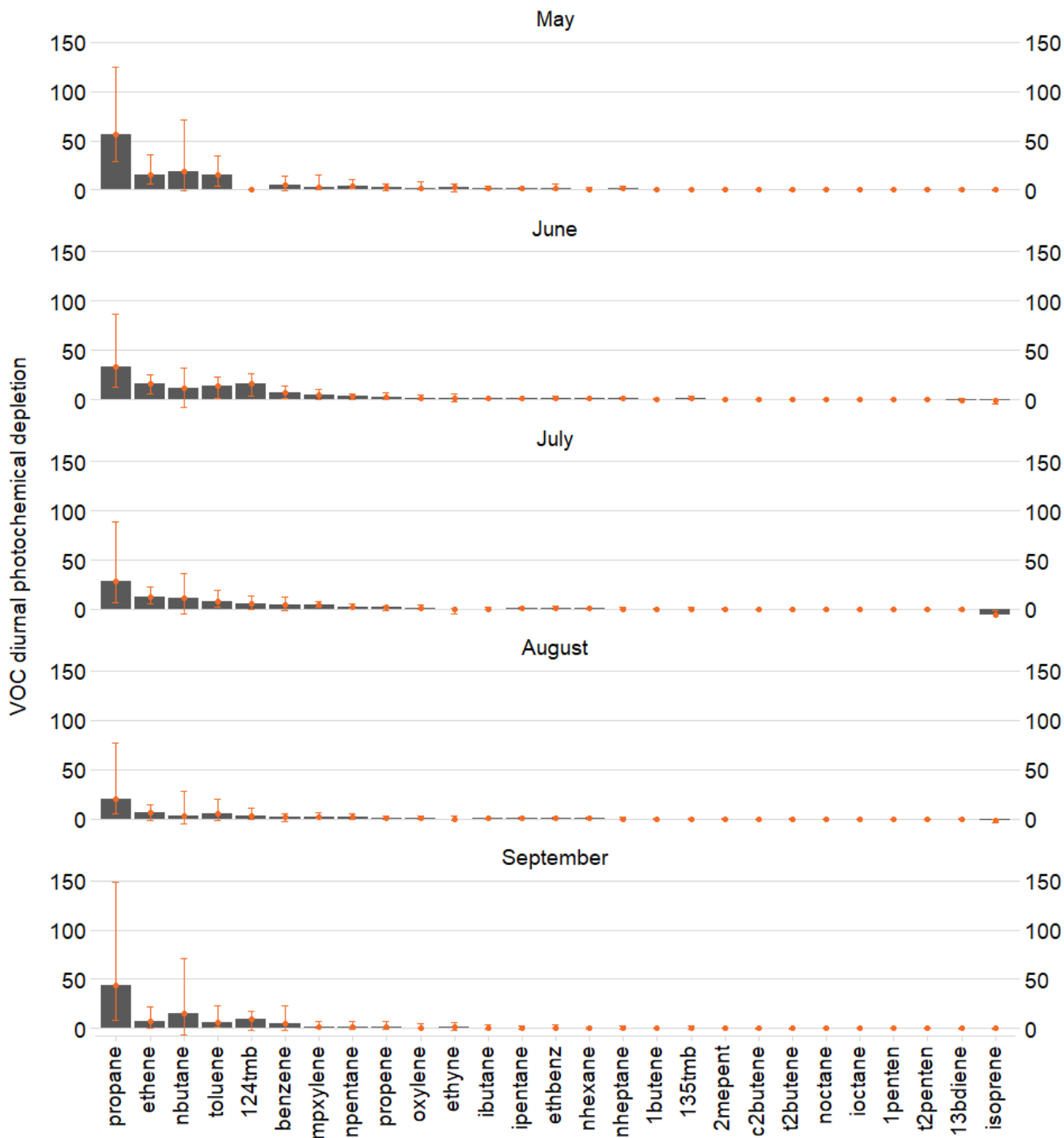
relative contribution of each VOC to total VOC photochemical depletion, which in turn represents the relative contribution to the production of regional O₃.

Figure 12: Median of the diurnal VOC photochemical depletion at Chilbolton for each month in 2025. VOCs are ordered by their average diurnal photochemical depletion



To compare the relative contribution of each VOC to the regional O₃ increment, Figure 13 shows the median VOC diurnal photochemical depletion values in descending order for the months when regional O₃ increment was observed. Propane showed the largest contribution to regional O₃ increment during these months. n-butane, ethene, toluene, 1,2,4-trimethylbenzene, benzene, n-pentane, and propene also had a notable contribution to regional O₃ creation and were comparatively larger than other VOC species. The result might suggest that, of the measured VOCs, reduction in emission of propane, n-butane, ethene, toluene, 1,2,4-trimethylbenzene, benzene, n-pentane, and propene emissions would be most effective in reducing regional O₃ increment.

Figure 13: Median of the VOC diurnal photochemical depletion at Chilbolton between May and September in 2025. Error bar indicates the 25 and 75% percentile of the VOC diurnal photochemical depletion for that VOC in the relevant month.

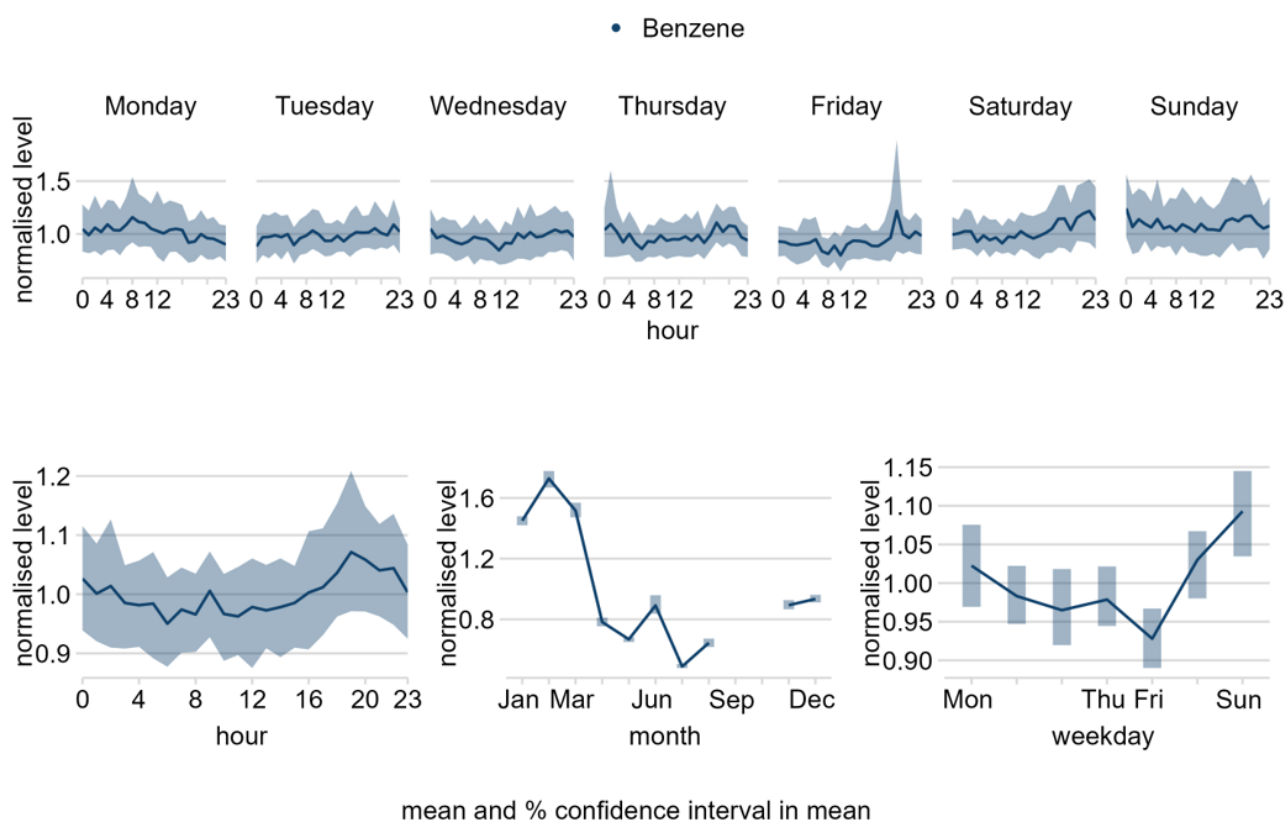


5.5 Automatic Data Time Variations for Benzene

The plots in this section analyse trends by average hourly measurements during each day of week, hour of every day, average of each month of the year and average of each day of the week. The scales are normalised such that comparisons can be made between species.

5.5.1 Auchencorth Moss

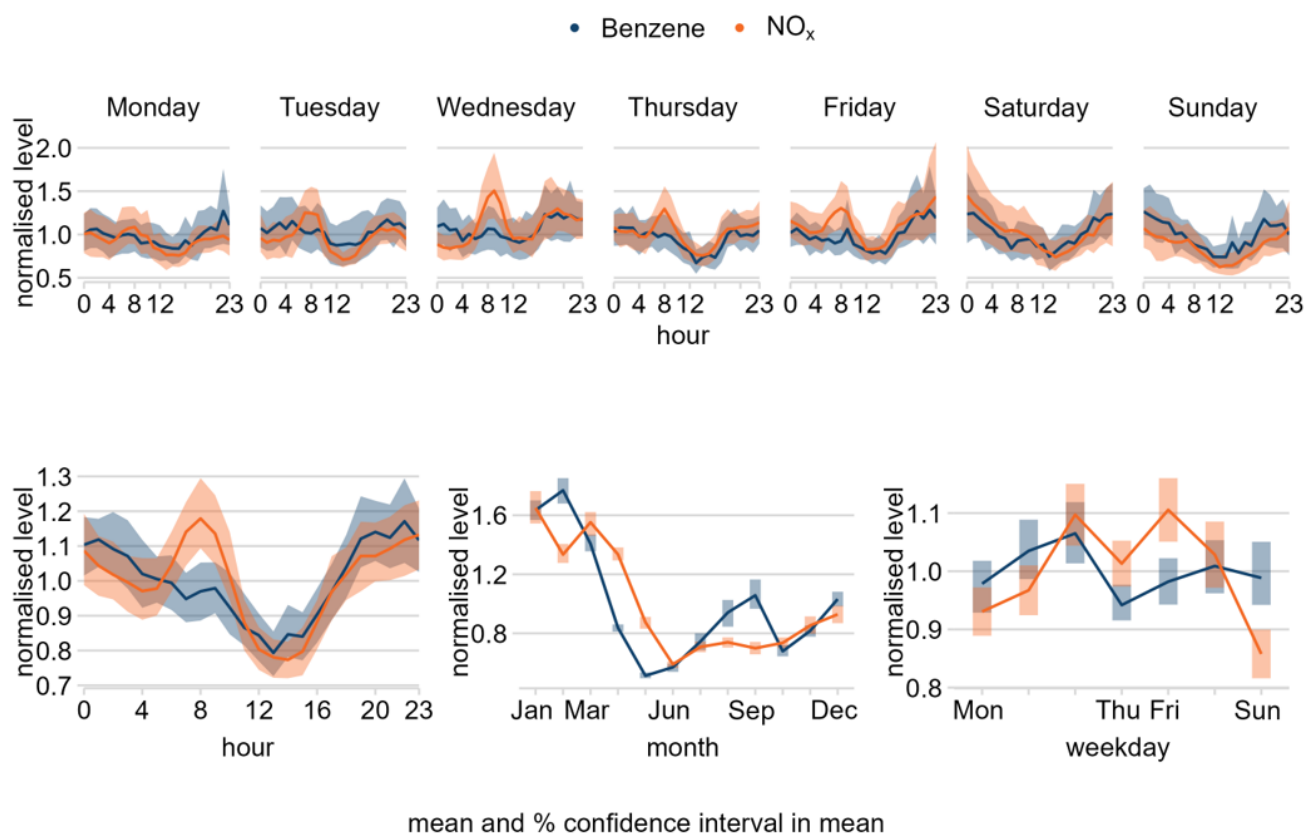
Figure 14: Diurnal, seasonal and week-daily variation of benzene at Auchencorth Moss in 2025.



Benzene concentrations at Auchencorth Moss are highest at 19:00. The highest monthly measurements were seen in January, February, and March. On a typical week, benzene was on average highest on Sundays.

5.5.2 Chilbolton Observatory

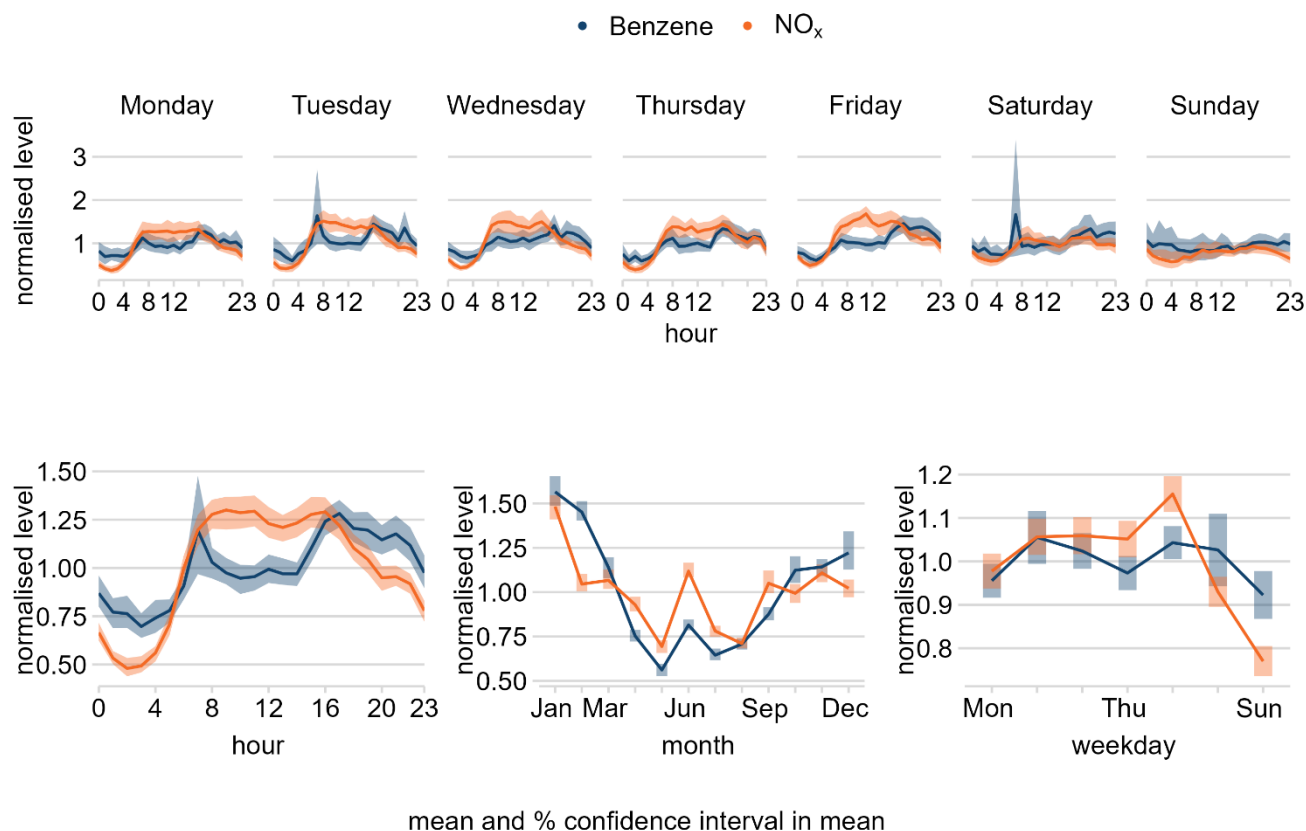
Figure 15: Diurnal, seasonal and week-daily variation of benzene at Chilbolton Observatory in 2025.



Benzene concentrations at Chilbolton Observatory were highest at between the hours of 19:00, and 23:00. The highest monthly measurements were seen in January, February, and March. On a typical week, benzene was on average highest on Wednesdays. Comparatively, NO_x concentrations were highest at the hours of 7:00, 8:00, and 9:00, in January, March, and April, and on Tuesdays and Thursdays.

5.5.3 Marylebone Road

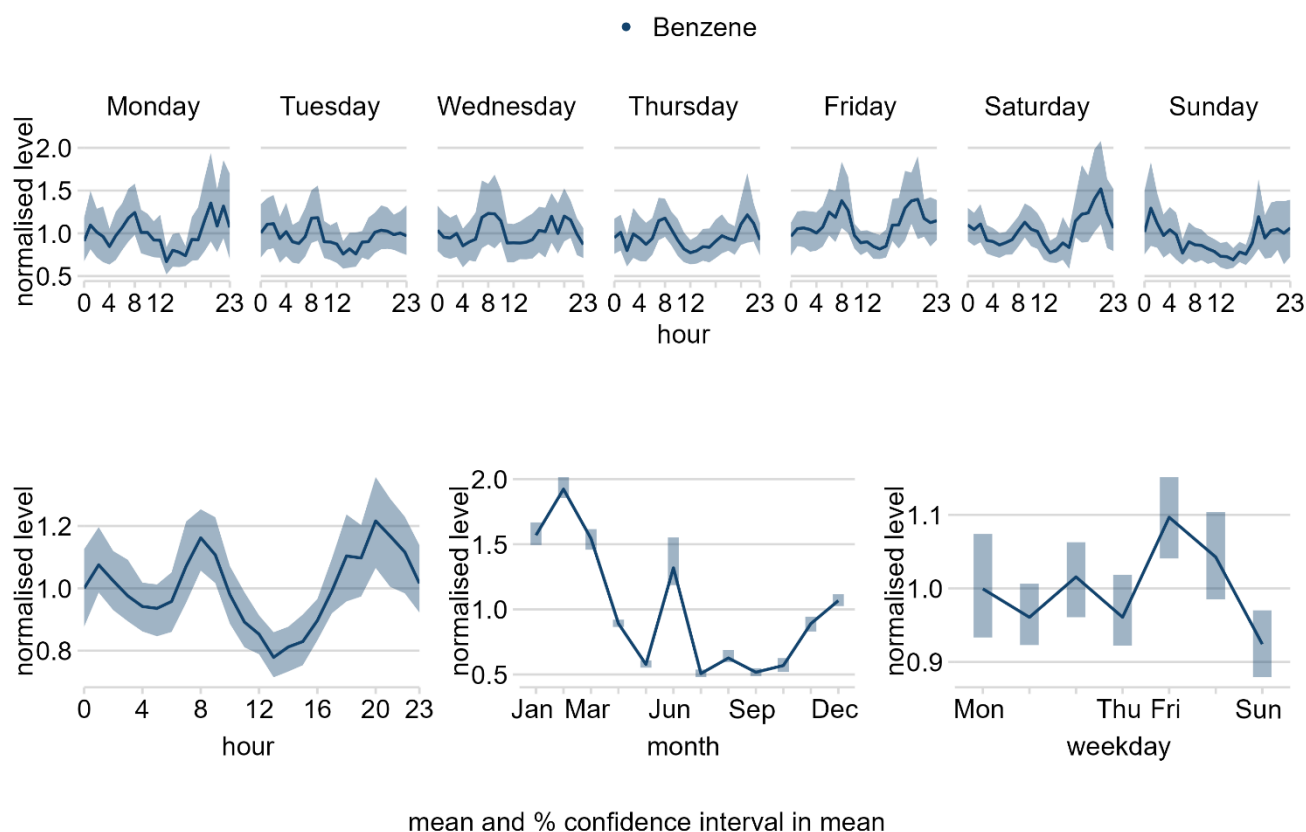
Figure 16: Diurnal, seasonal and week-daily variation of benzene at Marylebone Road in 2025.



Benzene concentrations at Marylebone Road were highest at the hours of 07:00 and after 16:00 until 22:00. The highest monthly measurements were seen in January, February, and December. On a typical week, benzene was on average highest on Tuesdays, Fridays, and Saturdays. Comparatively, NO_x concentrations were highest at the hours of 9:00, 11:00, and 16:00, in January, June, and November, and on Tuesdays, Wednesdays, and Fridays.

5.5.4 London Honor Oak Park

Figure 17: Diurnal, seasonal and week-daily variation of benzene at London Honor Oak Park in 2025.



Benzene concentrations at London Honor Oak Park were highest at the hours of 8:00, 20:00, and 21:00. The highest monthly measurements were seen in January, February, and March. On a typical week, benzene was on average highest on Wednesdays, Fridays, and Saturdays.

5.6 Benzene Modelling

Measurements from the HCs network are made available to Defra and its modelling contractors to ensure that the national compliance modelling results are grounded in reality in accordance with the Government's AQUA book guidance on Analytical Quality Assurance.²

² <https://www.gov.uk/guidance/the-aqua-book>

6. Developments and recommendations

6.1 BS EN14662-1:2023

Standard BS EN14662-3:2023 has now formally replaced the previous version from 2005 by CEN Working Group 12. The replacement includes recommendations and requirements for duplex and sequential samplers as well as a simple single tube system.

6.2 Standard method for ozone precursors

There has never been a standard method for the measurement of ozone precursors to date. Under Working Group 13, funding from the European Commission had been requested in order to start a 5-year process for development of such a standard. A mandate for this has now been issued, however the funding requested was costed for the preparation of a single standard method, the EC issued a mandate for 6 standard methods to be developed. These include:

- Automatic pumped sampling, pre-concentration and on-line gas chromatography with flame ionisation detector (FID) and/or mass spectrometer detector (MSD);
- Manual or automatic canister sampling followed by off-line gas chromatography with FID and/or MSD;
- Manual or automatic pumped sampling followed by off-line thermal desorption and gas chromatography with FID and/or MSD;
- Diffusive sampling followed by thermal desorption by off-line gas chromatography with FID and/or MSD;
- Manual or automatic pumped sampling of formaldehyde on dinitrophenylhydrazine (DNPH) followed by off-line high-performance liquid chromatography (HPLC)/ ultraviolet (UV) detection;
- Diffusive sampling of formaldehyde on DNPH followed by off-line HPLC/UV detection.

A first draft work programme was provided to the EC in August 2019. Working Group 13 has been resumed in order to cover most parts of this, with Working Group 11 covering the diffusive methodologies. Presently, the new standard method publication date has been set as 4th June 2027.

7. Conclusions

The annual mean benzene concentration across all non-automatic monitoring stations in the UK for 2025 was $0.49 \mu\text{g m}^{-3}$. All 34 monitoring stations used for non-automatic benzene measurements are situated in urban locations. The mean data capture for benzene measured at the non-automatic hydrocarbon monitoring stations in operation from January to December 2025 was 94%.

The annual mean benzene concentration across all automatic monitoring stations in the UK was $0.43 \mu\text{g m}^{-3}$, of the 4 automatic monitoring stations used for hourly automatic measurements, 2 are situated at rural locations. The mean data capture for benzene measured by the automatic hydrocarbon network in 2025 was 67%.

In 2025, none of the automatic or non-automatic monitoring stations in the UK exceeded the $5 \mu\text{g m}^{-3}$ annual mean Limit Value or the Upper Assessment Threshold of $3.5 \mu\text{g m}^{-3}$ for benzene set out in the AQSR 2010. The results confirm no exceedances of UK limit values and objectives at any of the Urban, Traffic and Background monitoring stations during 2025. The highest concentrations observed during 2025 have been seen at roadside and industrial locations. The trends from sites classified as urban traffic and urban background do show similar trends, indicating that benzene sources in these urban areas are typically from road traffic. Industrial locations do not share the same trend, most likely due to additional sources of benzene from industrial processes and combustion from point sources and fugitive emissions.

Annual means of less than $1 \mu\text{g m}^{-3}$ have been observed at urban background and urban traffic locations. Bath A4 Roadside, an urban traffic site, recorded the highest time weighted annual mean of $0.83 \mu\text{g m}^{-3}$.

All sites showed a decrease in benzene concentration over the period 2002 to 2025. Long term trends from 2002 to 2008 show benzene concentrations have declined significantly. This demonstrates that over this period motor vehicle exhaust catalysts and evaporative canisters have effectively and efficiently controlled vehicular emissions of benzene in the UK. This should have led to reduced health impact on individuals living in the UK because of long term exposure to these pollutants. Since 2010, concentrations have remained relatively stable up to and including 2025. Benzene emissions data provided by the National Atmospheric Emissions Inventory shows a steady decline in benzene emissions from 2010 to 2025, conversely, the stability seen in benzene monitoring data could be due to alternative sources of benzene, such as from increased use of wood-burning appliances used for domestic and commercial space and water heating.

Data measured at Chilbolton Observatory indicates that, of the VOCs measured, Propane, n-butane, ethene, toluene, 1,2,4-trimethylbenzene, benzene, n-pentane, and propene showed the largest contribution to regional O_3 increment during the daylight hours in summer. 1,2,3-trimethylbenzene is not typically measured due to interference (co-elution) caused by the presence of another unknown VOC.

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9. Appendices

Table 9-1: Information of the monitoring stations in the automatic hydrocarbon network.

The “Map ID” allows this table to be cross-referenced with Figure 2.

Map ID	Site name	Site type	Region	Latitude	Longitude
3	Auchencorth Moss	Rural Background	Central Scotland	55.79216	-3.242900
31	London Marylebone Road	Urban Traffic	Greater London	51.52253	-0.154611
34	London Eltham	Suburban Background	Greater London	51.45258	0.070766
35	London Honor Oak Park	Urban Background	Greater London	51.44967	-0.037418
38	Chilbolton Observatory	Rural Background	South East	51.14962	-1.438228

Table 9-2: Information of the monitoring stations in the non-automatic hydrocarbon network.

The “Map ID” allows this table to be cross-referenced with Figure 2.

Map ID	Site name	Site type	Region	Latitude	Longitude
1	Grangemouth	Urban Industrial	Central Scotland	56.01032	-3.704399
2	Glasgow Kerbside	Urban Traffic	Central Scotland	55.85894	-4.259122
4	Newcastle Centre	Urban Background	North East	54.97825	-1.610528
5	Carlisle Morton A595	Urban Traffic	North West & Merseyside	54.88582	-2.964955
6	Belfast Centre	Urban Background	Northern Ireland	54.59965	-5.928833
7	Middlesbrough	Urban Background	North East	54.56930	-1.220874
8	Stockton-on-Tees Eaglescliffe	Urban Traffic	North East	54.51667	-1.358547
9	York Bootham	Urban Background	Yorkshire & Humberside	53.96751	-1.086514
10	York Fishergate	Urban Traffic	Yorkshire & Humberside	53.95189	-1.075861
11	Leeds Centre	Urban Background	Yorkshire & Humberside	53.80378	-1.546472
12	Scunthorpe Town	Urban Industrial	Yorkshire & Humberside	53.58634	-0.636811

Map ID	Site name	Site type	Region	Latitude	Longitude
13	Barnsley Gawber	Urban Background	Yorkshire & Humberside	53.56292	-1.510436
14	Bury Whitefield Roadside	Urban Traffic	North West & Merseyside	53.55903	-2.293772
15	Manchester Piccadilly	Urban Background	North West & Merseyside	53.48152	-2.237881
16	Sheffield Devonshire Green	Urban Background	Yorkshire & Humberside	53.37862	-1.478096
17	Liverpool Speke	Urban Industrial	North West & Merseyside	53.34633	-2.844333
18	Chesterfield Roadside	Urban Traffic	East Midlands	53.23175	-1.456928
19	Stoke-on-Trent Centre	Urban Background	West Midlands	53.02821	-2.175133
20	Nottingham Kenmore Gardens	Urban Background	East Midlands	52.95944	-1.138650
21	Norwich Lakenfields	Urban Background	Eastern	52.61482	1.302686
22	Birmingham Ladywood	Urban Background	West Midlands	52.48135	-1.918235
23	Birmingham A4540 Roadside	Urban Traffic	West Midlands	52.47615	-1.874978
24	Leamington Spa	Urban Background	West Midlands	52.28881	-1.533119
25	Cambridge Roadside	Urban Traffic	Eastern	52.20237	0.124456
26	Oxford Centre Roadside	Urban Traffic	South East	51.75174	-1.257463
27	Oxford St Ebbes	Urban Background	South East	51.74481	-1.260278
28	Newport	Urban Background	South Wales	51.60120	-2.977281
29	Haringey Roadside	Urban Traffic	Greater London	51.59930	-0.068218
30	Port Talbot Margam	Urban Industrial	South Wales	51.58395	-3.770822
32	London Bloomsbury	Urban Background	Greater London	51.52229	-0.125889
33	London Farringdon Street	Urban Traffic	Greater London	51.51474	-0.104522
36	Bath A4 Roadside	Urban Traffic	South West	51.39092	-2.355030
37	Chatham Roadside	Urban Traffic	South East	51.37426	0.547970

Map ID	Site name	Site type	Region	Latitude	Longitude
39	Southampton Centre	Urban Background	South East	50.90817	-1.395757

Table 9-3: Summary statistics for all VOCs measured at the automatic monitoring sites in 2025.

Site	VOC	Annual data capture	Annual maximum	Annual mean	Annual minimum
Auchencorth Moss	13bdiene	0.62	0.52	0.02	0.01
Auchencorth Moss	2mepent	0.65	3.84	0.06	0.01
Auchencorth Moss	benzene	0.53	1.95	0.23	0.02
Auchencorth Moss	ethane	0.65	17.63	2.56	1.00
Auchencorth Moss	ethbenz	0.57	1.01	0.04	0.02
Auchencorth Moss	ethene	0.64	7.17	0.35	0.02
Auchencorth Moss	ethyne	0.65	2.51	0.29	0.04
Auchencorth Moss	ibutane	0.65	31.38	0.36	0.01
Auchencorth Moss	ioctane	0.56	0.35	0.03	0.02
Auchencorth Moss	ipentane	0.65	19.61	0.22	0.01
Auchencorth Moss	isoprene	0.65	5.13	0.08	0.01
Auchencorth Moss	mpxylene	0.57	3.81	0.07	0.02
Auchencorth Moss	nbutane	0.65	58.51	0.59	0.03
Auchencorth Moss	nheptane	0.56	1.17	0.03	0.02
Auchencorth Moss	nhexane	0.61	4.84	0.07	0.00
Auchencorth Moss	noctane	0.57	0.39	0.03	0.02
Auchencorth Moss	npentane	0.65	18.74	0.17	0.01
Auchencorth Moss	oxylene	0.56	1.41	0.04	0.02
Auchencorth Moss	propane	0.65	291.79	1.23	0.07
Auchencorth Moss	propene	0.52	2.40	0.24	0.04
Auchencorth Moss	toluene	0.60	4.48	0.16	0.01
Chilbolton Observatory	13bdiene	0.82	0.43	0.05	0.01

Site	VOC	Annual data capture	Annual maximum	Annual	
Chilbolton Observatory	2mepent	0.88	57.84	0.17	0.01
Chilbolton Observatory	benzene	0.70	3.03	0.39	0.04
Chilbolton Observatory	ethane	0.94	20.21	2.43	0.72
Chilbolton Observatory	ethbenz	0.85	1.43	0.09	0.02
Chilbolton Observatory	ethene	0.92	6.76	0.58	0.04
Chilbolton Observatory	ethyne	0.82	2.63	0.35	0.01
Chilbolton Observatory	ibutane	0.92	64.68	0.69	0.06
Chilbolton Observatory	ioctane	0.84	6.57	0.06	0.02
Chilbolton Observatory	ipentane	0.92	8.68	0.45	0.01
Chilbolton Observatory	isoprene	0.94	1.88	0.04	0.01
Chilbolton Observatory	mpxylene	0.82	3.95	0.17	0.02
Chilbolton Observatory	nbutane	0.92	163.73	1.06	0.06
Chilbolton Observatory	nheptane	0.85	16.49	0.08	0.02
Chilbolton Observatory	nhexane	0.86	3.86	0.13	0.02
Chilbolton Observatory	noctane	0.83	0.83	0.06	0.02
Chilbolton Observatory	npentane	0.88	6.44	0.28	0.02
Chilbolton Observatory	oxylene	0.85	1.53	0.09	0.02
Chilbolton Observatory	propane	0.94	268.81	2.11	0.14

Site	VOC	Annual data capture	Annual maximum	Annual	
Chilbolton Observatory	propene	0.91	13.40	0.38	0.02
Chilbolton Observatory	toluene	0.91	6.39	0.42	0.06
London Honor Oak Park	123tmb	0.46	0.96	0.03	0.00
London Honor Oak Park	124tmb	0.46	3.08	0.10	0.00
London Honor Oak Park	135tmb	0.46	1.42	0.03	0.00
London Honor Oak Park	13bdiene	0.65	0.49	0.02	0.00
London Honor Oak Park	1butene	0.65	1.29	0.07	0.00
London Honor Oak Park	1penten	0.65	0.45	0.03	0.00
London Honor Oak Park	2mepent	0.65	116.89	0.39	0.00
London Honor Oak Park	3mepent	0.65	55.35	0.25	0.00
London Honor Oak Park	acetaldehyde	0.43	10.23	2.20	0.29
London Honor Oak Park	acetone	0.54	226.74	3.79	0.49
London Honor Oak Park	benzene	0.55	3.68	0.51	0.07
London Honor Oak Park	c2butene	0.65	0.50	0.02	0.00
London Honor Oak Park	cyclopentane	0.65	1.31	0.14	0.00
London Honor Oak Park	ethane	0.65	52.89	5.32	1.24
London Honor Oak Park	ethanol	0.43	81.31	6.28	0.18
London Honor Oak Park	ethbenz	0.51	5.73	0.19	0.00

Site	VOC	Annual data capture	Annual maximum	Annual	
London Honor Oak Park	ethene	0.65	5.28	0.61	0.04
London Honor Oak Park	ethyne	0.65	3.48	0.39	0.05
London Honor Oak Park	ibutane	0.65	329.89	2.30	0.22
London Honor Oak Park	ibutene	0.64	1.60	0.10	0.00
London Honor Oak Park	ioctane	0.52	0.86	0.08	0.00
London Honor Oak Park	ipentane	0.65	77.71	1.31	0.07
London Honor Oak Park	isoprene	0.24	2.42	0.07	0.00
London Honor Oak Park	mxylene	0.51	16.61	0.43	0.00
London Honor Oak Park	nbutane	0.65	1485.78	4.60	0.36
London Honor Oak Park	nheptane	0.54	2.06	0.12	0.00
London Honor Oak Park	nhexane	0.65	10.39	0.25	0.00
London Honor Oak Park	nnonane	0.44	1.11	0.06	0.00
London Honor Oak Park	noctane	0.54	0.41	0.04	0.00
London Honor Oak Park	npentane	0.65	10.06	0.56	0.04
London Honor Oak Park	oxylene	0.51	8.03	0.22	0.00
London Honor Oak Park	propane	0.65	226.42	3.46	0.42
London Honor Oak Park	propene	0.65	4.91	0.25	0.00
London Honor Oak Park	pxylene	0.52	7.25	0.16	0.00

Site	VOC	Annual data capture	Annual maximum	Annual	
London Honor Oak Park	t2butene	0.65	0.65	0.02	0.00
London Honor Oak Park	t2penten	0.65	0.72	0.03	0.00
London Honor Oak Park	toluene	0.55	11.05	0.99	0.04
London Marylebone Road	123tmb	0.00	NA	NA	NA
London Marylebone Road	124tmb	0.93	70.35	0.89	0.02
London Marylebone Road	135tmb	0.87	15.59	0.18	0.01
London Marylebone Road	13bdiene	0.96	1.69	0.16	0.00
London Marylebone Road	1butene	0.92	2.37	0.23	0.01
London Marylebone Road	1penten	0.90	2.75	0.09	0.01
London Marylebone Road	2mepent	0.96	88.36	0.56	0.02
London Marylebone Road	benzene	0.89	23.67	0.58	0.05
London Marylebone Road	c2butene	0.86	1.79	0.15	0.01
London Marylebone Road	ethane	0.96	108.44	7.67	1.35
London Marylebone Road	ethbenz	0.93	371.85	1.26	0.01
London Marylebone Road	ethene	0.96	14.09	1.75	0.23
London Marylebone Road	ethyne	0.95	8.23	0.78	0.12
London Marylebone Road	ibutane	0.96	135.22	2.84	0.32
London Marylebone Road	ioctane	0.93	70.98	0.36	0.02

Site	VOC	Annual data capture	Annual maximum	Annual	
London Marylebone Road	ipentane	0.96	211.72	1.79	0.03
London Marylebone Road	isoprene	0.90	3.16	0.23	0.01
London Marylebone Road	mpxylene	0.92	1504.15	4.62	0.01
London Marylebone Road	nbutane	0.96	256.72	4.59	0.46
London Marylebone Road	nheptane	0.94	36.22	0.34	0.01
London Marylebone Road	nhexane	0.95	47.82	0.35	0.02
London Marylebone Road	noctane	0.91	14.46	0.14	0.00
London Marylebone Road	npentane	0.96	82.12	0.79	0.11
London Marylebone Road	oxylene	0.94	458.53	1.58	0.01
London Marylebone Road	propane	0.96	122.23	4.98	0.75
London Marylebone Road	propene	0.95	8.56	0.82	0.08
London Marylebone Road	t2butene	0.93	2.19	0.20	0.01
London Marylebone Road	t2penten	0.92	6.41	0.11	0.01
London Marylebone Road	toluene	0.94	451.90	1.90	0.01

