AIR QUALITY MONITORING AT STANSTED AIRPORT 2022

Report for Manchester Airports Group plc

Ref. MAG03880 Amendment Number MAG 03

Ricardo ref. ED12982 Issue: 1 23/05/2023

Customer:
Manchester Airports Group – Stansted Airport

Customer reference:
MAG03880 AMENDMENT NUMBER MAG 03

Confidentiality, copyright and reproduction:

This report is the Copyright of Manchester Airports Group plc. It has been prepared by Ricardo Energy & Environment, a trading name of Ricardo-AEA Ltd, under contract to Manchester Airports Group dated 01/01/2022. The contents of this report may not be reproduced in whole or in part, nor passed to any organisation or person without the specific prior written permission of Manchester Airport Group plc. Ricardo Energy & Environment accepts no liability whatsoever to any third party for any loss or damage arising from any interpretation or use of the information contained in this report, or reliance on any views expressed therein.

Ricardo reference:
ED12982

Contact:
Nick Rand
Ricardo Energy & Environment
Gemini Building, Harwell, Didcot, OX11 0QR, United Kingdom

T: +44 (0) 1235 75 8434
E: nick.rand@ricardo.com

Author:
Georgina McCarthy

Approved by:
Nick Rand

Signed

Date:
23 May 2023

Ricardo is certified to ISO9001, ISO14001, ISO27001 and ISO45001.

Ricardo, its affiliates and subsidiaries and their respective officers, employees or agents are, individually and collectively, referred to as the 'Ricardo Group'. The Ricardo Group assumes no responsibility and shall not be liable to any person for any loss, damage or expense caused by reliance on the information or advice in this document or howsoever provided, unless that person has signed a contract with the relevant Ricardo Group entity for the provision of this information or advice and in that case any responsibility or liability is exclusively on the terms and conditions set out in that contract.

EXECUTIVE SUMMARY

This report provides details of air quality monitoring conducted around Stansted Airport during 2022. The work, carried out by Ricardo Energy & Environment on behalf of Manchester Airports Group, is a continuation of monitoring undertaken at Stansted Airport since 2004. The aims of the programme are to monitor air quality around the airport, to assess compliance with relevant air quality objectives, and to investigate changes in air pollutant concentrations over time.

Automatic continuous monitoring was carried out at three fixed locations previously agreed with Uttlesford District Council and Natural England (in respect of Hatfield Forest) and are referred to as Stansted 3, Stansted 4 and Stansted 5. Stansted 3 is located to the southeast of the airport at High House, Stansted 4 is located to the north of the runway, and Stansted 5 is located in the National Trust office car park in the north-east corner of Hatfield Forest. All sites monitored oxides of nitrogen (nitric oxide and nitrogen dioxide), PM_{10} particulate matter and $PM_{2.5}$ particulate matter.

In addition to automatic monitoring, indicative monitoring of nitrogen dioxide was carried out using diffusion tubes. These were co-located with the continuous automatic monitor at Stansted 3 and also used at four other sites around Stansted, to the north, south, east and west of the airport. From August 2017, indicative monitoring of nitrogen dioxide has been carried out using diffusion tubes at nine locations around Hatfield Forest.

The minimum applicable data capture target of 85% (recommended in the European Commission Air Quality Directive[1] and Defra Technical Guidance LAQM.TG (22)[1]) was achieved for all pollutants in 2022 at Stansted 3 (NO_x, PM_{10} and $PM_{2.5}$) and Stansted 5 (NO_x, PM_{10} and $PM_{2.5}$). However, this target was not achieved for each pollutant at Stansted 4 (NO_x, PM_{10} and $PM_{2.5}$) due to critical analyser faults and air conditioning issues.

The UK AQS hourly mean objective for NO_2 is 200 µg m^{-3}, with no more than 18 exceedances allowed each year. Both Stansted 3 and Stansted 5 met this objective, recording no hourly means above the objective. As Stansted 4 only had a data capture rate of 57.3%, it was not possible to sufficiently assess the AQS objective for 1 hour mean NO_2 concentrations at this site. **The UK AQS annual mean objective for NO_2 of 40 µg m^{-3} was met at the automatic monitoring sites of Stansted 3 and Stansted 5 during 2022, whilst the annualised mean met this objective at Stansted 4. All diffusions tube data also met this objective, including the five Stansted and the nine Hatfield Forest diffusion tube sites.**

PM_{10} may exceed the 24-hour mean limit of 50 µg m^{-3} no more than 35 times per year to meet the AQS objective. Stansted 3 exceeded the 24-hour mean limit of 50 µg m^{-3} on six occasions throughout 2022, whilst Stansted 5 exceeded on four days during 2022. As Stansted 4 only had a data capture rate of 72.3%, it was not possible to sufficiently assess the AQS objective for the 24-hour mean PM_{10} concentration limit at this site. **The annual mean AQS for PM_{10} of 40 µg m^{-3} was met at Stansted 3 and Stansted 5 during 2022, whilst the annualised mean met this objective at Stansted 4.**

The annual mean objective for $PM_{2.5}$ is 25 µg m^{-3}. At Stansted 3 and Stansted 5 annual mean $PM_{2.5}$ concentrations were 8 µg m^{-3} and 9 µg m^{-3} respectively, whilst the annualised $PM_{2.5}$ mean at Stansted 4 was 8 µg m^{-3}. **Therefore, these sites met the AQS objective for $PM_{2.5}$ annual means during 2022.**

Wind speed and direction data accessed via the National Oceanic and Atmospheric Administration (NOAA) were used to produce bivariate plots showing hourly mean pollutant concentrations against the corresponding weather conditions. The bivariate plots for NO_2 at all Stansted sites show elevated concentrations when wind speeds are low. There also appears to be a possible indication of activities around the airport terminal buildings affecting NO_2 concentrations at these sites, as well as other local sources.

The bivariate plots for $PM_{2.5}$ indicate high concentrations under calm conditions but also under more unsettled conditions, especially from southeast and northeast directions. High concentrations of $PM_{2.5}$ from a south-easterly direction are likely attributed to long range transport of polluted air from the continent.

The bivariate plots for PM_{10} showed varying results for each site. At Stansted 3 high concentrations are associated with high windspeeds from the southeast, which is likely a result of transboundary air movements from the continent. PM_{10} sources at Stansted 4 appear under calmer conditions although there are still elevated concentrations that appear under moderate to higher wind speeds to the northeast and southwest of the site. At Stansted 5, the bivariate plot shows higher PM_{10} concentrations are associated with higher wind speeds towards the northeast of the monitoring site which are possibly associated with localised agricultural activity.

At all three sites particularly high concentrations of PM_{10} and $PM_{2.5}$ were recorded between 21st March and 25th March 2022. Air masses coming from southern and eastern Europe coupled with calm conditions promoting poor dispersion are the expected reasons for these high concentration episodes.

Average NO_2 concentrations are broadly similar to those from comparable urban background monitoring sites and have remained lower than concentrations at London Heathrow Airport.

Annual mean concentrations of NO_2, PM_{10} and $PM_{2.5}$ at Stansted 3, Stansted 4 and Stansted 5 during 2022 showed small increases when compared with 2021, and were most likely due to a reuptake in activity since the lifting of restrictions during the Coronavirus pandemic.

TABLE OF CONTENTS

Appendices

1. INTRODUCTION

1.1 BACKGROUND

Stansted Airport is the third busiest international airport in London, which handled 23.3 million passengers in 2022. This is significantly more than during 2020 and 2021, where 7.5 million and 7.1 million passengers were handled respectively. This demonstrates the dramatic reduction in air travel caused by the coronavirus pandemic and the subsequent reuptake following the pandemic. The airport is situated approximately 40 miles north of London, in Northwest Essex. It is situated outside the general urbanised area of Greater London, and its surroundings are rural.

Manchester Airports Group is required, under the terms of its Section 106 obligations to the Local Authority (Uttlesford District Council), to carry out monitoring of oxides of nitrogen and particulate matter at agreed locations. Prior to 2006, monitoring was required for three months per year; from 2006 onwards, continuous monitoring throughout the year has been required.

Ricardo Energy & Environment was contracted by Manchester Airports Group to carry out the required programme of air pollution measurements for 2022, the seventeenth full year of continuous monitoring.

Provisional data are reported to Manchester Airports Group monthly throughout the year. This annual report presents and summarises the fully validated and quality-controlled dataset for the entire calendar year. Data in the annual report have been processed according to the rigorous quality assurance and quality control procedures used by Ricardo Energy & Environment. These ensure the data are reliable, accurate and traceable to UK national measurement standards.

This report covers the period 1st January to 31st December 2022.

1.2 AIMS AND OBJECTIVES

The aim of this monitoring programme is to monitor concentrations of three important air pollutants around the airport. The results of the monitoring are used to assess whether applicable air quality objectives have been met, and how pollutant concentrations in the area have changed over time. The pollutants monitored were as follows:

- Oxides of nitrogen (nitric oxide NO and nitrogen dioxide NO_2), using automatic techniques at three locations: Stansted 3 (High House), Stansted 4 (Runway) and Stansted 5 (Hatfield Forest).
- Particulate matter (PM_{10}), using automatic techniques at three locations: Stansted 3 (High House), Stansted 4 (Runway) and Stansted 5 (Hatfield Forest).
- Particulate matter ($PM_{2.5}$) using automatic techniques at three locations: Stansted 3 (High House), Stansted 4 (Runway) and Stansted 5 (Hatfield Forest).

The automatic monitoring was supplemented by indicative monitoring of NO_2 using diffusion tubes at five locations around Stansted Airport, and an additional nine locations in Hatfield Forest.

Monitoring data collected at Stansted are compared in this report with:

- Relevant UK air quality limit values and objectives.
- Corresponding results from a selection of national air pollution monitoring sites.
- Statistics related to airport activity.

In addition, periods of relatively high pollutant concentrations are examined in more detail.

1.3 UK AIR QUALITY STRATEGY

This report compares the results of the monitoring survey with air quality limit values and objectives applicable in the UK. These are summarised below.

1.3.1 European Community

Throughout Europe, ambient air quality is regulated by the European Commission Directive on Ambient Air Quality and Cleaner Air for Europe (EU/2015/1480)[1]. This Directive (referred to as the Air Quality Directive) consolidated three previously existing Directives, which set limit values for a range of air pollutants with known health impacts including NO_2, PM_{10}, CO and benzene.

All Member States of the European Union are required to transpose the requirements of the Directive into their national law. The original Directives were transposed into UK law via the Environment Act 1995 and subsequent Statutory Instruments. With the UK's exit from the EU the UK's AQS is no longer tied to that of the EU, however the current objectives are at least as stringent as the EC limit values.

1.3.2 World Health Organisation

The World Health Organisation (WHO) issued non-mandatory, advisory, guidelines for a variety of pollutants in 2005 using currently available scientific evidence on the effects of air pollution on human health. New, updated, guidelines were introduced in September 2021 which significantly reduced the annual mean limit of NO_2 from 40 µg m^{-3} to 10 µg m^{-3} and the 24h mean being reduced to 25 µg m^{-3}.

In light of the growing evidence of harm that PM_{10} and $PM_{2.5}$ can cause the annual mean limits were reduced from 20 µg m^{-3} to 15 µg m^{-3} and 10 µg m^{-3} to 5 µg m^{-3} respectively.

1.3.3 The UK Air Quality Strategy

The Environment Act also placed a requirement on the Secretary of State for the Environment to produce a national Air Quality Strategy containing standards, objectives and measures for improving ambient air quality. The original Air Quality Strategy was published in 1997, and contained air quality objectives based on the recommendations of the Expert Panel on Air Quality Standards (EPAQS) regarding the levels of air pollutants at which there would be little risk to human health.

The Air Quality Strategy has since undergone several revisions. These have reflected improvements in the understanding of air pollutants and their health effects. They have also incorporated new European limit values, both for pollutants already covered by the Strategy and for newly introduced pollutants such as polycyclic aromatic hydrocarbons and $PM_{2.5}$ particulate matter. The latest version of the strategy was published by Defra in 2007[2].

All Air Quality Strategy (AQS) objectives must be at least as stringent as the EC limit values. The current UK air quality objectives for the pollutants monitored at Stansted Airport are presented in Table 1. In some cases, Scotland, Wales or Northern Ireland have adopted different objectives: Table 1 shows the AQS objectives that apply in England.

Limit values (LV) are values which must not be exceeded. Limit values are established for individual pollutants and consist of a concentration value, an average measurement period, the number of permitted exceedances per year, if any, and an achievement date. Some pollutants have several limit values, each of which covers various endpoints or averaging periods. $PM_{2.5}$ has two stages to the limit value. Stage 1 is defined as a limit value of 25 µg m^{-3} is to be achieved by 2015 and Stage 2 is a limit value of 20 µg m^{-3} to be achieved by 2020 and upheld thereafter. Target values (TV) are similar to limit values and are to be reached, wherever possible, by doing all necessary actions that don't come at a disproportionate expense. Long term objectives (LTO) are not mandatory but are long term targets for specific pollutants.

Table 1: UK air quality objectives for protection of human health, July 2007

Pollutant	Metric	Type	Legal value
NO_2	1-hr	LV	200 µg m^{-3} (18 allowed)
NO_2	Annual mean	LV	40 µg m^{-3}
PM_{10}	24-hr	LV	50 µg m^{-3} (35 allowed)

Pollutant	Metric	Type	Legal value
PM_{10}	Annual mean	LV	40 µg m^{-3}
$PM_{2.5}$	Annual mean	LV (stage 1)	25 µg m^{-3}
$PM_{2.5}$	Annual mean	LV (stage 2)	20 µg m^{-3}
SO_2	1-hr	LV	350 µg m^{-3} (24 allowed)
SO_2	24-hr	LV	125 µg m^{-3} (3 allowed)
CO	8-hr mean	LV	10 mg m^{-3}
Ozone	Maximum daily running 8-hour mean	LV	100 µg m^{-3} (10 allowed)
Ozone	Maximum daily running 8-hour mean	LTO	120 µg m^{-3} (25 allowed, averaged over three years)
Benzene	Annual mean	LV	5.0 µg m^{-3}
Benzo[a]pyrene	Annual mean	TV	1.0 ng m^{-3}
Arsenic	Annual mean	TV	6.0 ng m^{-3}
Cadmium	Annual mean	TV	5.0 ng m^{-3}
Nickel	Annual mean	TV	20.0 ng m^{-3}
Lead	Annual mean	LV	0.5 µg m^{-3}

2. AIR QUALITY MONITORING

2.1 POLLUTANTS MEASURED

2.1.1 Nitrogen Oxides (NO_x)

Combustion processes emit a mixture of oxides of nitrogen – NO and NO_2 - collectively termed NO_x.

i) NO is described as a primary pollutant (meaning it is directly emitted from source). NO is not known to have any harmful effects on human health at ambient concentrations. However, it undergoes oxidation in the atmosphere to form the secondary pollutant NO_2.

ii) NO_2 has a primary (directly emitted) component and a secondary component, formed by oxidation of NO. NO_2 is a respiratory irritant and is toxic at high concentrations. It is also involved in the formation of photochemical smog and acid rain and may cause damage to crops and vegetation.

Of the NOx emissions (including NO_2) considered to be airport-related within the UK aviation sector, the National Atmospheric Emissions Inventory (NAEI) states that over 50 % arise from aircraft during take-off and landing, with around two-thirds of all emissions occurring at some distance from airport ground-level. The Air Quality Expert Group (AQEG)[3] has stated that: "*Around a third of all NO_x emissions from the aircraft (including ground-level emissions from auxiliary power units, engine testing etc., as well as take-off and landing) occur below 100 m in height. The remaining two-thirds occur between 100 m and 1000 m and contribute little to ground-level concentrations. Receptor modelling studies … show the impact of airport activities on ground-level NO_2 concentrations. Studies have shown that although emissions associated with road traffic are smaller than those associated with aircraft, their impact on population exposure at locations around the airport are larger*". Based on 2021 calendar year emissions data from the 2023 submission of (NAEI) data to the EU, civil aircraft taking off and landing (up to a height of 1000m) was estimated to contribute 0.7% to the total reported UK emissions of NOx[4].

Previous rounds of review and assessment within the LAQM process have not highlighted any cases where airports appear to have caused exceedances of air quality objectives for particulate matter measured as PM_{10}.

Therefore, in the context of LAQM, the key pollutant of concern from airports is NO_2. Local authorities whose areas contain airports with over 10 million passengers per annum must take these into account in their annual review and assessment of air quality[5].

2.1.2 Particulate Matter

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. The term PM_{10} is used to describe particles with an effective size less than 10 µm. These are of greatest concern with regard to human health, as they are small enough to penetrate deep into the lungs. They can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface absorbed carcinogenic compounds into the lungs. Larger particles, meanwhile, are not readily inhaled, and are removed relatively efficiently from the air by sedimentation.

The main sources of airborne particulate matter in the UK are combustion (industrial, commercial and residential fuel use). The next most significant source is road vehicle emissions. Based on 2021 calendar year emissions data from the 2023 National Atmospheric Emissions Inventory (NAEI) data to the EU, civil aircraft taking off and landing (up to a height of 1000m) was estimated to contribute less than 0.1% to the total reported UK emissions of PM_{10} and $PM_{2.5}$[4].

Previous rounds of review and assessment within the LAQM process have not highlighted any cases where airports appear to have caused exceedances of air quality objectives for particulate matter measured as PM_{10}[5].

2.2 MONITORING SITES AND METHODS

2.2.1 Site Locations

Automatic monitoring was carried out at three sites for the whole of 2022. These are Stansted 3, Stansted 4 and Stansted 5 (the numbering of the sites continues the sequence used for previous short-term sites in earlier monitoring studies). Following definitions within the Defra Technical Guidance on air quality monitoring LAQM.TG(22)[5], the location descriptions of both Stansted 3 and Stansted 4 sites fall into the category “other” (i.e. “any special source-oriented or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels”) whilst Stansted 5 falls into the “rural” category.

These automatic sites were supplemented by five sites at which diffusion tubes were used to monitor NO_2 on a monthly basis. These were located at the Stansted 3 automatic site, and four sites to the north, east, south and west of the airport. Further to this, an additional nine diffusion tube sites were located around Hatfield Forest.

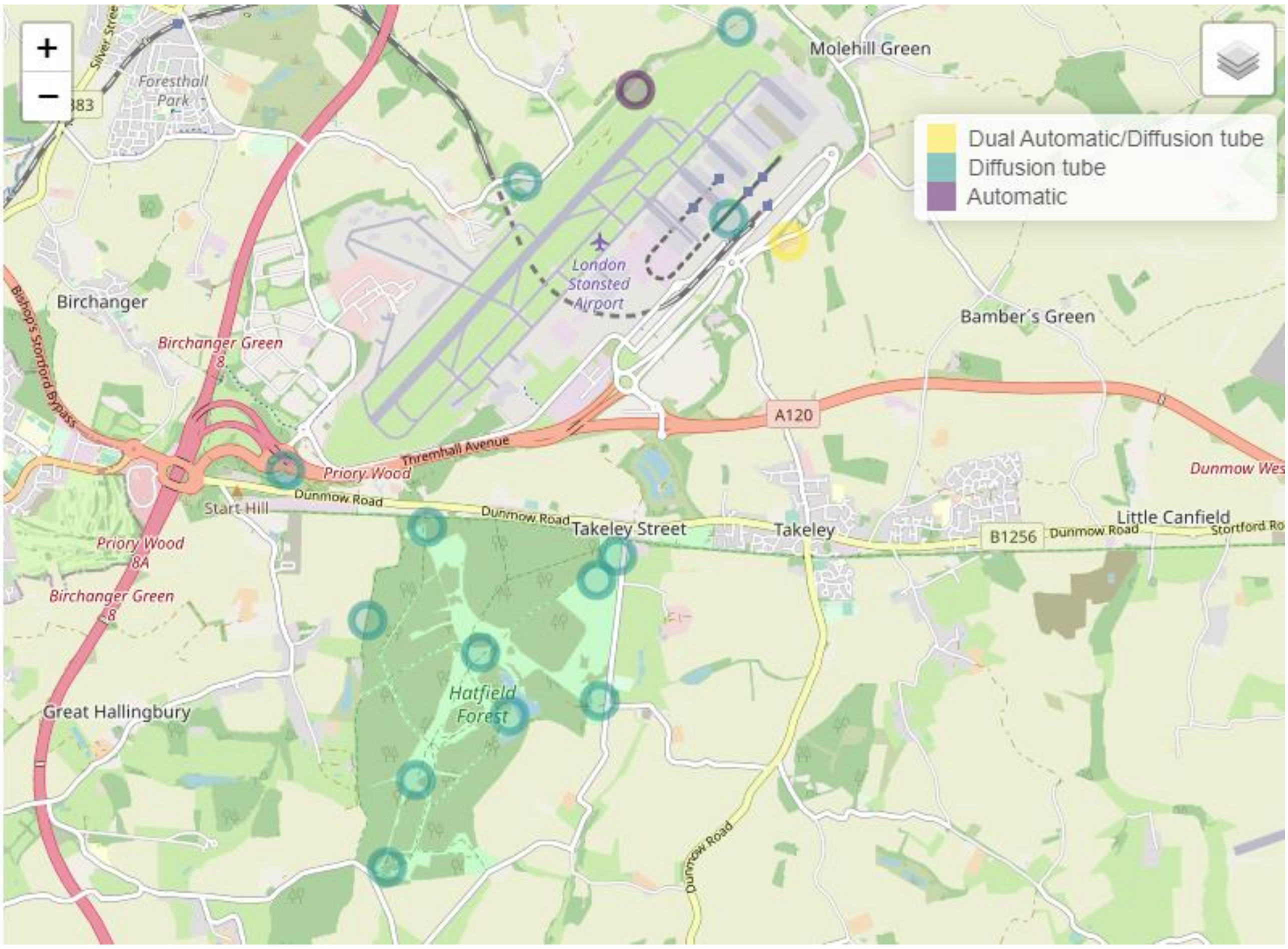
Table 2 describes the monitoring locations. Figure 1 shows a map of the locations of all monitoring sites used in this study. Automatic monitoring sites are shown by purple dots, diffusive samplers by yellow dots.

Table 2: Locations of air quality monitoring sites at Stansted and Hatfield Forest

Site name	Description	Parameters monitored	Grid reference
Stansted 3	East of High House	Automatic monitoring of NOx, PM_{10} and $PM_{2.5}$. Diffusion tube monitoring of NO_2 monthly (co-located).	TL 558 233
Stansted 4	Grass area near runway	Automatic monitoring of NOx, PM_{10} and $PM_{2.5}$.	TL 548 243
Stansted 5	National Trust office car park	Automatic monitoring of NOx, PM_{10} and $PM_{2.5}$.	TL547 210
23 Approach	North lights, north end of runway	Diffusion tube monitoring of NO_2 monthly.	TL 555 248

Site name	Description	Parameters monitored	Grid reference
Enterprise House	Enterprise House offices	Diffusion tube monitoring of NO_2 monthly.	TL 555 234
Pond B	Balancing pond south of site	Diffusion tube monitoring of NO_2 monthly.	TL 522 215
Ground Radar	Radar tower, Burton End	Diffusion tube monitoring of NO_2 monthly.	TL 536 235
Hatfield Forest 1	Southwest of National Trust office	Diffusion tube monitoring of NO_2 monthly.	TL 546 208
Hatfield Forest 2	South of B1256	Diffusion tube monitoring of NO_2 monthly.	TL 533 211
Hatfield Forest 3	Northeast of Bedlar's Green	Diffusion tube monitoring of NO_2 monthly.	TL 529 204
Hatfield Forest 4	Northwest of Hatfield Forest Lake	Diffusion tube monitoring of NO_2 monthly.	TL 537 202
Hatfield Forest 5	Shell House Café, Hatfield Forest	Diffusion tube monitoring of NO_2 monthly.	TL 540 198
Hatfield Forest 6	Southeast of Bedlar's Green	Diffusion tube monitoring of NO_2 monthly.	TL 533 193
Hatfield Forest 7	East of Bush End: St John the Evangelist	Diffusion tube monitoring of NO_2 monthly.	TL 546 199
Hatfield Forest 8	Southern edge of Hatfield Forest	Diffusion tube monitoring of NO_2 monthly.	TL 531 186
Hatfield Forest 9	National Trust office car park	Diffusion tube monitoring of NO_2 monthly.	TL 547 210

Figure 1: Locations of the Automatic and Diffusive air monitoring sites around Stansted Airport



The location of the automatic monitoring site at High House (Stansted 3) was agreed with Stansted Airport, Uttlesford District Council and Ricardo Energy & Environment. It is located just outside the eastern perimeter of the airport. It is considered to be close enough to the airport to detect effects relating to airport emissions. It is also close to vulnerable receptors, being located in a nursery school car park. The A120 main road runs approximately 1.5 km to the south of the site. The monitoring apparatus is housed in a purpose-built enclosure. Figure 2 shows a photograph of the Stansted 3 site.

Figure 2: Photo of the Stansted 3 air monitoring site

Stansted 4 is located on a site also agreed with Uttlesford District Council at the north-eastern end of the main runway, within the airport perimeter. It is intended to monitor any effects on air quality related to airport emissions. The location of Stansted 4 is included in Figure 1, and a photograph is provided in Figure 3

Figure 3: Photo of the Stansted 4 air monitoring site

Stansted 5 is located in the National Trust office car park in the north-east corner of Hatfield Forest. The location was agreed with between Uttlesford District Council and Natural England. It is intended to monitor any effects of air quality in the Hatfield Forest area related to airport emissions.

Figure 4: Photo of the Stansted 5 air monitoring site

2.2.2 Automatic Monitoring

The following techniques were used for the automatic monitoring of NO_x (i.e. NO and NO_2) and PM:

- NO, NO_2 – Chemiluminescence.
- PM_{10} - Fine Dust Analysis Systems (FIDAS).
- $PM_{2.5}$ - Fine Dust Analysis Systems (FIDAS).

The particulate matter was measured using a FIDAS instrument with no correction required for PM_{10}. $PM_{2.5}$ data has a correction factor applied being divided by 1.06 as per the certification - MCERTS for UK Particulate Matter specification.

Further information on these techniques is provided in Appendix 3 of this report. These analysers provide a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15-minute mean values by internal data loggers. The analysers are connected to a web logger which sends data every hour to a remote server, Ricardo Energy and Environment download data from the server hourly. The data are converted to concentration units at Ricardo Energy & Environment then averaged to hourly mean concentrations.

2.2.3 Diffusive Samplers

Diffusion tubes were used for additional indicative monitoring of NO_2. These are "passive" samplers which work by absorbing the pollutants direct from the surrounding air and need no power supply.

Diffusion tubes for NO_2 consist of a small plastic tube, approximately 7 cm long. During sampling, one end is open and the other closed. The closed end contains an absorbent for the gaseous species to be monitored, in this case NO_2. The tube is mounted vertically with the open end at the bottom. Ambient NO_2 diffuses up the tube during exposure and is absorbed as nitrite. The average ambient pollutant concentration for the exposure period is calculated from the amount of pollutant absorbed.

Diffusion tubes were prepared by a commercial laboratory Gradko International Ltd throughout 2022. The tubes were supplied in a sealed condition prior to exposure. They were exposed at the sites for a set period of time. After exposure, the tubes were again sealed and returned to the laboratory for analysis. The exposure periods used were approximately equivalent to calendar months.

3. QUALITY ASSURANCE AND DATA CAPTURE

3.1 QUALITY ASSURANCE AND QUALITY CONTROL

In line with current operational procedures within the Defra Automatic Urban and Rural Network (AURN) [6], full intercalibration audits of the Stansted air quality monitoring sites took place at six-monthly intervals. Full details of these UKAS-accredited calibrations, together with data validation and ratification procedures, are given in Appendix 3 of this report. In addition to instrument and calibration standard checking, the air intake sampling systems were cleaned and all other aspects of site infrastructure were checked.

Following the instrument and calibration gas checking, and the subsequent scaling and ratification of the data, the overall accuracy and precision figures for the pollutants monitored at Stansted are summarised in Table 3.

Table 3: Estimated precision and accuracy of the data presented

Pollutant	Precision	Accuracy
Nitric Oxide (NO)	±2.5 μgm^{-3}	±14%
Nitrogen Dioxide (NO_2)	±6.9 μgm^{-3}	±15%
Particles (PM_{10})	±2 μgm^{-3}	±7.5%
Particles ($PM_{2.5}$)	±2 μgm^{-3}	±9.3%

When using diffusion tubes for indicative NO_2 monitoring, the LAQM Technical Guidance LAQM.TG(22)[5] states that correction should be made for any systematic bias (i.e. over-read or under-read compared to the automatic chemiluminescent technique, which is the reference method for NO_2). Throughout this study, diffusion tubes have been exposed alongside the automatic NO_x analyser at Stansted 3. These co-located measurements were used for bias adjustment of the annual mean diffusion tube data from the other sites.

The diffusion tube methodologies used for this monitoring programme provide data that are accurate to ± 25% for NO_2. The limits of detection vary from month to month, but typically equate to 0.03 $\mu g\ m^{-3}$ for NO_2. Diffusion tube results that are below 10 times the limit of detection have a higher level of uncertainty associated with them. All were above this threshold.

4. RESULTS AND DISCUSSION

4.1 SUMMARY STATISTICS

Overall data capture statistics along with summary statistics for Stansted 3, Stansted 4 and Stansted 5 are given in Table 5 to Table 7. These represent the percentage of valid data for the whole reporting period. A data capture target of 85% is recommended in the Defra Technical Guidance LAQM.TG(22)5. This target was achieved for all pollutants at Stansted 3 and Stansted 5. However, Stansted 4 achieved 57.3% data capture for NO2 and 72.3% data capture for both PM10 and PM2.5. The long-term data gap of 155 days at Stansted 4 resulted from multiple issues. The air conditioning unit at this site failed in July and, following delays, the unit was replaced in September. Following the restarting of the NOx analyser, after the air conditioning replacement, the data collected was not satisfactory and a fault was identified with a critical analyser part. The cooler assembly had failed and required replacement. Due to the low data capture at Stansted 4, annualisation of NO2, PM10 and PM2.5 data at Stansted 4 was completed. This process involves estimating annual means from the extrapolation of short-term monitoring results using concentration data from both the site in question and other nearby sites continuous monitoring sites. More information on the procedure can be found in LAQM.TG(22)5.

Significant data gaps for the stations are shown in Table 4.

Table 4: Significant data gaps, 2022

Site	Pollutant	Start date	End date	No. of days	Reason
Stansted 4	PM_{10}, $PM_{2.5}$	16/01/2022	26/01/2022	10.1	Instrument fault
Stansted 4	PM_{10}, $PM_{2.5}$	29/01/2022	21/02/2022	23.0	Instrument fault
Stansted 3	NO, NO_2, NO_x	28/02/2022	29/03/2022	29.0	LSO operator error
Stansted 5	NO, NO_2, NO_x	19/07/2022	29/07/2022	9.9	Instrument fault
Stansted 4	NO, NO_2, NO_x	29/07/2022	01/01/2023	155.5	Air conditioning and instrument fault • Site air conditioning failure from July to September • Critical part failure following analyser restart in September
Stansted 5	NO, NO_2, NO_x	02/08/2022	05/08/2022	2.4	Instrument fault
Stansted 3	PM_{10}, $PM_{2.5}$	08/08/2022	17/08/2022	9.2	Instrument fault
Stansted 4	PM_{10}, $PM_{2.5}$	12/08/2022	19/10/2022	67.9	Air conditioning fault, instrument switched off
Stansted 5	NO, NO_2, NO_x, PM_{10}, $PM_{2.5}$	29/11/2022	30/11/2022	1.0	Communications error
Stansted 5	NO, NO_2, NO_x, PM_{10}, $PM_{2.5}$	03/12/2022	04/12/2022	0.5	Communications error
Stansted 5	NO, NO_2, NO_x, PM_{10}, $PM_{2.5}$	04/12/2022	05/12/2022	0.5	Communications error

Table 5: Summary statistics for Stansted 3

Stansted 3	NO (µg m^{-3})	NO_2 (µg m^{-3})	NO_x (µg m^{-3})	PM_{10} (µg m^{-3})	PM2.5 (µg m^{-3})
Maximum hourly mean	238	93	417	1064	157
Maximum running 8-hour mean	130	78	241	184	77
Maximum running 24-hour mean	89	70	187	86	60
Maximum daily mean	59	60	139	85	59
Average	4	15	20	15	8
Data capture	91.8%	91.8%	91.8%	97.3%	97.3%

Table 6: Summary statistics for Stansted 4

Stansted 4	NO (µg m^{-3})	NO_2 (µg m^{-3})	NO_x (µg m^{-3})	PM_{10} (µg m^{-3})	PM2.5 (µg m^{-3})
Maximum hourly mean	503	288	1060	97	79
Maximum running 8-hour mean	113	72	233	84	69
Maximum running 24-hour mean	59	52	142	68	51
Maximum daily mean	53	52	130	64	50
Average	4	12	19	12	8
Annualised average	-	13	-	12	8
Data capture	57.3%	57.3%	57.3%	72.3%	72.3%

Table 7: Summary statistics for Stansted 5

Stansted 5	NO (µg m^{-3})	NO_2 (µg m^{-3})	NO_x (µg m^{-3})	PM_{10} (µg m^{-3})	PM2.5 (µg m^{-3})
Maximum hourly mean	179	68	325	113	86
Maximum running 8-hour mean	76	62	171	91	73
Maximum running 24-hour mean	40	47	105	79	56
Maximum daily mean	32	47	86	71	53
Average	2	10	12	14	9
Data capture	95.5%	95.5%	95.5%	98.9%	98.9%

Daily average and hourly time series plots of all pollutant data for the full year, as measured by the automatic monitoring site, are shown in Figures 5 – 10.

Figure 5: Hourly mean NO_2 timeseries, 2022

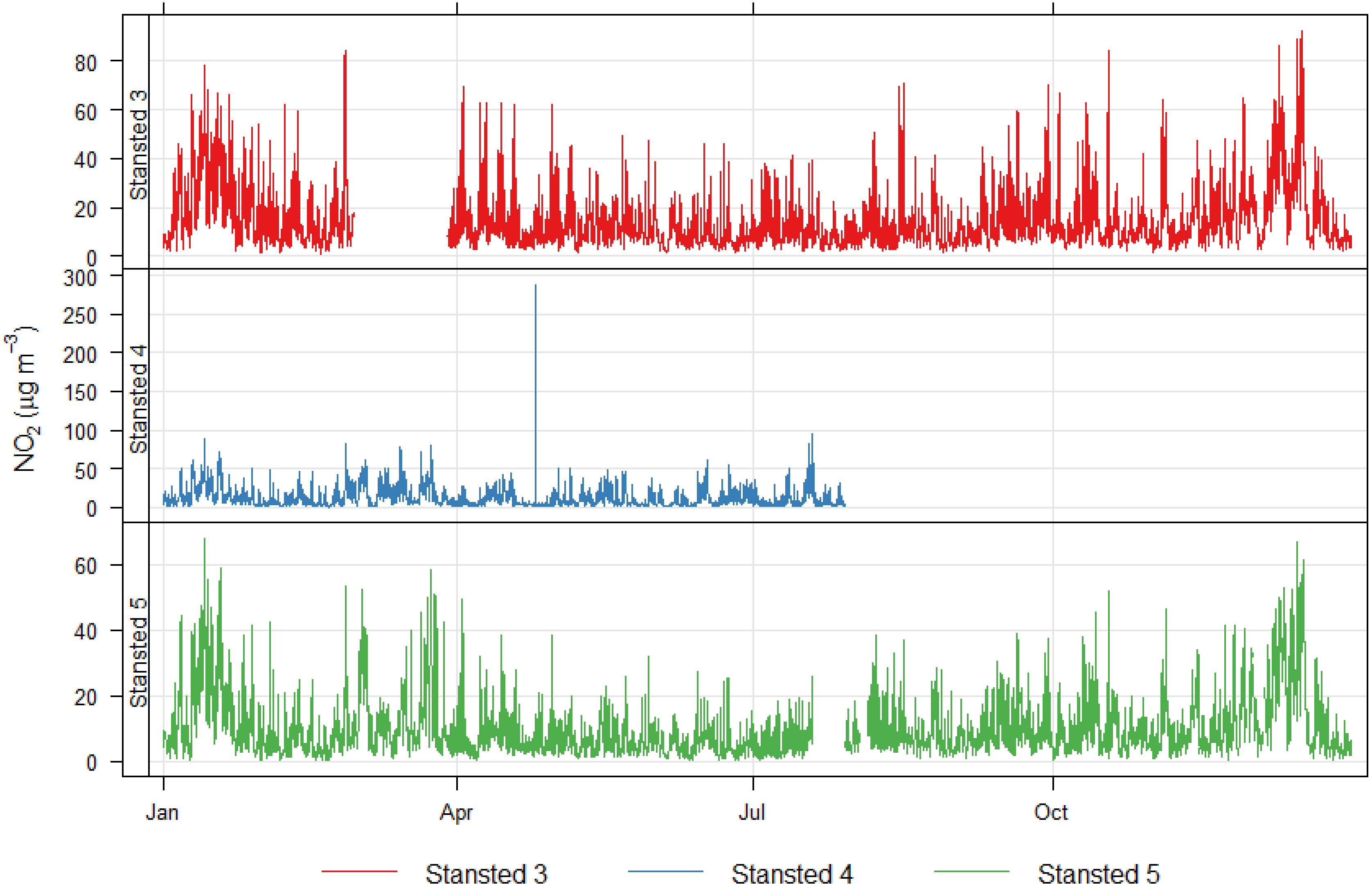


Figure 6: Daily mean NO_2 timeseries, 2022

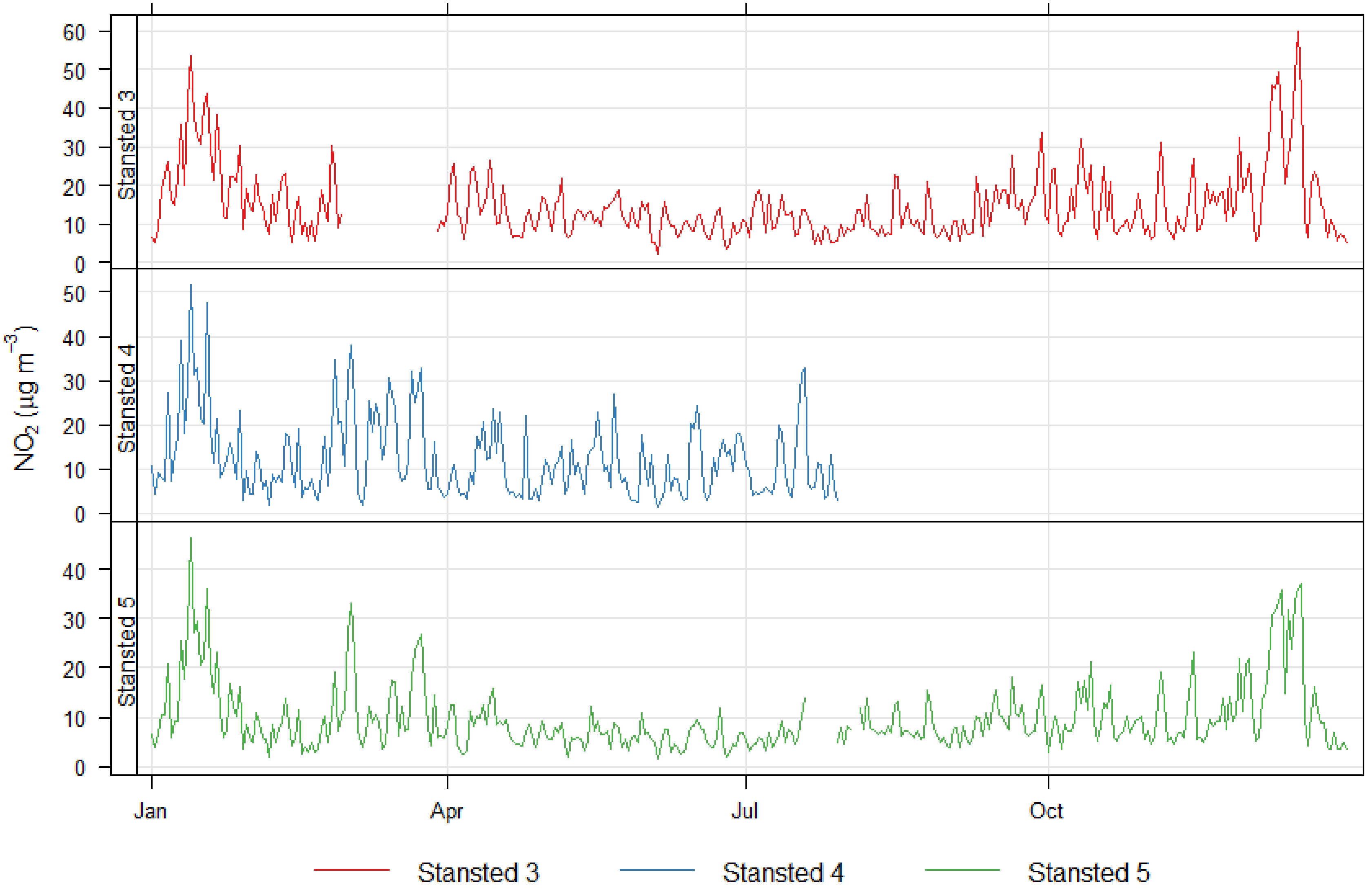


Figure 7: Hourly mean $PM_{2.5}$ timeseries, 2022

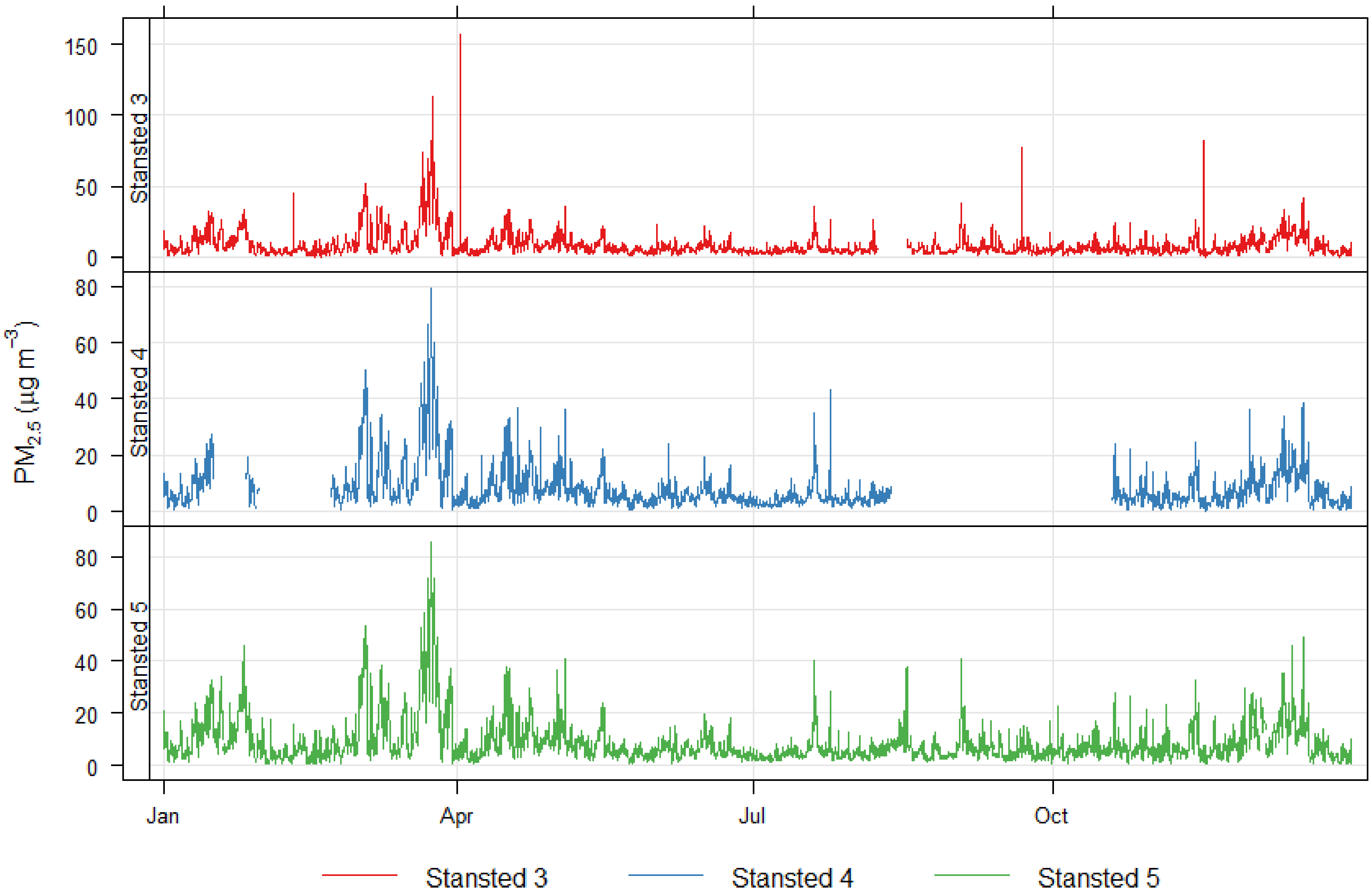


Figure 8: Daily mean $PM_{2.5}$ timeseries, 2022

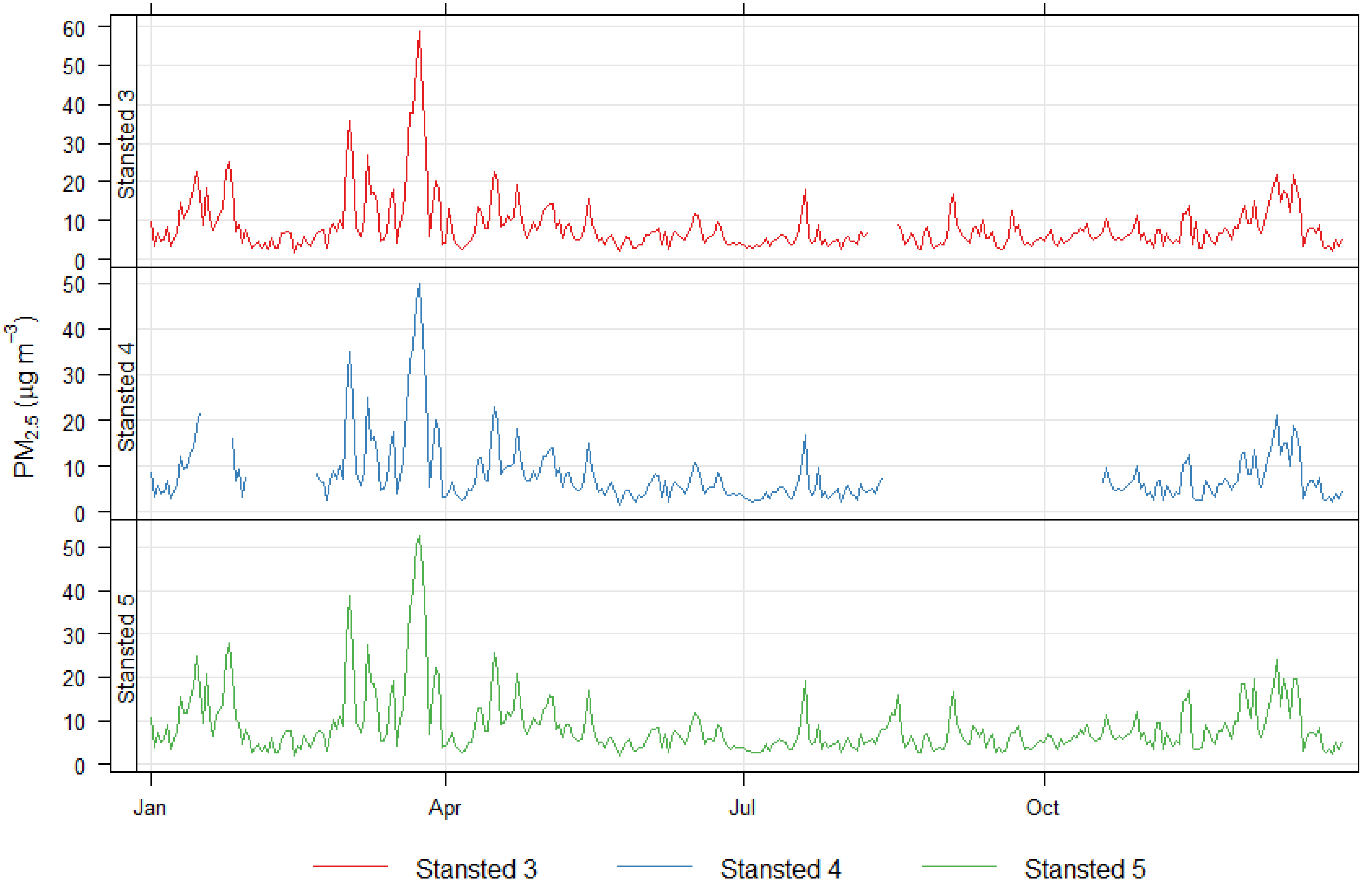


Figure 9: Hourly mean PM_{10} timeseries, 2022

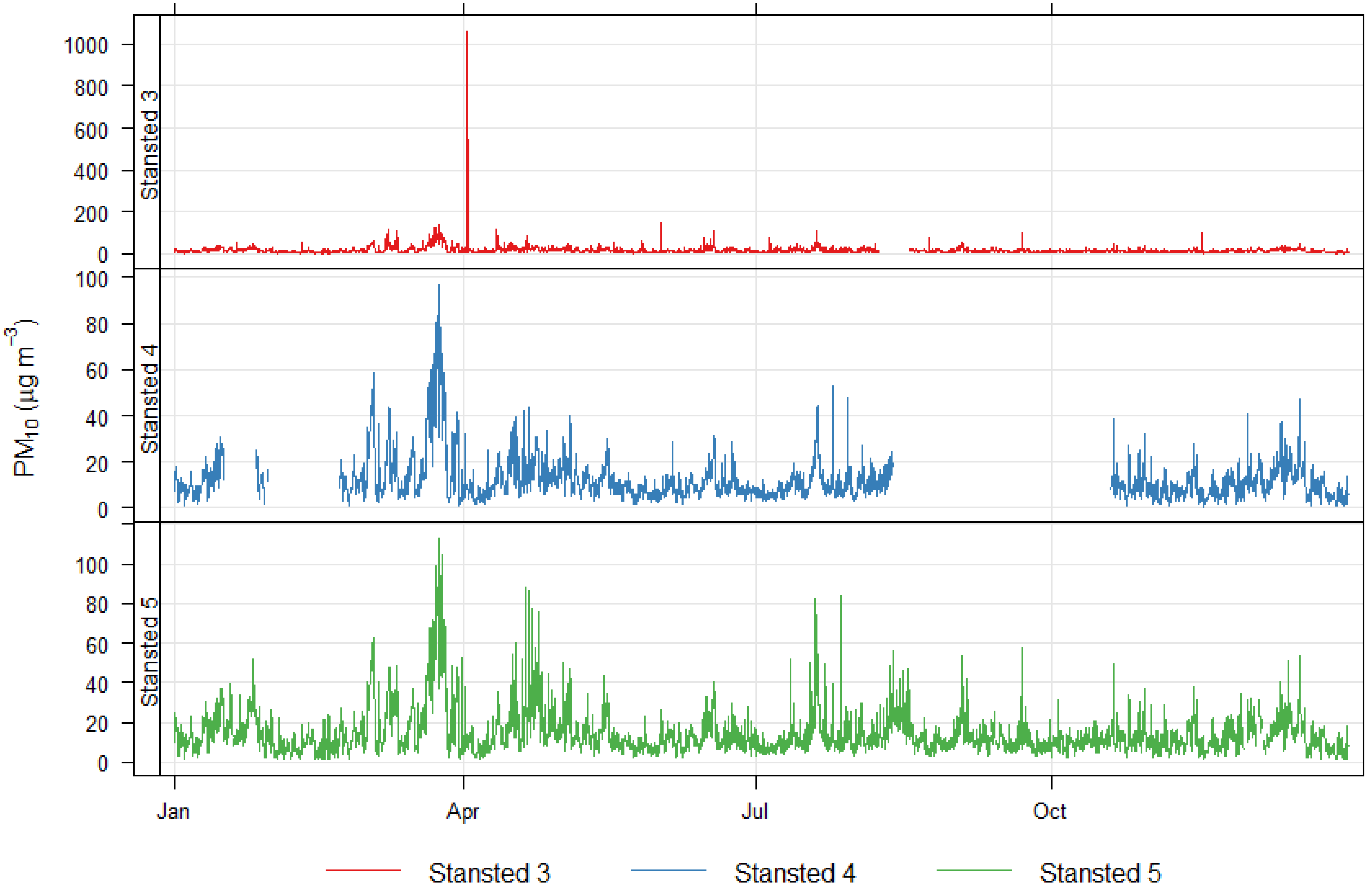
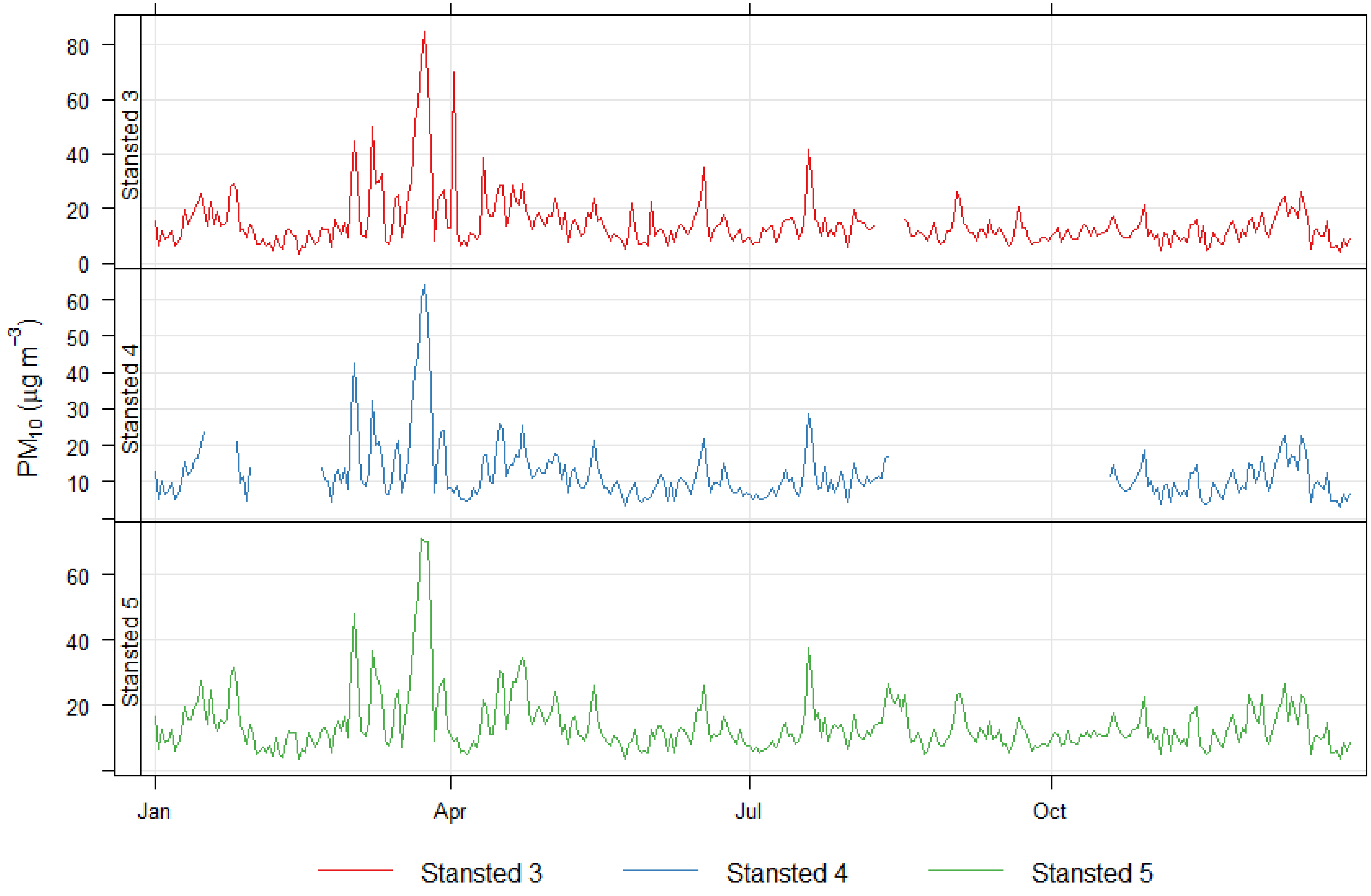


Figure 10: Daily mean PM_{10} timeseries, 2022



At Stansted 3, the highest hourly concentration of NO_2 (93 µg m^3) was recorded in December 2022. Peaks in daily concentrations were shown in January and December 2022 which is also true for Stansted 4 and Stansted 5 sites. Stansted 3 also exhibits a peak in PM_{10} and $PM_{2.5}$ hourly concentrations of 1064 µg m^3 and 157 µg m^3 respectively on 2nd April 2022. These peaks are likely a result of agricultural activity due to the proximity of Stansted 3 to farming operations in surrounding land as described in previous years. Localised short term pollution episodes caused by local operations surrounding air quality sites are normal, these are regularly noted within the national network and can be caused by a variety of operations including agricultural activity, as well as mechanical activity or temporary establishments such as festivals. Unfortunately, localised pollution episodes are a limitation of all national network and other air quality monitoring sites. The local environment is something that is reviewed in detail within the air quality station siting selection process to minimise the effects of local activity.

At Stansted 4, there is a defined peak in hourly NO_2 concentration of 288 µg m^3 on 25th April 2022. In previous years, spikes such as this have been likely a result of a generator a few metres north of the site being turned on. However, this has been confirmed to not be the case. This value exceeds the 200 µg m^{-3} AQS hourly limit however it is the only occasion where this limit is exceeded in 2022. The limit value of 200 µg m^3 may be exceeded up to 18 times per calendar year. Peaks in daily PM_{10} and $PM_{2.5}$ of 64 µg m^3 and 50 µg m^3 respectively, were recorded in March 2022 at this site.

At Stansted 5, the highest concentration of hourly average NO_2 of 68 µg m^3 was recorded in January 2022. NO_2 concentrations at Stansted 5 averaged the lowest of the three sites at 10 µg m^{-3}. This site also experienced peaks in daily PM_{10} and $PM_{2.5}$ in March, similar to trends exhibited at Stansted 3 and Stansted 4. Maximum hourly PM_{10} and $PM_{2.5}$ concentrations recorded were 113 µg m^{-3} and 86 µg m^{-3} respectively, both documented in March 2022.

4.2 DIFFUSION DATA

NO_2 diffusion tube results for 2022 are shown in Table 8. Tubes were exposed in triplicates at all sites. The means of those replicate measurements are the results shown below. Diffusion tube data is provided by the analyst to two decimal places. In accordance with the reported uncertainty of the method, these values have been rounded to one decimal place in the table below and are quoted as integer values in this report. Time series plots of monthly mean NO_2 at Stansted and Hatfield Forest diffusion tube sites are shown in Figure 11 and 12.

Table 8: NO_2 diffusion tube results for 2022 ($\mu g\ m^{-3}$).

Start date	End date	23 Approach	Enterprise House	Ground Radar	High House Nursery	Pond B	HF1	HF2	HF3	HF4	HF5	HF6	HF7	HF8	HF9
06/01/2022	31/01/2022	24.4	33.5	18.7	26.4	28.1	19.6	20.6	21.6	18.9	16.7	18.3	19.2	16.4	21.0
31/01/2022	28/02/2022	15.3	20.1	12.1	15.1	19.0	10.3	11.0	10.8	9.4	8.9	9.2	11.0	19.2	9.9
28/02/2022	29/03/2022	17.2	23.5	19.3	17.8	22.5	15.3	15.3	12.4	13.7	11.9	12.3	14.3	11.4	14.5
29/03/2022	05/05/2022	9.7	18.4	9.8	14.4	19.5	6.8	10.4	9.0	8.3	7.6	7.7	7.1	6.6	9.6
05/05/2022	08/06/2022	12.6	20.0	10.1	12.7	15.9	7.1	8.4	7.0	6.2	7.0	7.0	8.3	7.0	8.4
08/06/2022	07/07/2022	13.3	18.3	10.0	10.4	13.7	6.5	7.5	6.5	6.3	6.1	5.8	6.8	5.7	7.0
07/07/2022	02/08/2022	11.0	15.6	11.3	10.2	13.1	6.9	7.7	6.5	6.9	6.4	5.8	6.8	5.6	7.1
02/08/2022	31/08/2022	12.5	21.1	12.2	13.4	19.4	8.9	11.1	9.1	8.8	8.1	8.0	8.5	7.4	10.1
31/08/2022	30/09/2022	14.2	25.4	8.5	17.9	21.1	11.6	13.2	10.4	11.0	8.8	9.4	9.9	8.9	12.5
30/09/2022	01/11/2022 (02/11/2022)	26.7	25.5	18.6	18.3	18.9	12.5	12.0	11.0	12.3	9.6	10.8	(11.2)	(10.1)	(11.9)
01/11/2022	30/11/2022	*NA*	*NA*	*NA*	*NA*	*NA*	14.7	14.6	12.7	14.4	11.9	13.0	*NA*	*NA*	*NA*
01/11/2022	28/11/2022	25.7	26.4	19.7	21.1	18.6	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
02/11/2022	30/11/2022	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	14.0	13.0	14.6
28/11/2022	03/01/2023	25.9	31.1	17.4	24.0	25.0	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
30/11/2022	03/01/2023	*NA*	*NA*	*NA*	*NA*	*NA*	19.8	20.5	18.5	18.6	15.3	17.2	17.3	15.8	20.2
Mean	**-**	**17.4**	**23.2**	**14.0**	**16.8**	**19.6**	**11.7**	**12.7**	**11.3**	**11.2**	**9.9**	**10.4**	**11.2**	**10.6**	**12.2**
Bias adjusted	**-**	**15.5**	**20.7**	**12.4**	**15.0**	**17.4**	**10.4**	**11.3**	**10.0**	**10.0**	**8.8**	**9.2**	**10.0**	**9.4**	**10.9**

Figure 11: Time series of monthly mean NO_2 at Stansted diffusion tube sites

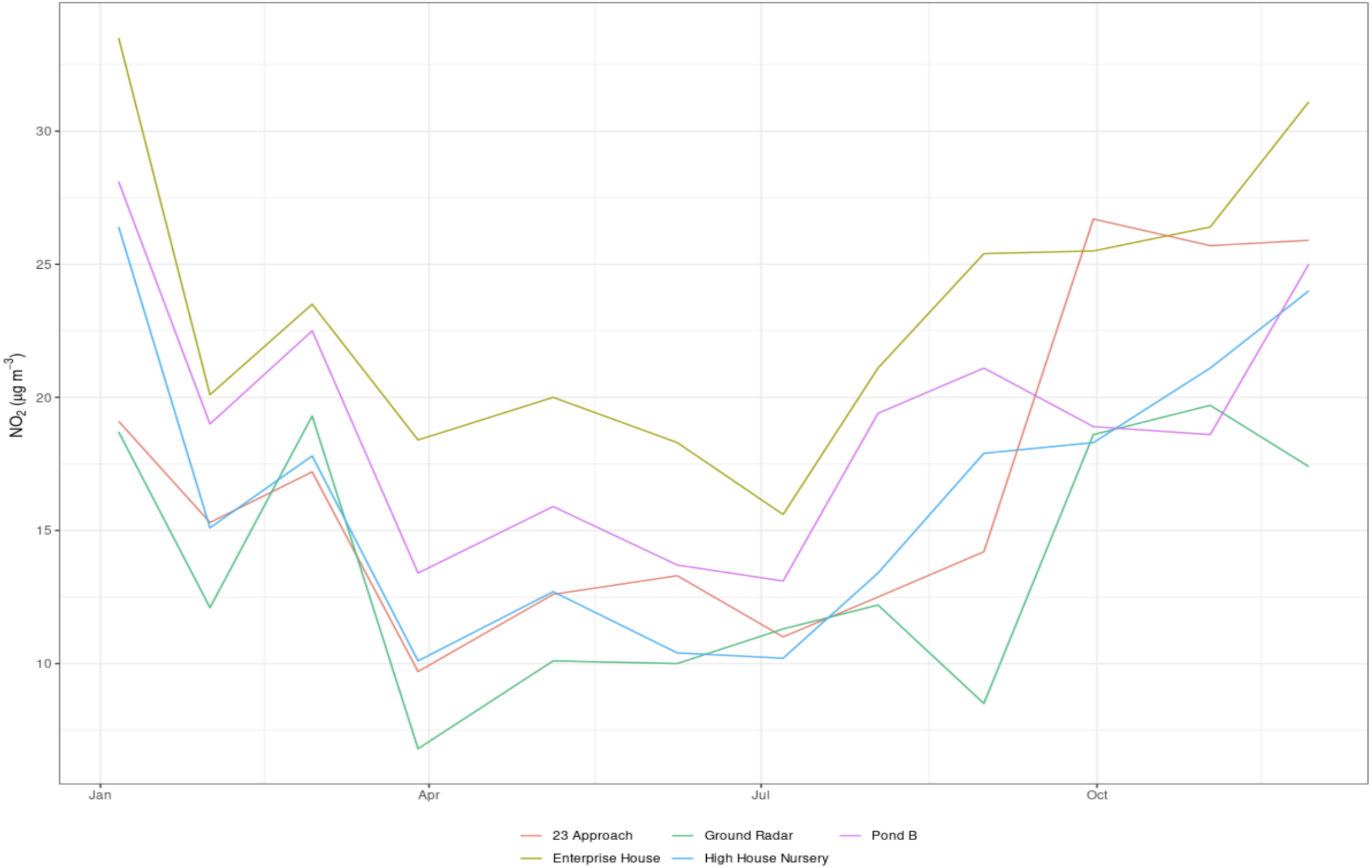
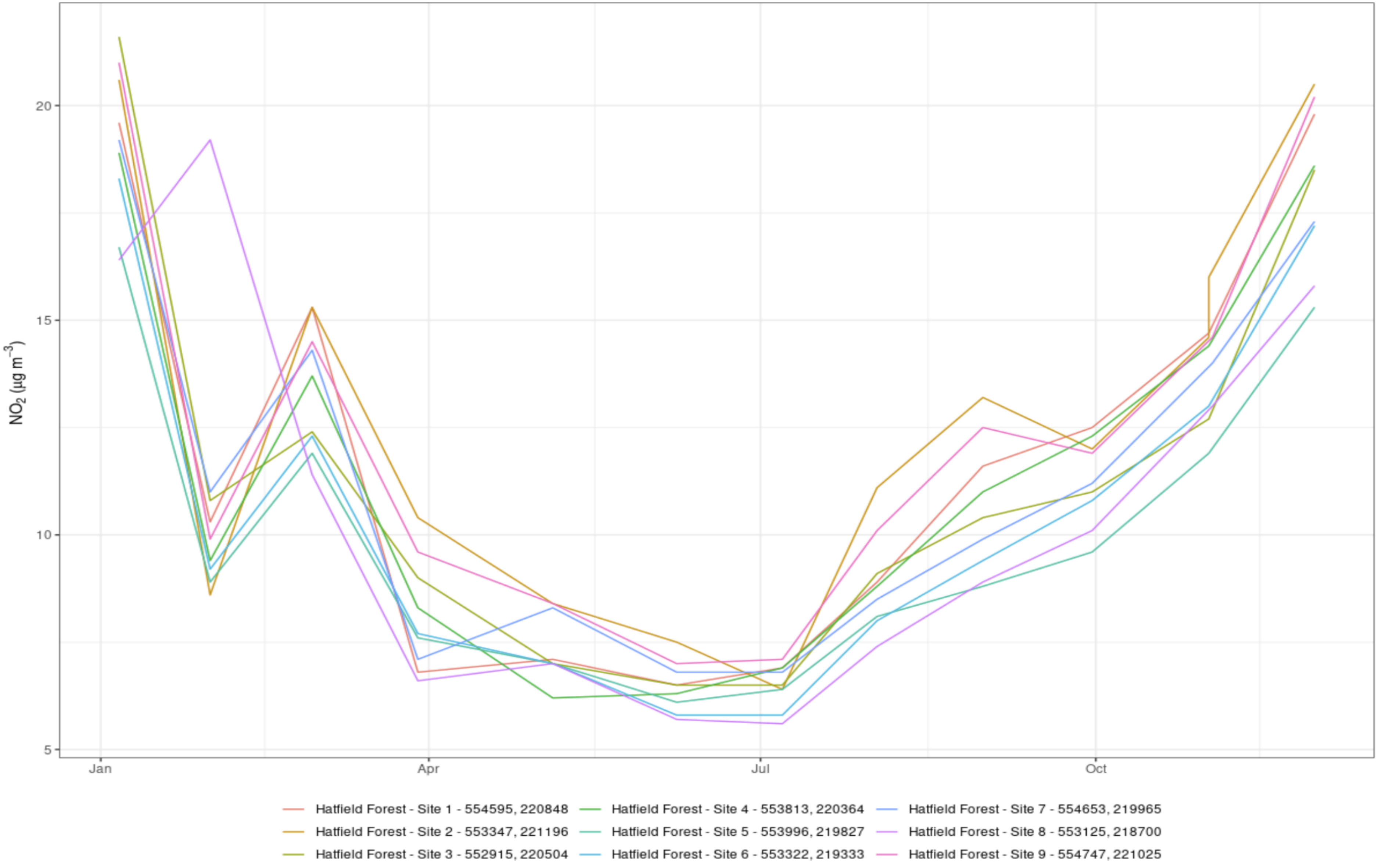


Figure 12: Time series of monthly mean NO_2 at Hatfield Forest diffusion tube sites



Twenty two results were rejected or were missing on collection. Rejected results were removed as they were suspected to be spurious, some due to environmental contamination and others were obvious outliers. Details of these results are shown in Table 9. All results considered to be "outliers"; the concentrations are much lower than those of the other two co-exposed tubes, subsequently resulting in rejection. Tube 1 of the November exposure at Hatfield Forest site 2 was accidentally left on until the December exposure collection (03/01/2023), therefore the result from this prolonged exposure (16.0 µg m^{-3}) was rejected as it did not fall in line the other exposure periods.

Table 9: Details of the NO_2 diffusion tube results rejected/missing during 2022.

Site	Month	Tube number	$[NO_2]$ (µg m^{-3})	Reason for rejection
23 Approach	January	2	8.4	Found upside down with moisture in tube
Enterprise House	February	2	-	Missing on collection
23 Approach	February	1	-	Missing on collection
Hatfield Forest 2	February	3	3.9	Missing on collection
Pond B	April	2	1.4	Outlier compared to other two tubes at site.
Ground Radar	April	1	0.9	Outlier compared to other two tubes at site.
High house Nursery	April	2	1.4	Outlier compared to other two tubes at site.
23 Approach	May	2	0.5	Tube found upside down and full with water – outlier compared to other two tubes at site.
Hatfield Forest 4	May	2	4.8	Tube found on floor, debris inside - outlier compared to other two tubes at site.
Enterprise House	July	2	12.6	Tube found on floor - outlier compared to other two tubes at site.
Pond B	July	1	-	Missing on collection
Pond B	July	2	-	Missing on collection
Hatfield Forest 2	July	3	3.8	Outlier compared to other two tubes at site.
Hatfield Forest 4	July	1	-	Missing on collection
Pond B	August	1	0.6	Tube found on floor - outlier compared to other two tubes at site.
Pond B	August	2	-	Missing on collection
Ground Radar	August	2	0.6	Tube found on floor, moisture inside - outlier compared to other two tubes at site.

Site	Month	Tube number	$[NO_2]$ ($\mu g\ m^{-3}$)	Reason for rejection
Hatfield Forest 8	August	3	-	Missing on collection
Ground Radar	October	3	-	Missing on collection
Hatfield Forest 2	November & December	1	16.0	Left on by accident over two exposures

Annual mean NO_2 concentrations, measured with diffusion tubes, across the five Stansted sites range between 12.4 and 20.7 µg m^{-3}. Diffusion tube results from Stansted 3 can be directly compared to data from the automatic monitoring site. The annual mean NO_2 concentrations for the diffusion tubes and automatic NO_x analyser at Stansted 3, were both 15 µg m^{-3}.

Diffusion tubes are affected by several artefacts, which can cause them to under-read or over-read with respect to the reference technique. It has therefore become common practice to calculate and apply a “bias adjustment factor” to annual mean NO_2 concentrations measured by diffusion tubes, using co-located diffusion tube and automatic analyser measurements. This bias adjustment factor is calculated as the ratio of the automatic analyser result to the diffusion tube result. This factor can then be used to correct the annual means measured at the other monitoring locations. The bias adjustment factor was calculated using unrounded values from all months. On this basis, the bias adjustment factor was calculated to be 0.89.

The annual mean values from the other four diffusion tube sites were all corrected using the same bias adjustment factor.

Annual mean NO_2 concentrations, measured with diffusion tubes, at the nine Hatfield Forest sites ranged from 8.8 to 11.3 µg m^{-3}.

Please note:

i. Only the annual mean concentration (not individual monthly values) should be adjusted in this way. This is because diffusion tube bias can vary considerably from month to month due to meteorological and other factors.
ii. Even after application of a bias adjustment factor, diffusion tube measurements remain indicative only.

4.3 COMPARISON WITH AIR QUALITY OBJECTIVE

Details of the UK air quality standards and objectives specified by Defra are provided in Appendix 1.

The AQS objective for hourly mean NO_2 concentration is 200 µg m^{-3} which may be exceeded up to 18 times per calendar year. There were no recorded hourly mean NO_2 concentrations in excess of 200 µg m^{-3} at Stansted 3 and Stansted 5, these sites therefore met the AQS objective for this pollutant. At Stansted 4 there was one recorded hourly mean NO_2 concentrations in excess of the hourly mean AQS objective of 200 µg m^{-3} (April 2022). Although this is below the maximum number of times the hourly concentration can be exceeded, it was not possible to sufficiently assess the AQS objective for 1 hour mean NO_2 concentrations at this site because of the low data capture rate of 57.3%.

Stansted 3 and Stansted 5 measured annual mean NO_2 concentrations of 14.7 µg m^{-3} and 9.7 µg m^{-3} respectively, during 2022. Therefore, these two automatic sites were within the annual mean AQS objective for NO_2 of 40 µg m^{-3} for protection of human health and the objective of 30 µg m^{-3} for protection of vegetation and ecosystems. The annualised NO_2 mean at Stansted 4 was 12.8 µg m^{-3}, therefore this site met both of the above objectives based on the annualised NO_2 mean.

The bias-adjusted annual mean NO_2 concentrations measured at the five Stansted diffusion tube sites and nine Hatfield Forest diffusion tube sites were all well within the AQS objective of 40 µg m^{-3}.

PM_{10} was measured at all three sites. At Stansted 3, Stansted 4 and Stansted 5 the number of days when the 24-hour mean was in excess of 50 µg m^{-3} were seven, three and four respectively. Stansted 3 and Stansted 5 met the AQS objective for 24-hour mean PM_{10}, as these exceedances are well below the maximum permitted number of exceedances of 35. It was not possible to sufficiently assess the AQS objective for 24-hour mean PM_{10} concentrations at this site because of the low data capture rate of 72.3%.

$PM_{2.5}$ annual mean concentrations measured at Stansted 3 and Stansted 5 were 8.4 µg m^{-3} and 8.6 µg m^{-3} respectively, during 2022. These are both all well within the annual mean objective of 25 µg m^{-3}, therefore these sites met the AQS objective for annual means for $PM_{2.5}$. $PM_{2.5}$ annualised mean concentrations measured at Stansted 4 were 7.9 µg m^{-3}, therefore this site met the AQS objective for $PM_{2.5}$ annual mean concentrations based on the annualised mean.

4.4 SMOOTH TREND PLOTS

The figures below show smoothed time series plots of NO_2, PM_{10}, and $PM_{2.5}$. Points represent monthly concentrations and bold lines represent the trend modelled by Generalised Additive Model (GAM). The shaded pink area corresponds to 95% confidence interval.

Figure 13: Smooth trend plot of monthly mean NO_2 at Stansted 3, Stansted 4, and Stansted 5 during 2022

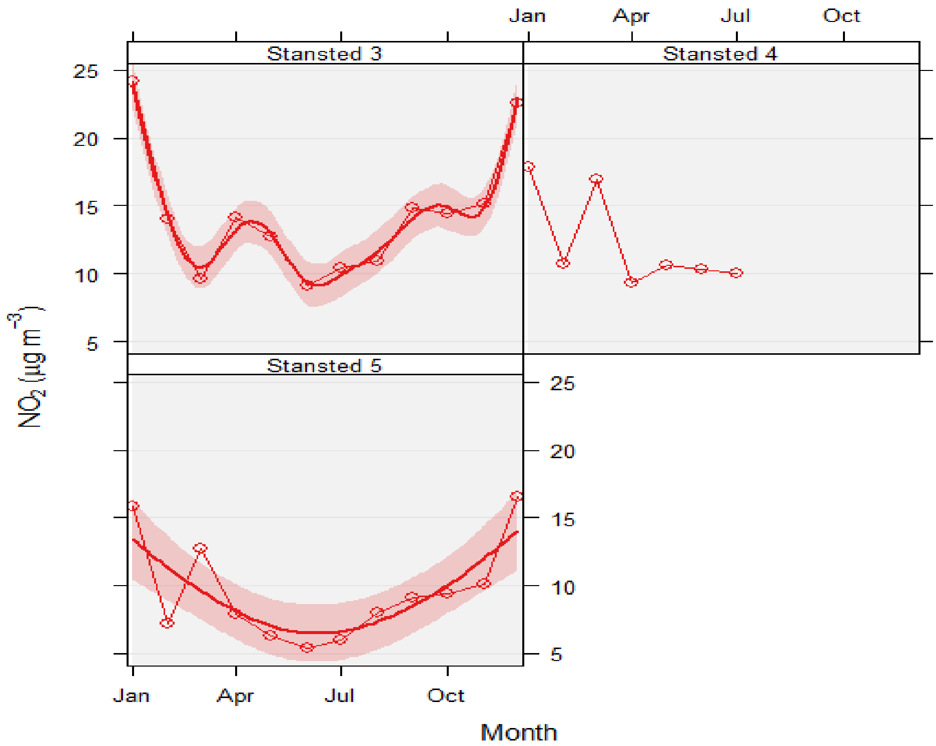


Figure 14: Smooth trend plot of monthly mean $PM_{2.5}$ at Stansted 3, Stansted 4, and Stansted 5 during 2022

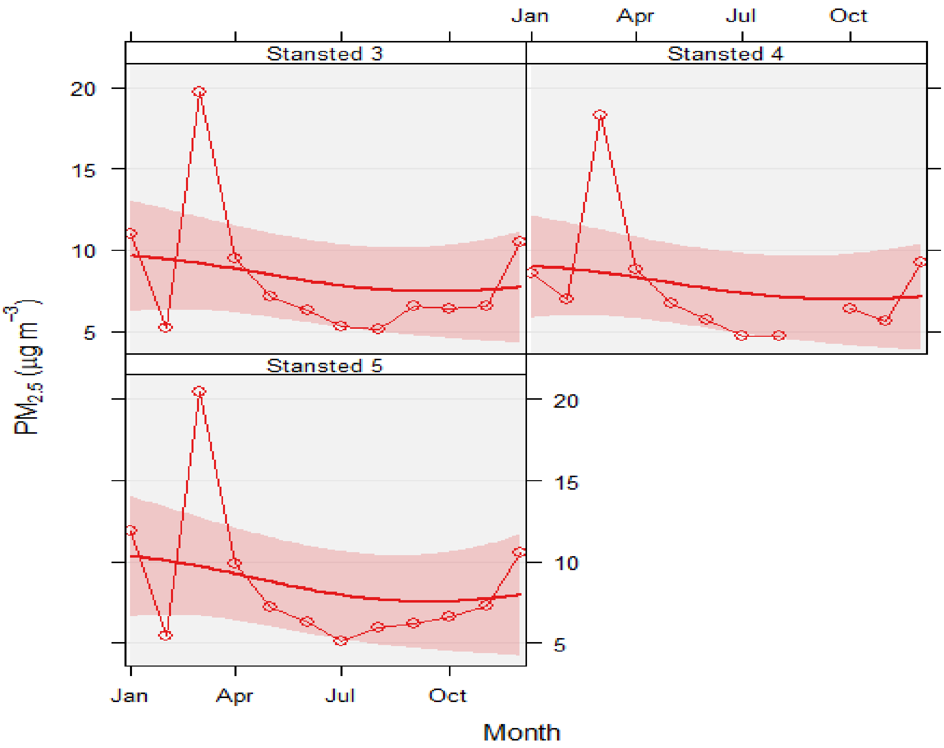
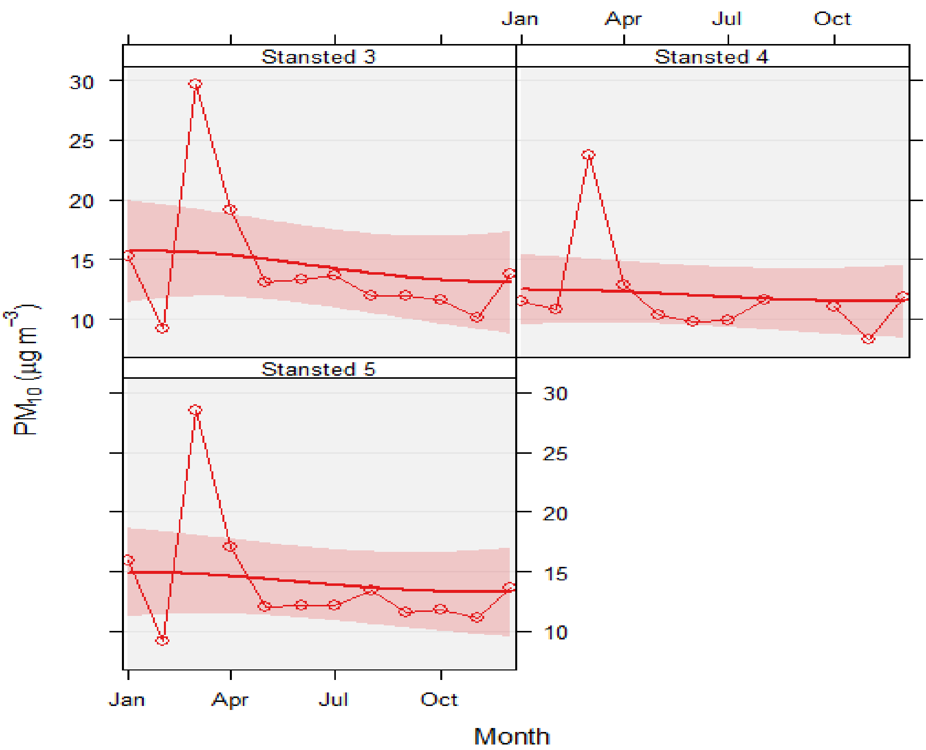


Figure 15: Smooth trend plot of monthly mean PM_{10} at Stansted 3, Stansted 4, and Stansted 5 during 2022



4.5 TEMPORAL VARIATIONS IN POLLUTANT CONCENTRATIONS

4.41 Seasonal variation

Figures 16, 17 and 18 show the average NO_2, PM_{10} and $PM_{2.5}$ concentrations during 2022 at Stansted 3, Stansted 4 and Stansted 5 for each hour on a given day (top), any hour (bottom left), each month (bottom centre) and any day (bottom right).

Figure 16 shows different temporal averages of NO_2 recorded at all three sites. Peaks in NO_2 concentrations are shown at all three sites during winter months, mainly January and December. This pattern is expected as pollution dispersion is reduced during the periods of cold weather and relatively low wind speeds that occur during winter months. Each site also shows an increase in concentrations in March.

Figure 17 shows different temporal averages of $PM_{2.5}$ recorded at all three sites. It shows peaks in $PM_{2.5}$ concentrations in January and December that are likely caused by reduced pollutant dispersion as described above. There are also significant peaks in $PM_{2.5}$ concentrations in March at all three sites. Due to the persistence of $PM_{2.5}$ molecules, it is likely that these elevated periods are a result of low wind speeds and air masses being imported from the continent.

Figure 18 shows different temporal averages of PM_{10} recorded at all three sites. Peaks in PM_{10} concentrations at each site show similar trends to those seen in $PM_{2.5}$ concentrations, with a similar magnitude in concentration peaks also. These elevations can also be explained by relatively low wind speeds and air masses moving from the continent.

4.5.1 Diurnal variation

Bottom left graphs in Figure 16, Figure 17, and Figure 18 show diurnal variation in pollutant concentrations, as measured at Stansted 3, Stansted 4 and Stansted 5.

In Figure 16, all sites showed significant peaks for NO_2 during the mornings, specifically around 06:00, which corresponds with rush hour traffic at this time. Concentrations then illustrate a decrease during the middle of the day, followed by another peak for the evening rush hour. The peak associated with morning rush hour is of higher magnitude for each site, whereas the afternoon peak is generally broader than the morning peak, due to NO_2 concentrations starting to increase in the early afternoon. Concentrations then remain elevated for much of the night which results in enhanced oxidation of NO to NO_2. This is due to increased concentrations of oxidising agents in the atmosphere (e.g. ozone) in the afternoon.

Figure 17 shows $PM_{2.5}$ concentrations at all sites demonstrate similar diurnal trends. Concentrations decrease from around 05:00 and continue to decrease until mid-afternoon. After this, concentrations are shown to increase back to concentrations exhibited in the morning. Primary particulate matter emissions can be attributed to these diurnal changes. Emissions of sulphur dioxide and NO_x can also be responsible for the patterns. These emissions can react with other atmospheric chemicals to form secondary sulphate and nitrate particles. This can then result in concentrations of PM_{10} and $PM_{2.5}$ becoming elevated.

Diurnal patterns in PM_{10} varied between sites as shown in Figure 18. Stansted 4 shows similar diurnal trends to those exhibited by $PM_{2.5}$ at all sites, displaying decreasing concentrations between morning and mid-afternoon followed by increasing concentrations back to the morning peak throughout the evening and night. However, Stansted 3 and 5 show different diurnal patterns to this. At Stansted 3, pronounced peaks in PM_{10} concentration can be seen in the morning and afternoon. This is likely due to the contribution of local emissions from the car park next to which this site is located. These morning and afternoon peaks are also shown in the diurnal profile of Stansted 5 but to a lower magnitude than at Stansted 3. These peaks are also likely the result of vehicle activity in the car park located at this site.

4.5.2 Weekly Variation

Analysis of weekly variations of each pollutant highlight trends of increasing concentrations from Monday to Thursday, and show decreased in concentrations for the rest of the working week and especially at the weekend. However, NO_2 concentrations at Stansted 4 do not follow these trends. At Stansted 4, NO_2 concentrations are shown to generally decrease through the week from Monday to Sunday.

Figure 16: Temporal variation in NO_2 concentrations during 2022 at Stansted 3, Stansted 4, and Stansted 5

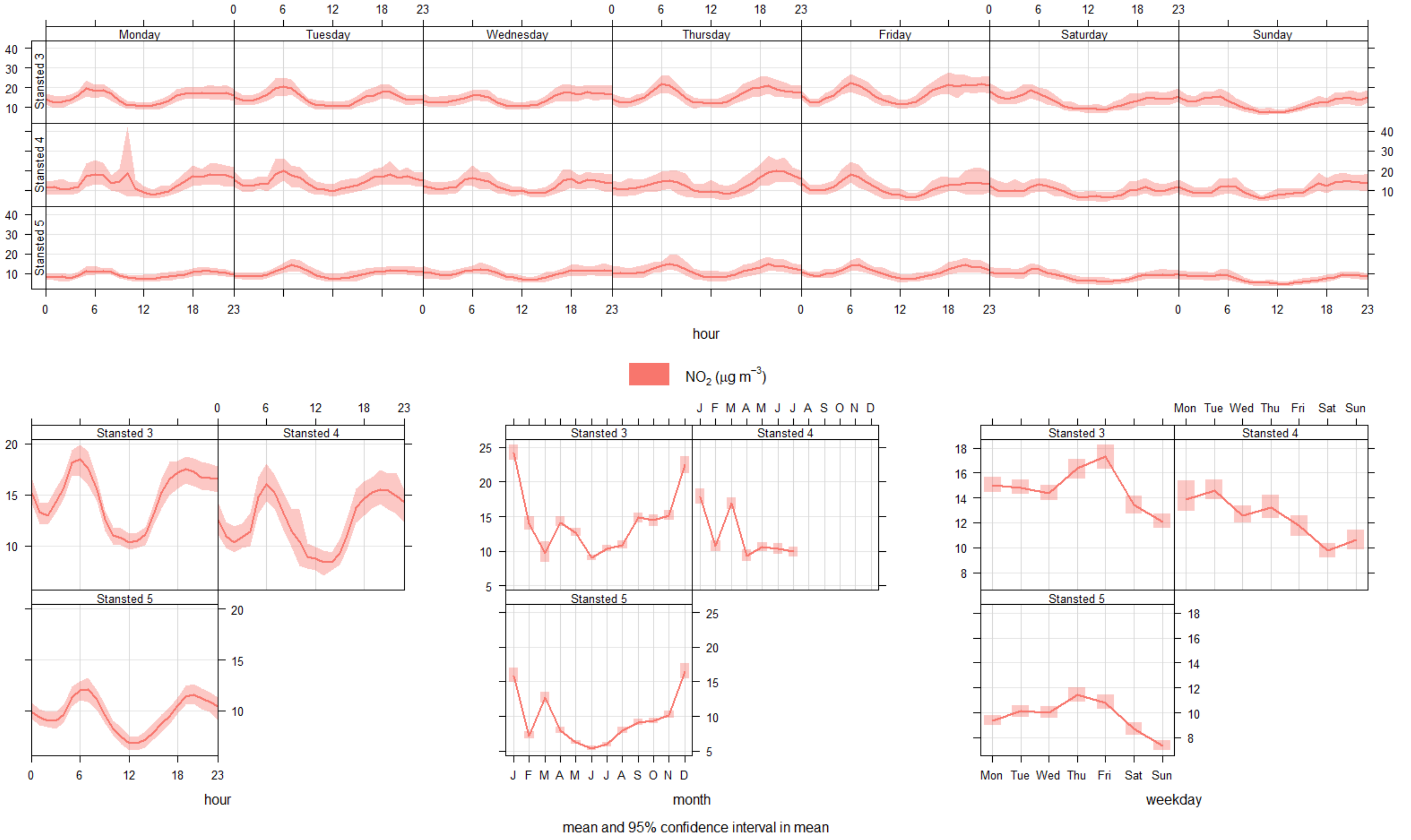


Figure 17: Temporal variation in $PM_{2.5}$ concentrations during 2022 at Stansted 3, Stansted 4, and Stansted 5

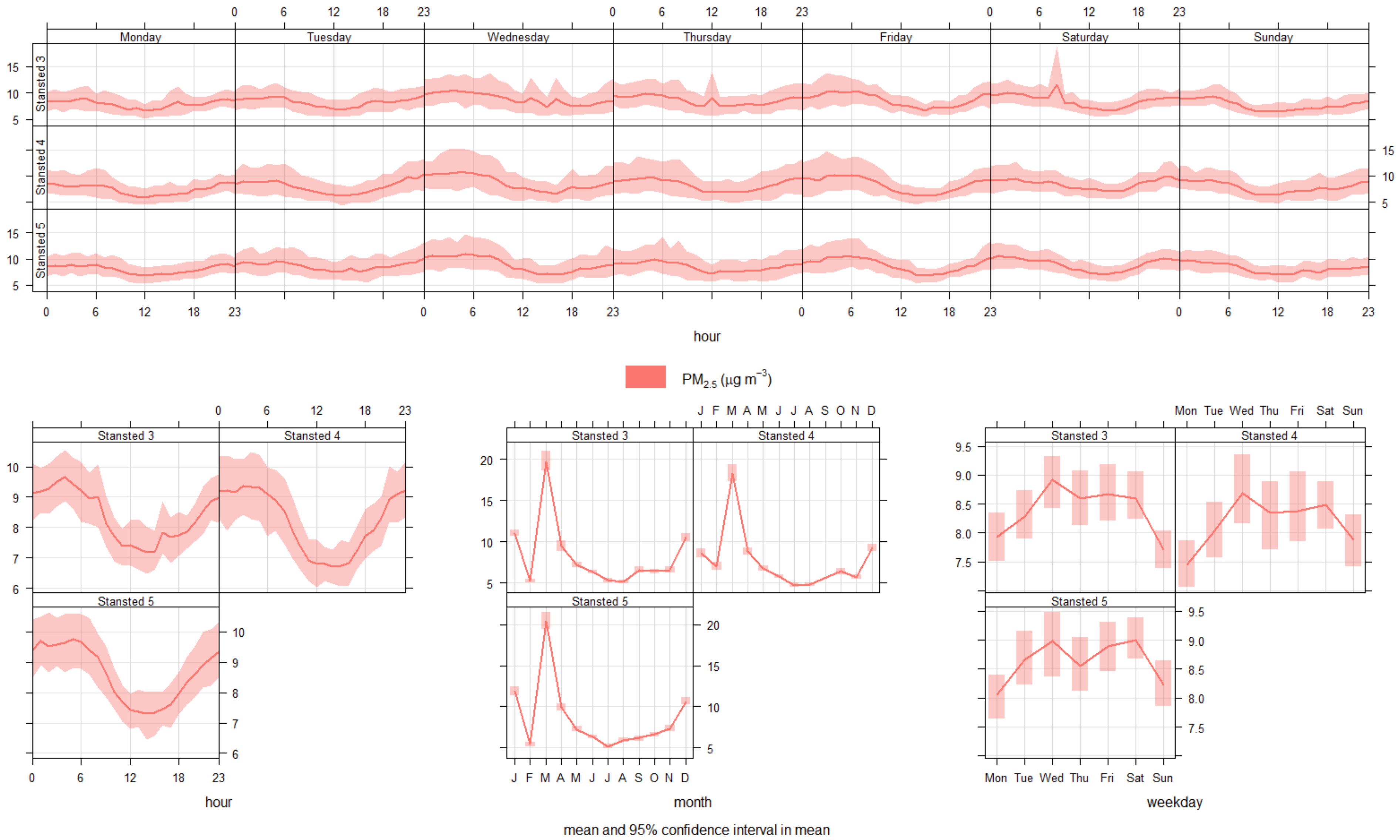
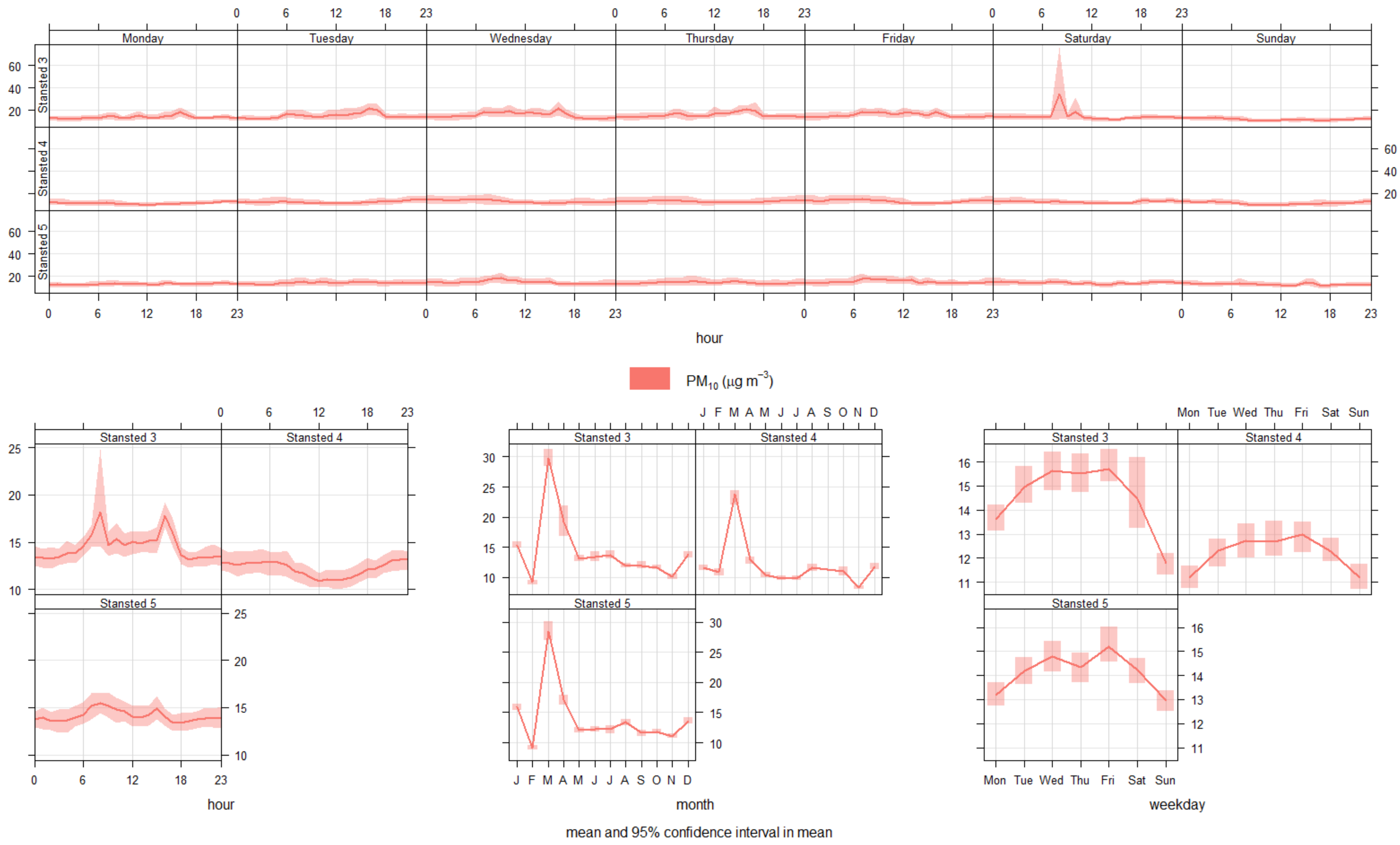


Figure 18: Temporal variation in PM_{10} concentrations during 2022 at Stansted 3, Stansted 4, and Stansted 5



4.6 PERIODS OF ELEVATED POLLUTANT CONCENTRATION

As well as the AQS Objectives, a Daily Air Quality Index (DAQI) is used in the UK to communicate information about current and forecast air quality to the public. The Index is based on a scale of 1-10, divided into four bands (Low, Moderate, High and Very High): this provides a simple indication of pollution levels, similar to the pollen index. Low air pollution is between 1 and 3, Moderate is between 4 and 6, High is between 7 and 9, and Very High is 10 on the scale. This is intended to allow sensitive people to take any necessary action.

The concentration ranges associated with each band within the index are presented in Appendix 1.

NO_2 concentrations at Stansted 3 and Stansted 5 remained within the Low band throughout 2022. At Stansted 4, NO_2 concentrations moved into the Moderate band on one occasion. At Stansted 3, PM_{10} and PM2.5 concentrations both moved into the High band on one occasion each during 2022.

The historic Air Quality Index data presented at the Department of Environment, Food & Rural Affairs (Defra) UK-AIR website[8] shows air quality index bands that entered high banding from 23rd to 25th March and 19th to 20th June. These pollution episodes are consistent with the period of elevated PM and NO_x concentrations measured at the three Stansted monitoring stations.

Moderate and High particle pollution was recorded across much of London and Eastern England between 21st March 2022 to 26th March, as seen at Stansted 3 and Stansted 5 when the sites highest daily PM_{10} and $PM_{2.5}$ measurements were recorded. Air masses from large areas of Europe imported high amounts of particulate pollution from urban, industrial, and agricultural sources. Coupled with calm conditions, dispersion of local pollution was poor and this brought about high particulate concentrations across much of South and Eastern England. These conditions persisted and lead to the pollution episode lasting 6 days in total.

Figure 19: DAQI for 24th March 2022

4.7 BACK TRAJECTORY ANALYSIS

The average daily concentration for each pollutant across all the sites have been calculated, with the top 10 most polluted days (the redder coloured lines) identified and linked to its back trajectory data in the plots below. Figures 23 to 28 illustrate the origins of the pollution episode in late March as described above, demonstrating wind sources from southern Europe.

Figure 20: Trajectory plot for top ten highest daily NO_2 concentrations in 2022 at Stansted 3

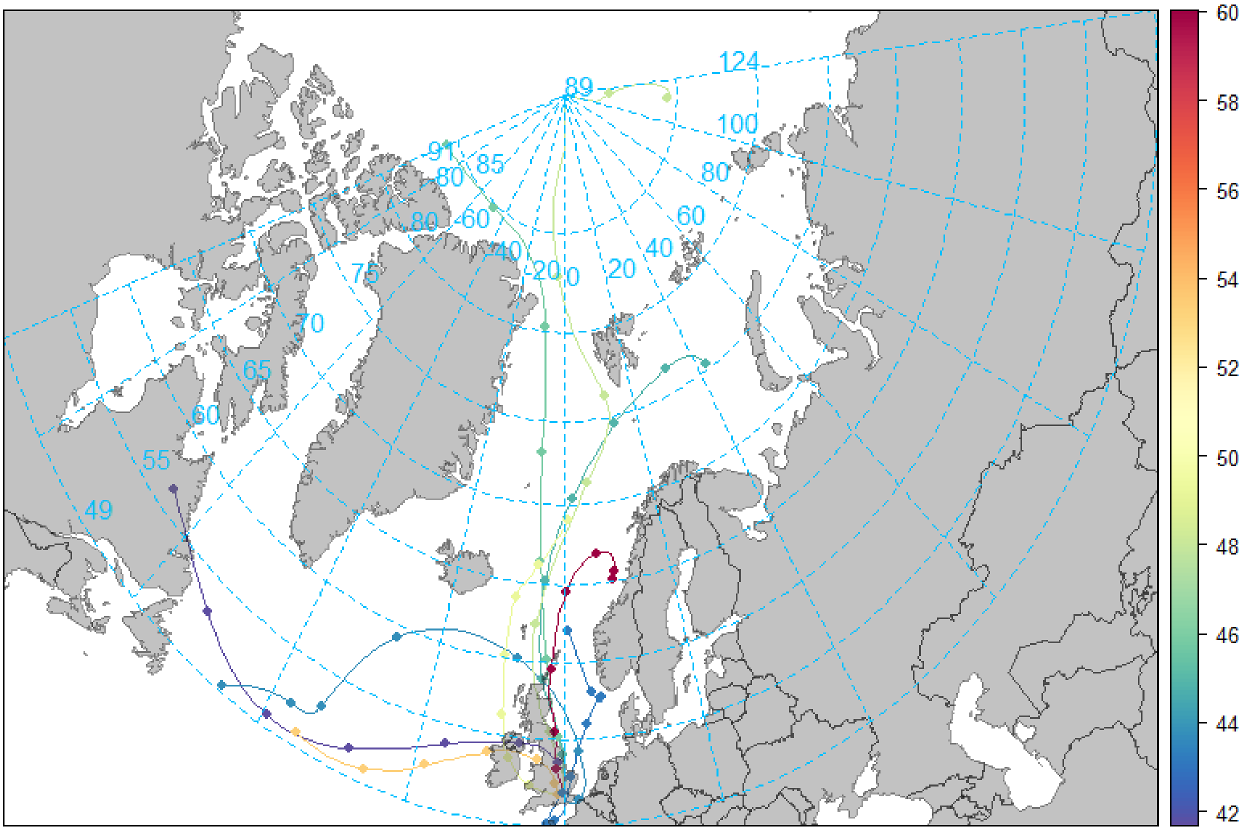


Figure 21: Trajectory plot for top ten highest daily NO_2 concentrations in 2022 at Stansted 4

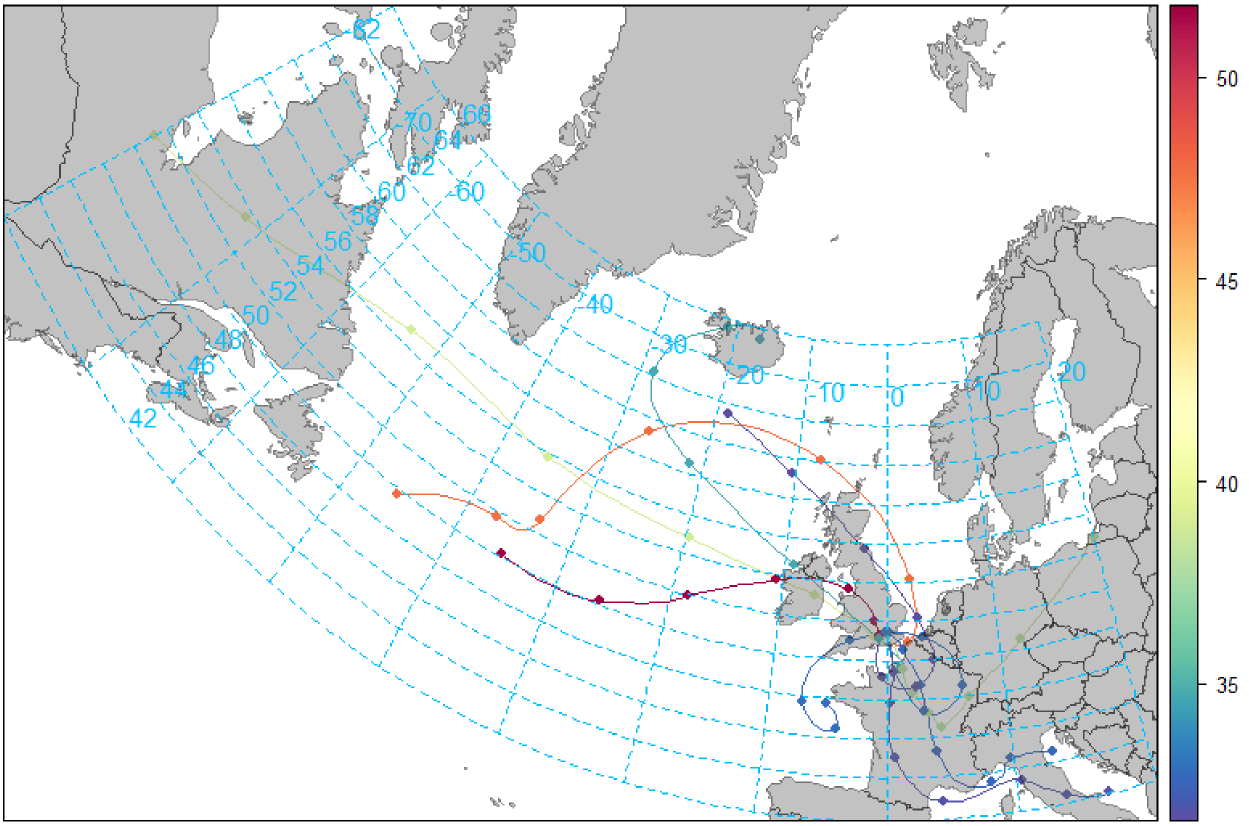


Figure 22: Trajectory plot for top ten highest daily NO_2 concentrations in 2022 at Stansted 5

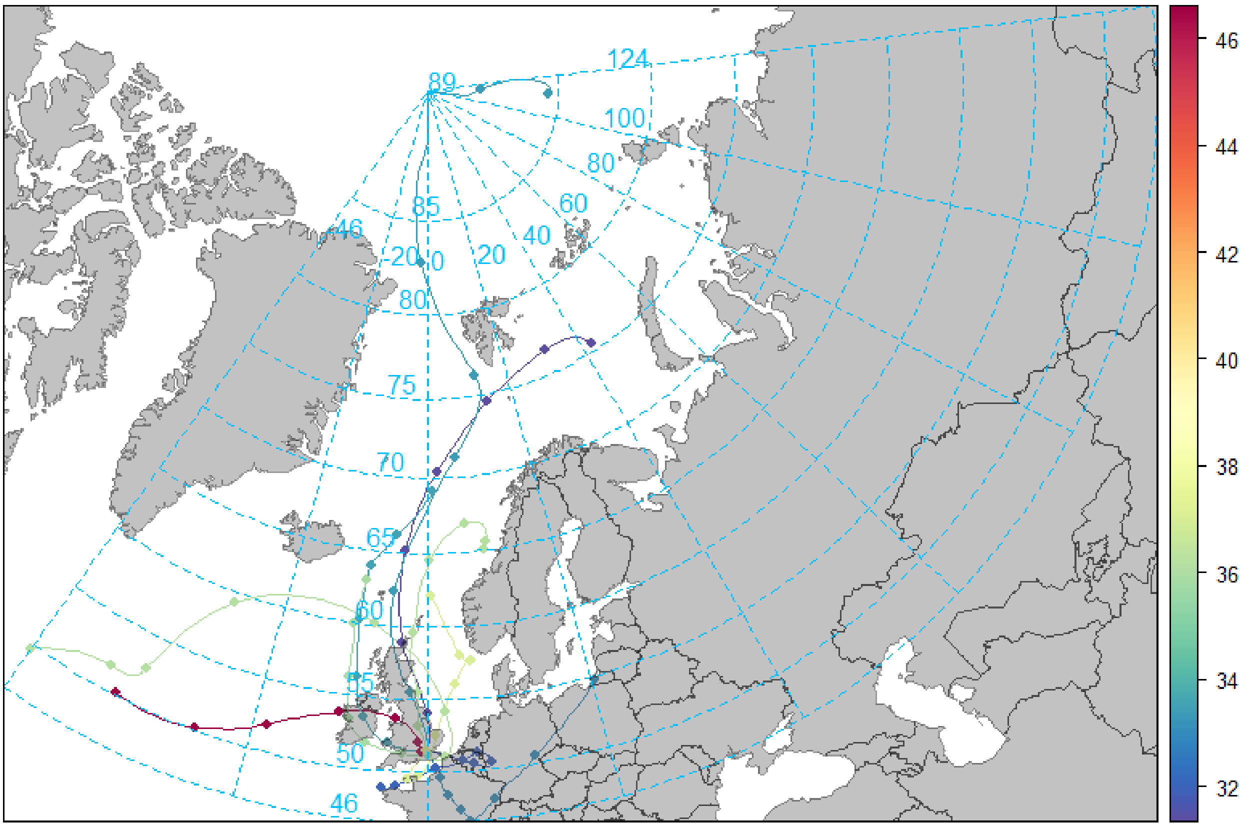


Figure 23: Trajectory plot for top ten highest daily $PM_{2.5}$ concentrations in 2022 at Stansted 3

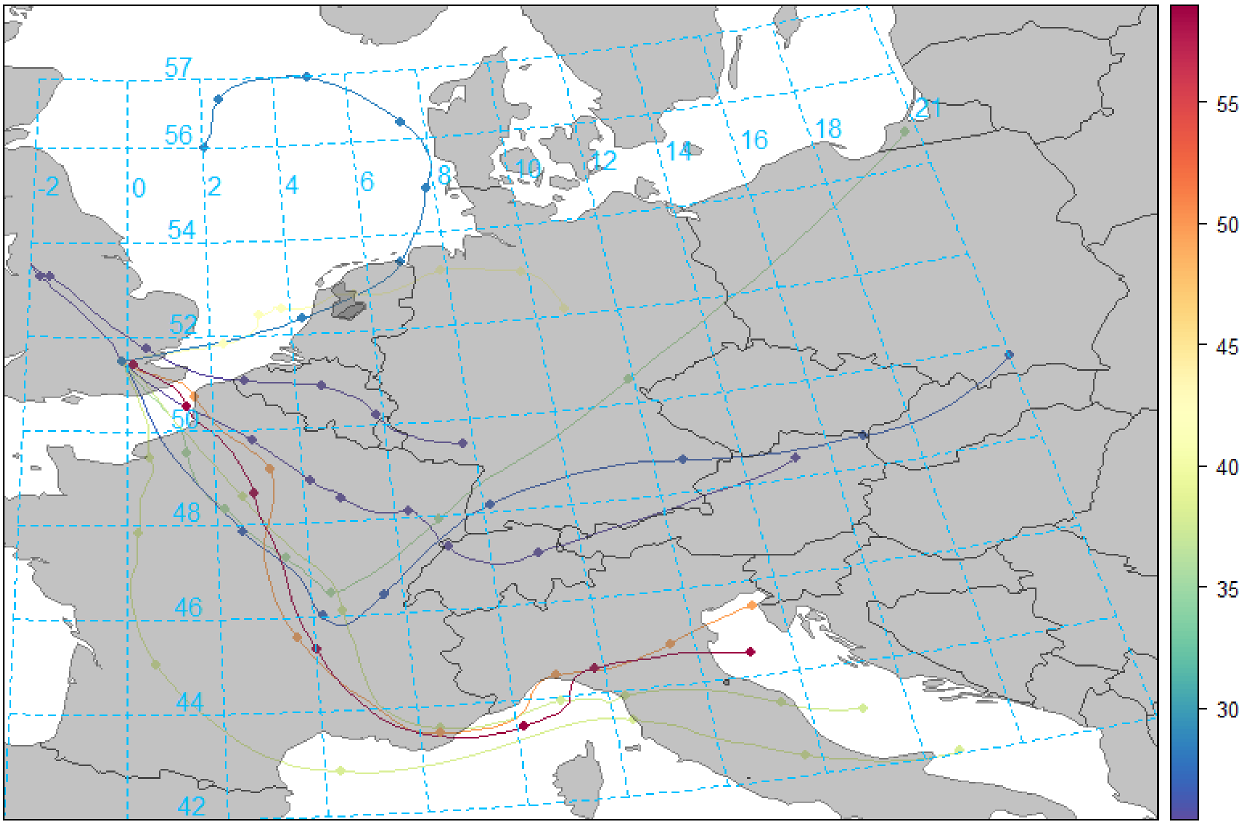


Figure 24: Trajectory plot for top ten highest daily $PM_{2.5}$ concentrations in 2022 at Stansted 4

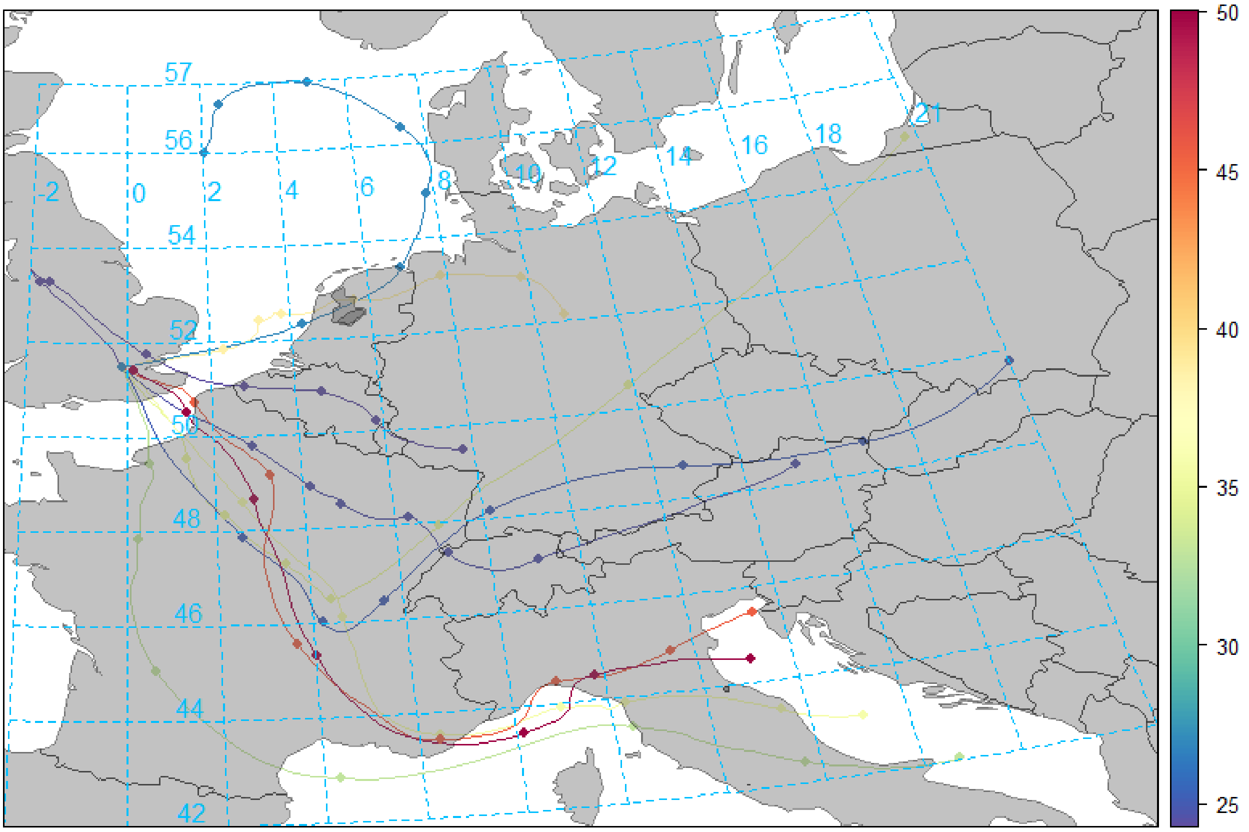


Figure 25: Trajectory plot for top ten highest daily $PM_{2.5}$ concentrations in 2022 at Stansted 5

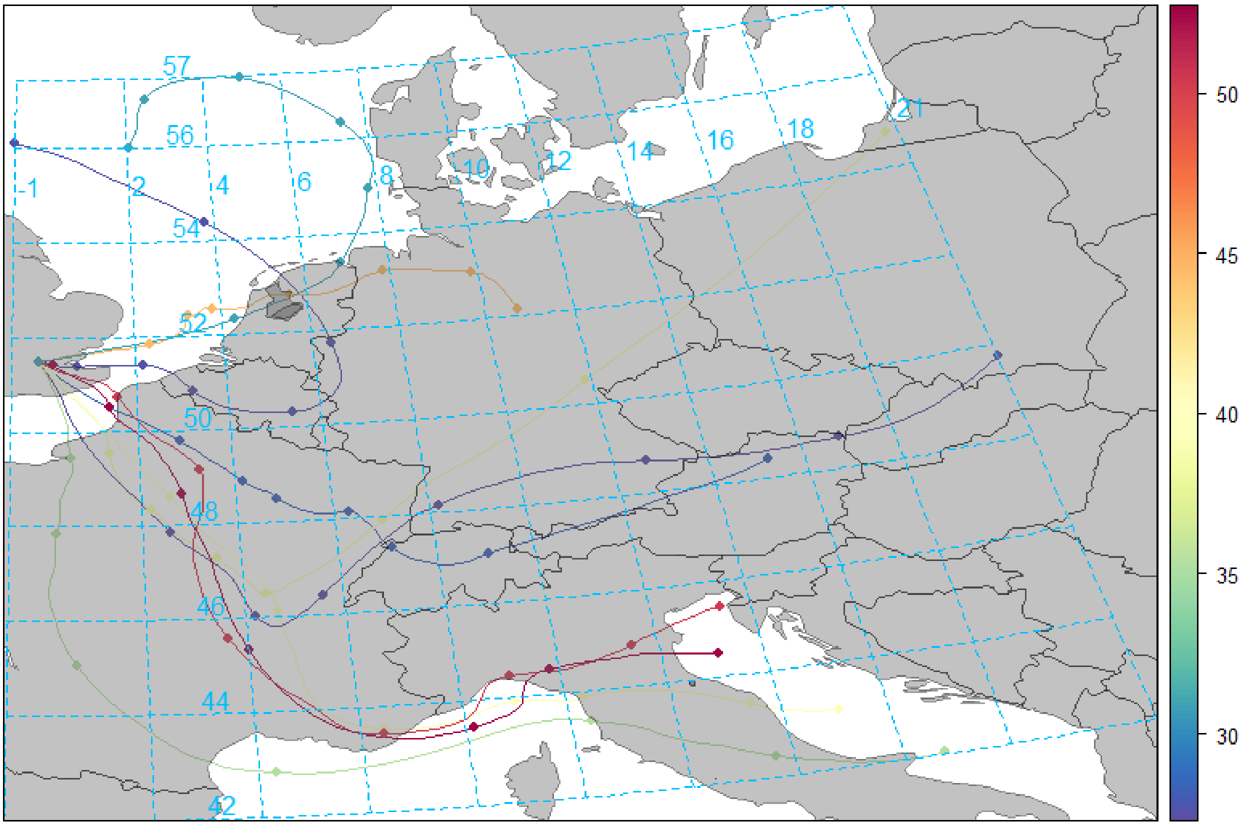


Figure 26: Trajectory plot for top ten highest daily PM_{10} concentrations in 2022 at Stansted 3

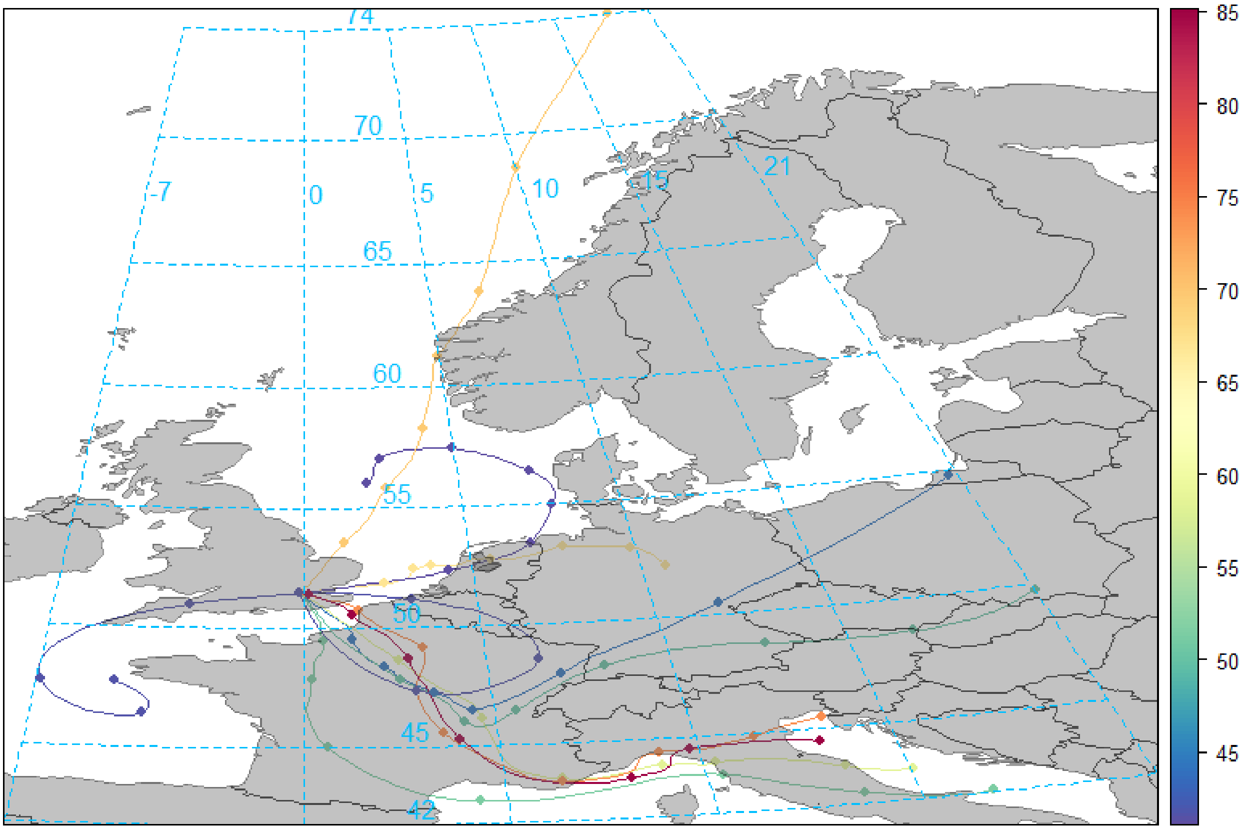


Figure 27: Trajectory plot for top ten highest daily PM_{10} concentrations in 2022 at Stansted 4

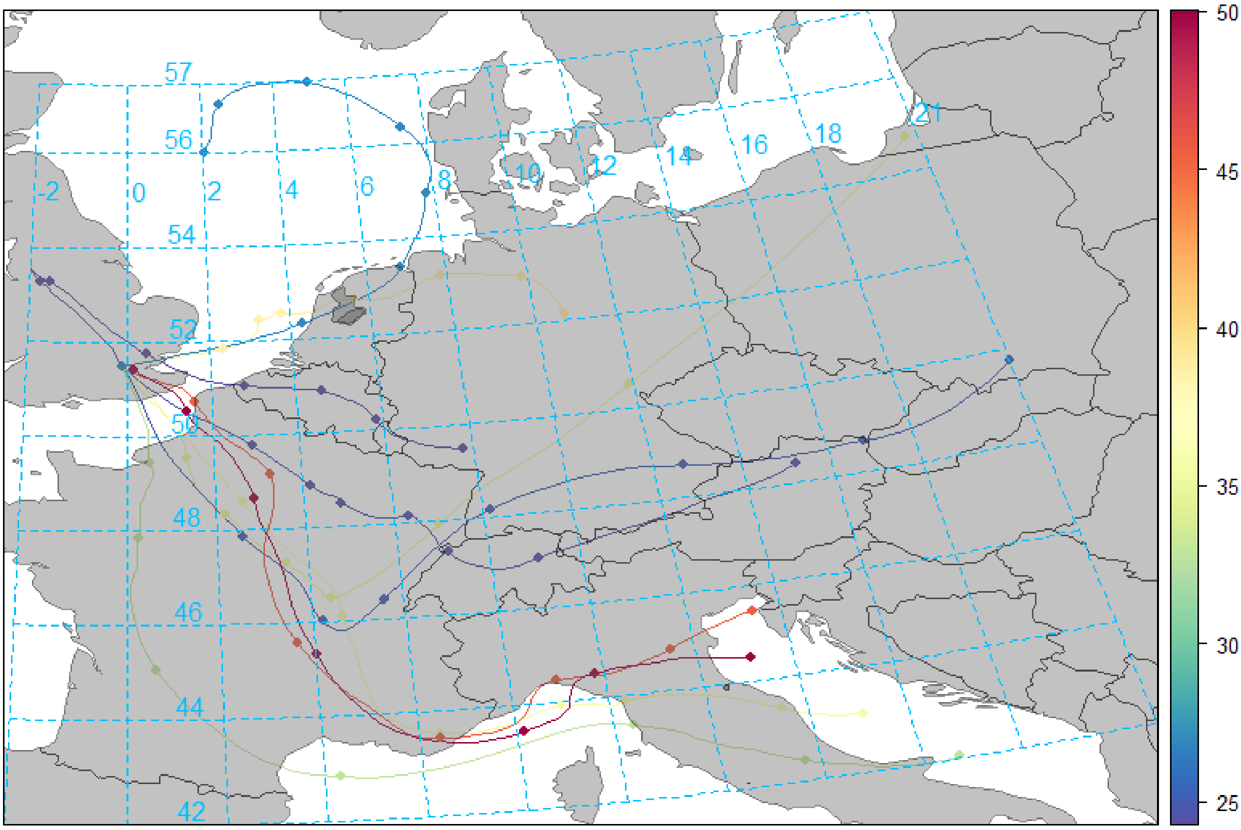
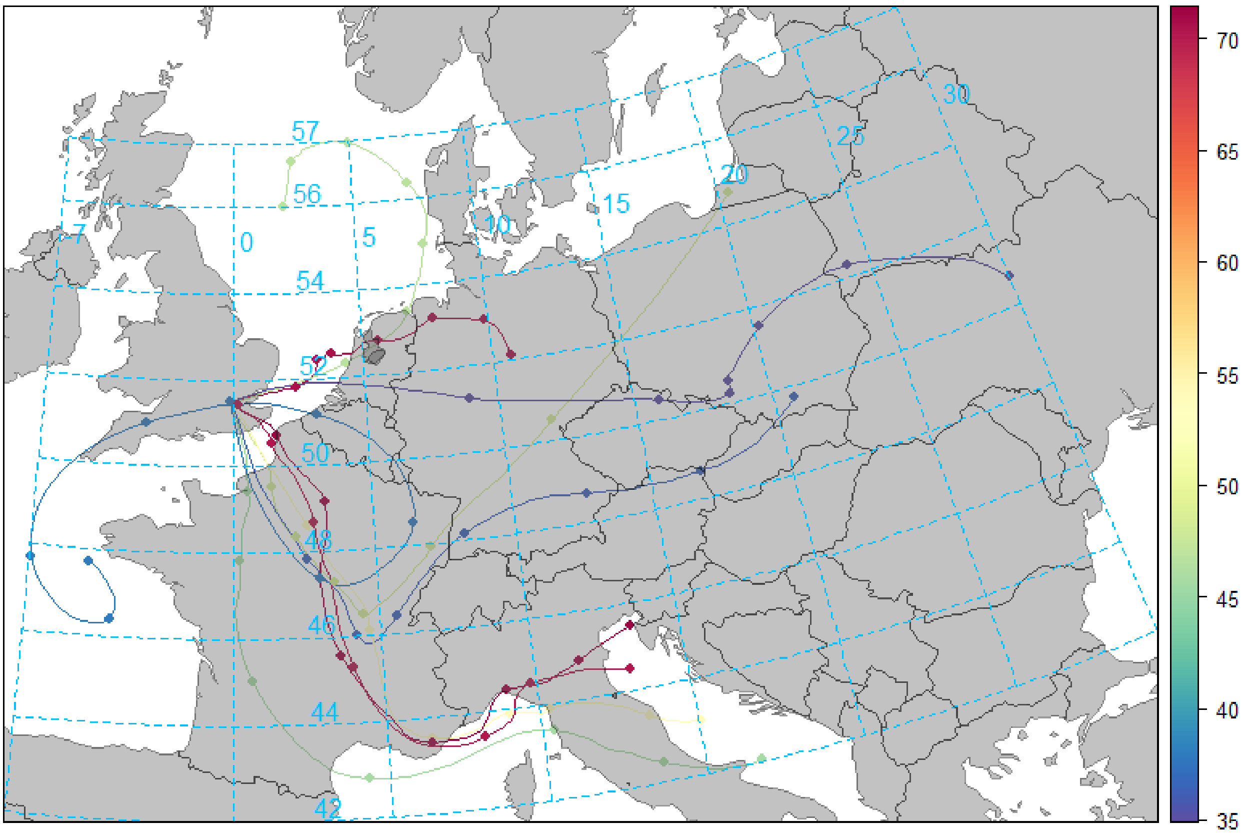


Figure 28: Trajectory plot for top ten highest daily PM_{10} concentrations in 2022 at Stansted 5

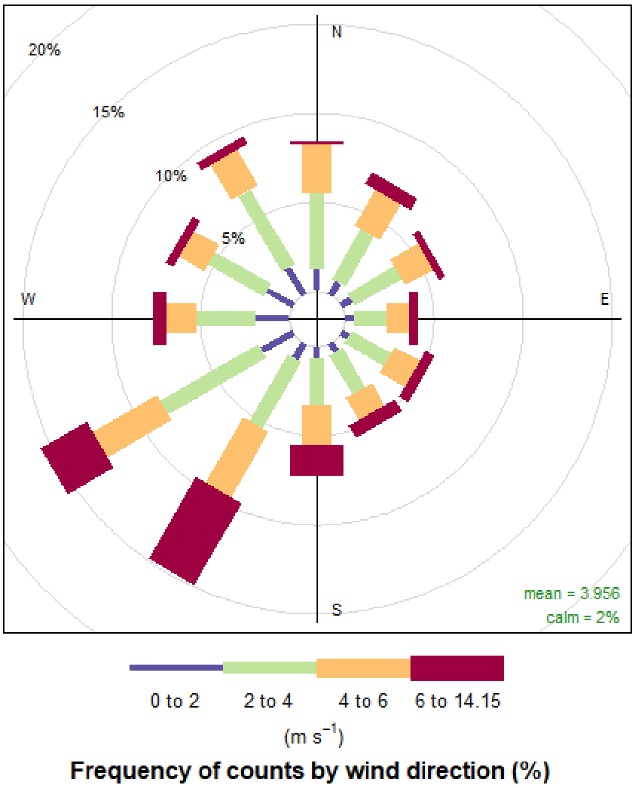


4.8 SOURCE INVESTIGATION

In order to investigate the possible sources of air pollution that were monitored at Stansted Airport, meteorological data were used to add a directional component to the air pollutant concentrations. Wind speed and direction data was gathered using data from the National Oceanic and Atmospheric Administration (NOAA) meteorological database. The QA/QC procedures for checking of these data are not known.

Figure 29 shows the wind speed and direction data for Stansted Airport during 2022. The lengths of the "spokes" against the concentric circles indicate the percentage of time during the year that the wind was measured from each direction. The prevailing wind direction was between 200° to 240°, which represents the prevailing wind direction from the southwest. Each "spoke" is divided into coloured sections representing wind speed intervals of 2 m s^{-1} as shown by the scale bar in the plot, followed by a final interval of 8.15 m s^{-1}. The mean wind speed was 3.96 m s^{-1}. The maximum hourly measured wind speed was 14.15 m s^{-1}. Some of the highest wind speeds occurred during February 2022.

Figure 29: Wind rose showing wind speed and direction from the on-field anemometer at Stansted Airport in 2022



4.9 CALENDAR PLOT

Figure 30 to Figure 38 show calendar plots for each site. The date is coloured by the NO_2, $PM_{2.5}$ and PM_{10} concentration (µg m^{-3}) for that day.

Figure 30: NO_2 calendar plot for Stansted 3 during 2022

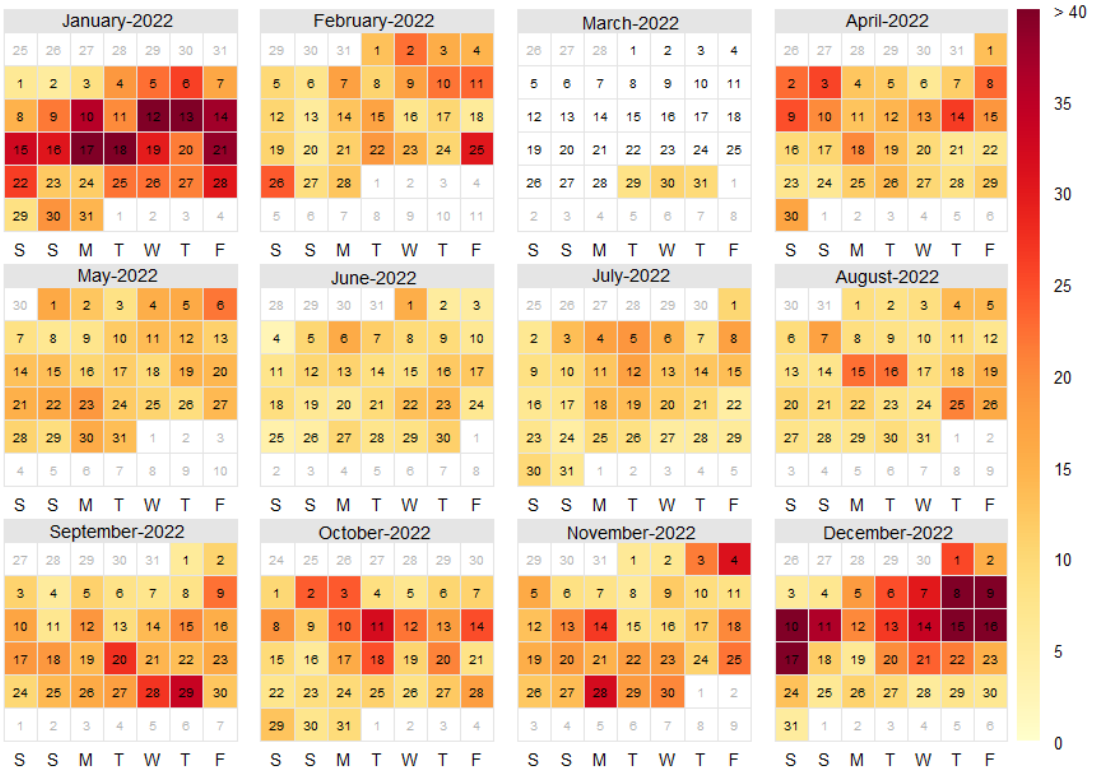


Figure 31: NO_2 calendar plot for Stansted 4 during 2022

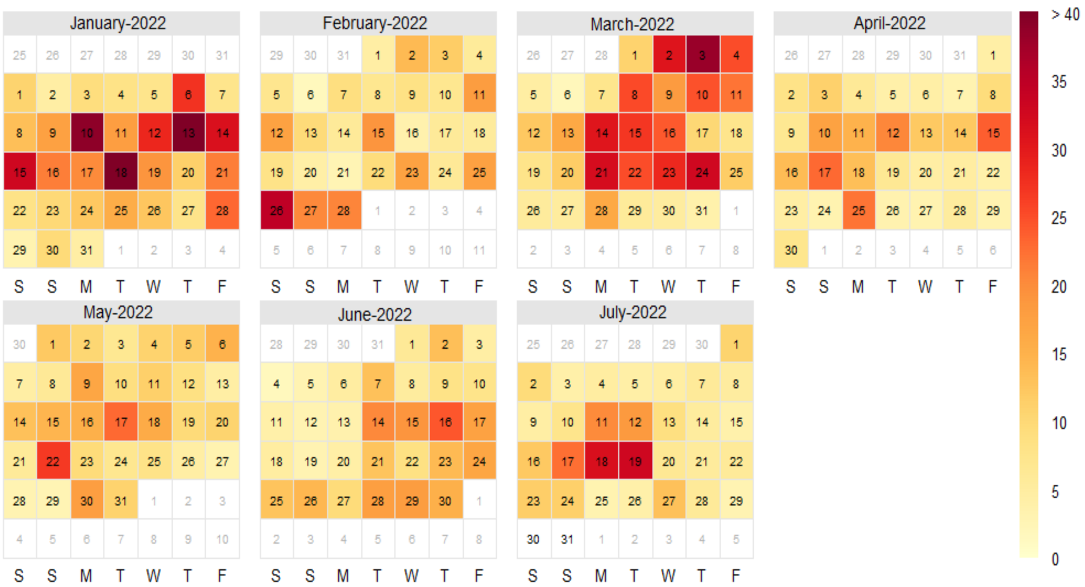


Figure 32: NO_2 calendar plot for Stansted 5 during 2022

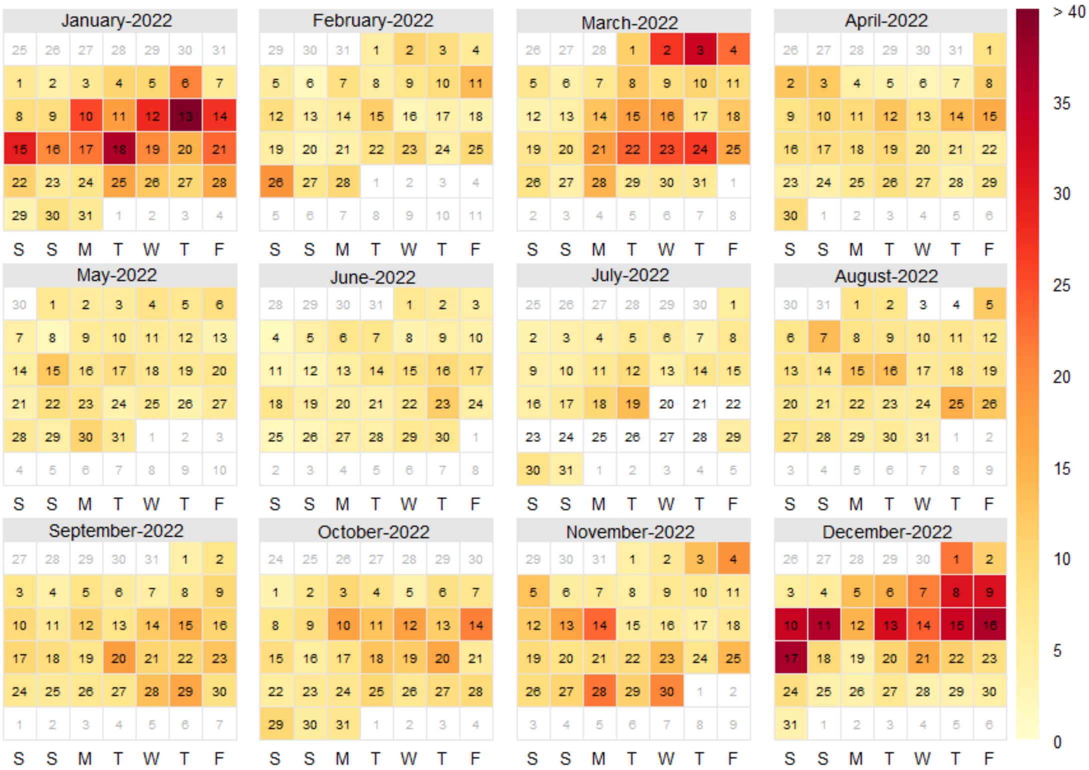


Figure 33: $PM_{2.5}$ calendar plot for Stansted 3 during 2022

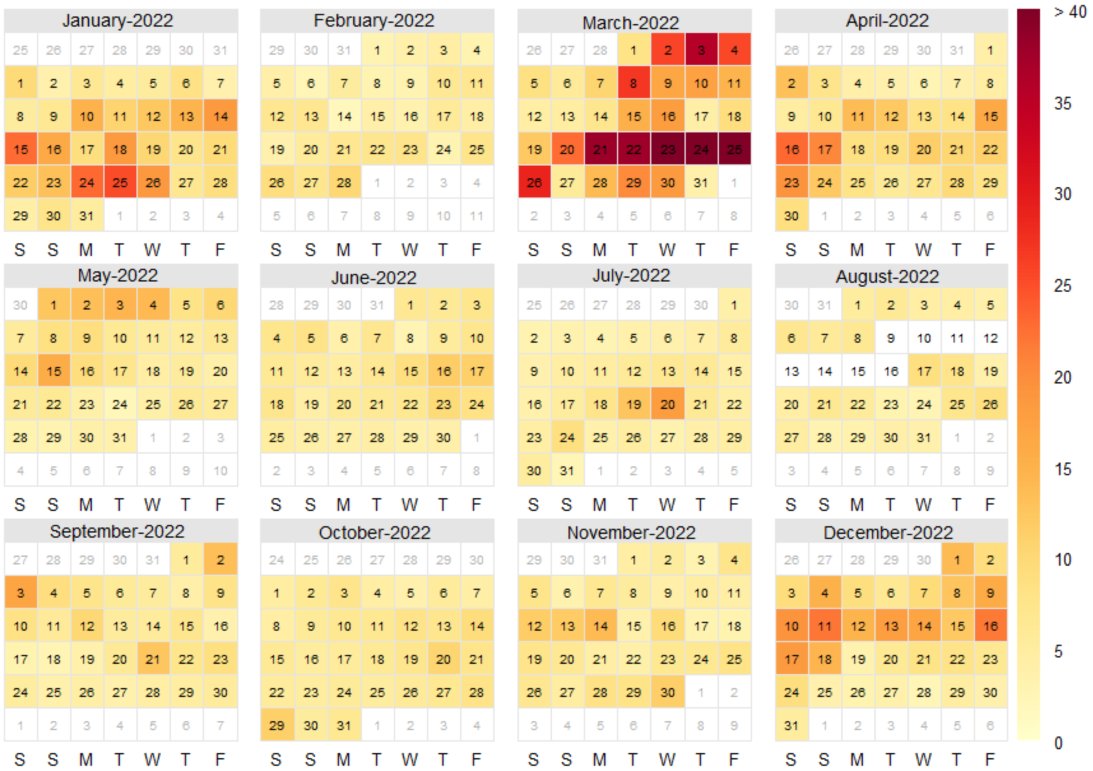


Figure 34: $PM_{2.5}$ calendar plot for Stansted 4 during 2022

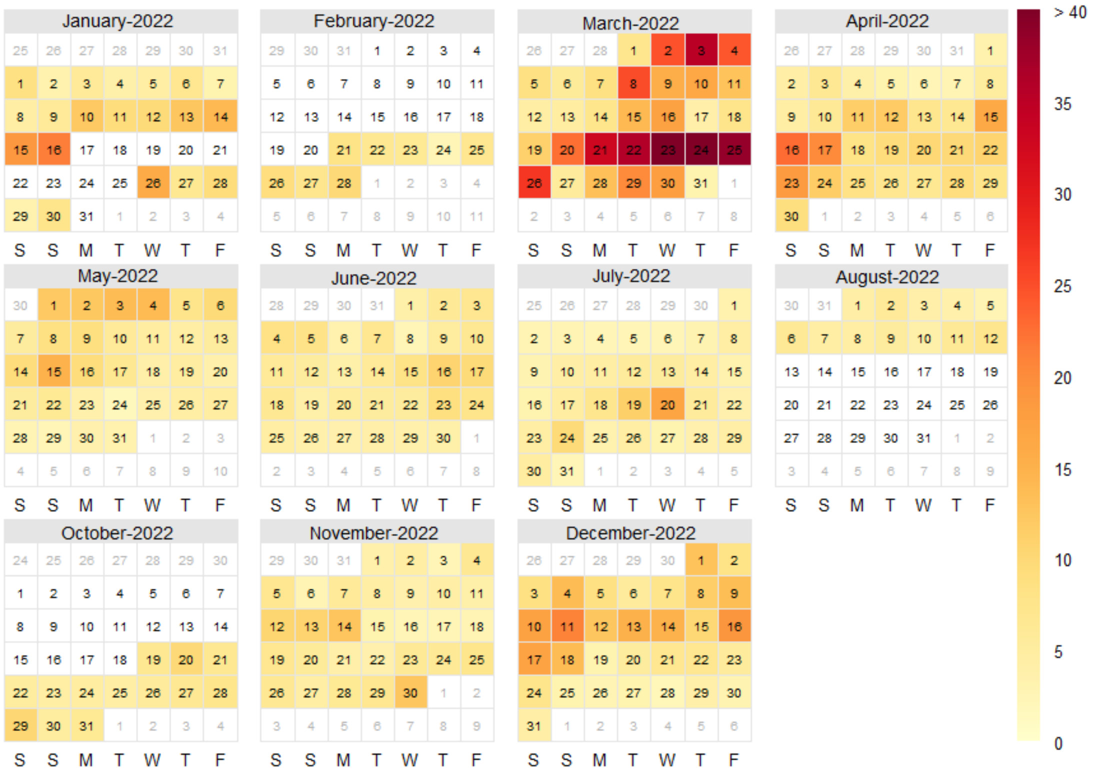


Figure 35: $PM_{2.5}$ calendar plot for Stansted 5 during 2022

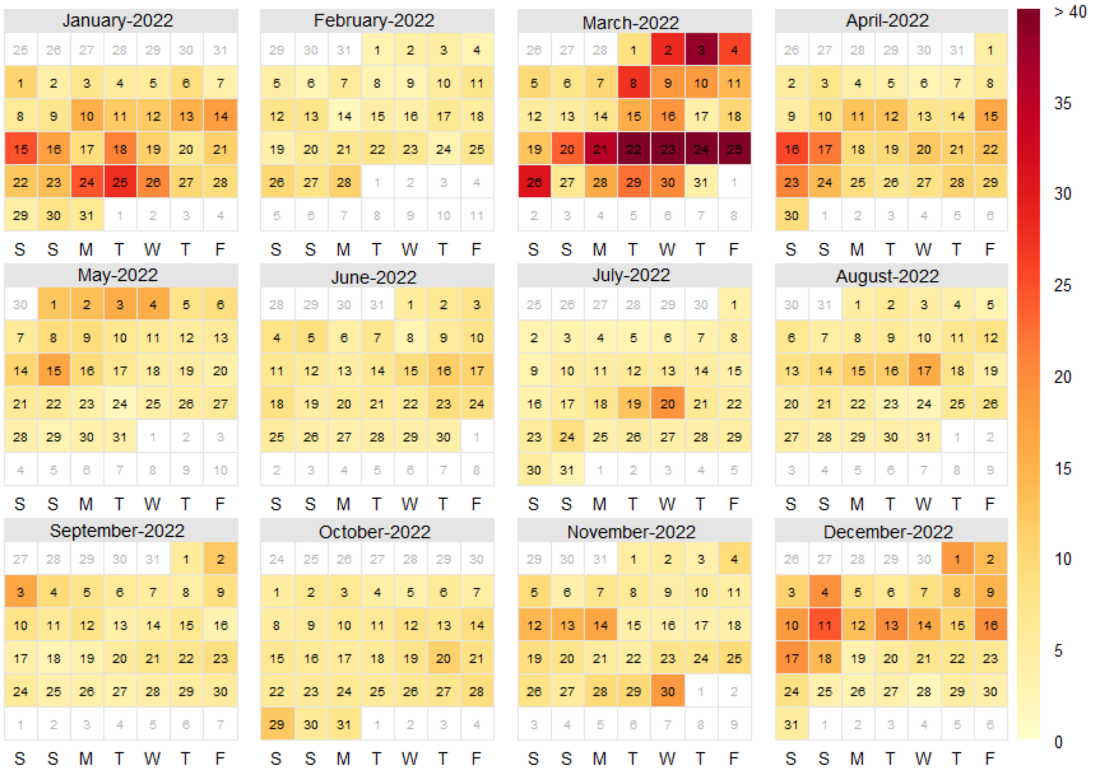


Figure 36: PM_{10} calendar plot for Stansted 3 during 2022

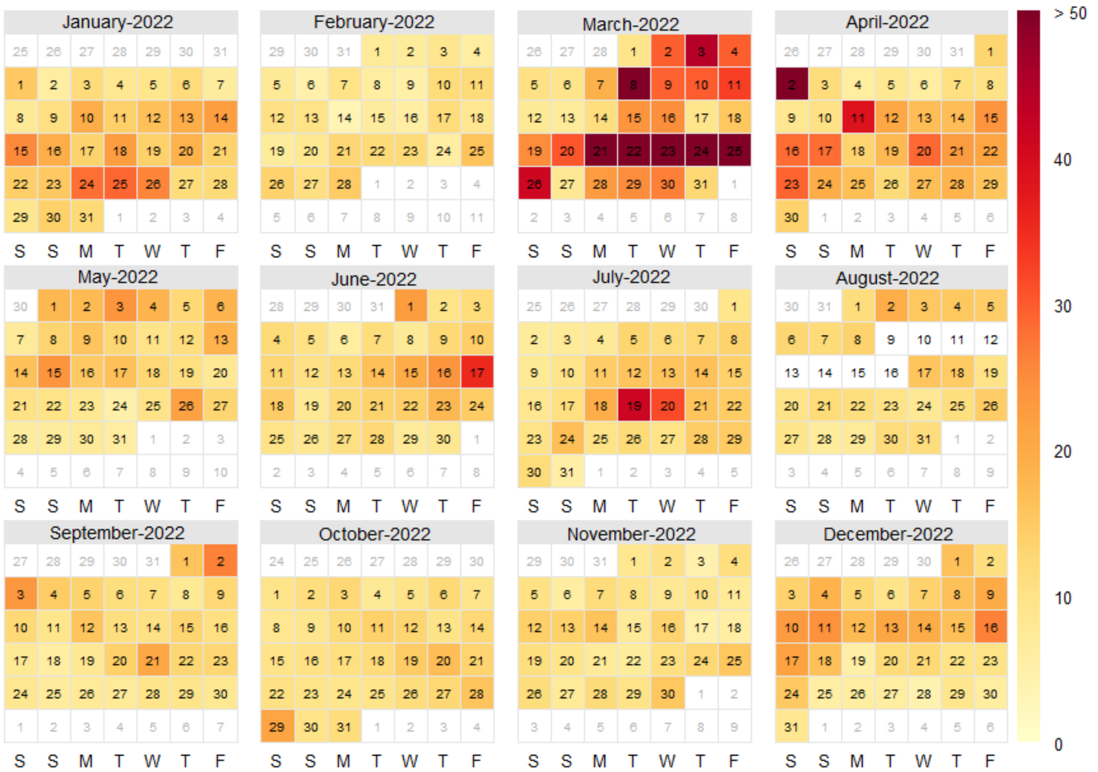


Figure 37: PM_{10} calendar plot for Stansted 4 during 2022

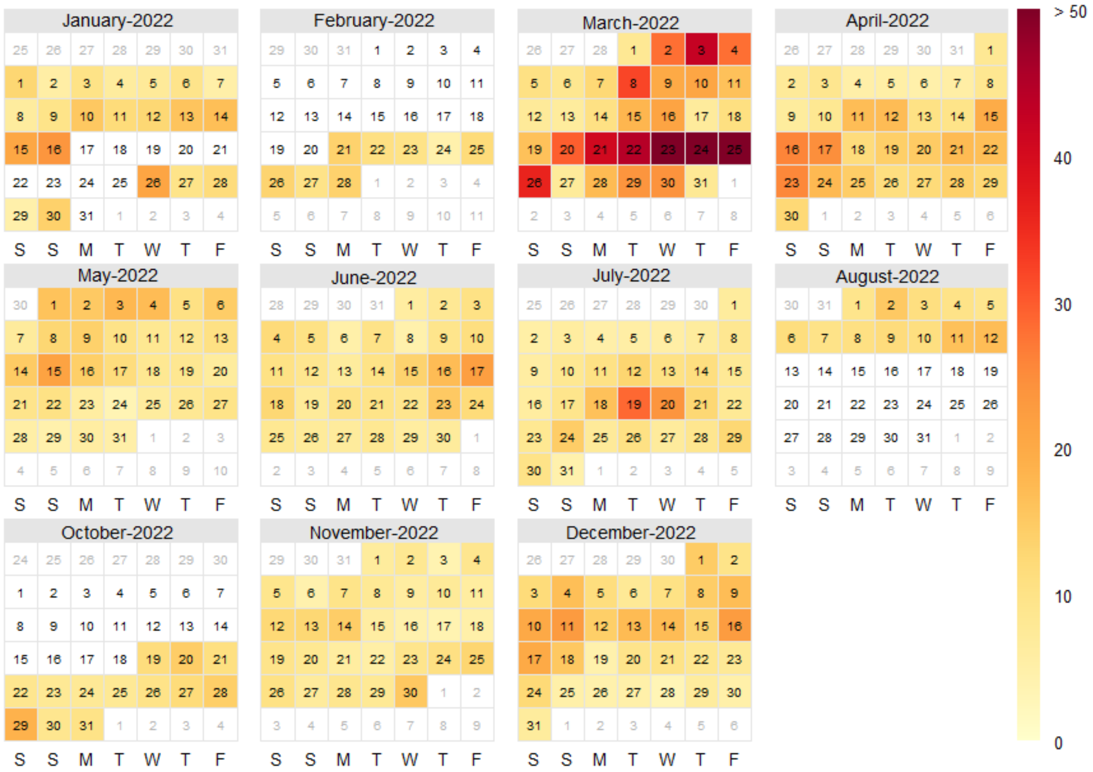
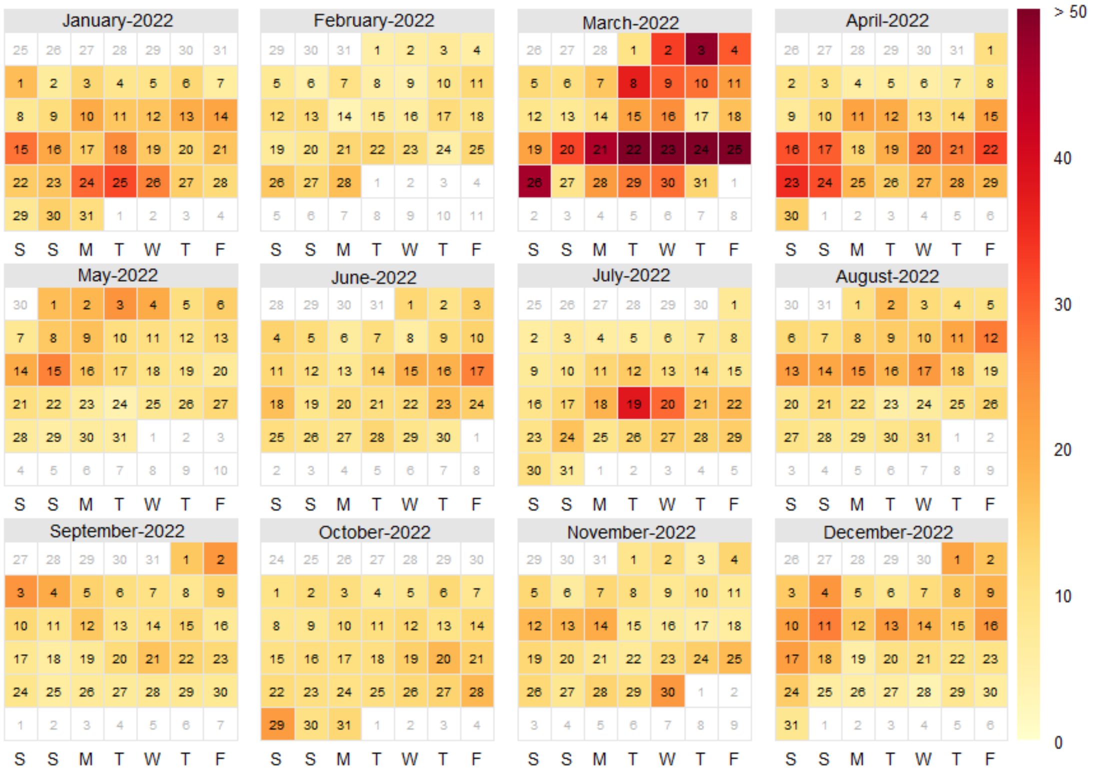


Figure 38: PM_{10} calendar plot for Stansted 5 during 2022



4.10 POLAR PLOT

Figure 39, Figure 40 and Figure 41 show bivariate plots, ''pollution roses'' of hourly mean pollutant concentrations against the corresponding wind speed and wind direction. These plots should be interpreted as follows:

- The wind direction is indicated as in the wind rose above (north, south, east, and west are indicated).
- The wind speed is indicated by the distance from the centre of the plot: the concentric circles indicate wind speeds in 2 ms^{-1} intervals.
- The pollutant concentration is indicated by the colour (as indicated by the scale).

These plots therefore show how pollutant concentration varies with wind direction and wind speed.

Figure 39 shows the main source of NO_2 at all three sites appear to be close to the monitoring sites, with the highest concentrations occurring at low wind speeds. At higher wind speeds, between 5-9 m s^{-1}, there is shown to be a mild source to the northwest of Stansted 3. It is possible that this may be the result of activities around the airport terminal buildings. Local NO emissions reacting with ozone may be the cause of this NO_2 source, with increased wind speeds causing a faster reaction.

There is also evidence of sources close to the monitoring site at Stansted 4 as well as indication of a moderate source coming from the southeast and another mild source from the southwest at varying wind speeds. These are likely associated with the main airport terminal building, runway, and surrounding access roads.

At Stansted 5, under moderate wind speeds there appears to be signatures from southeast, southwest, and northeast directions. Both Harlow (one of the nearest towns) and London are both located to the southwest of this site, therefore longer range NO_2 transport could explain this signature.

Figure 40 shows $PM_{2.5}$ concentrations at all three sites appear to be higher at windspeeds between 0 and 12 m s^{-1} originating from a south-easterly direction. This can likely be attributed to the transboundary movement of polluted air from the continent. All sites also show a high concentration at high wind speeds (8 to 11 m s^{-1}) from the northeast. Furthermore, each of the three sites exhibits higher $PM_{2.5}$ concentrations under calm conditions. This is likely the result of local emissions from vehicles in close proximity to the site as $PM_{2.5}$ sources are strongly associated with road vehicles, with natural sources only contributing only a small amount to the total concentration.

Figure 41 shows PM_{10} concentrations at Stansted 3, where there is shown to be a strong signature at higher wind speeds (7-13 m s^{-1}) from the southeast. This could be attributed to the transboundary movement of polluted air. PM_{10} concentrations at Stansted 4 show trends similar to those exhibited by $PM_{2.5}$ at the same site, PM_{10} concentrations are highest at varying windspeeds between 0 and 20 m s^{-1} from southeast and northeast directions. Stansted 5 clearly shows higher PM_{10} concentrations occur under moderate to higher wind speeds (over 6 m s^{-1}) towards the northeast of the monitoring site in the direction of the airport and main terminal buildings. Furthermore, a moderate source is indicated from a southeast direct at all wind speeds at this site which could be resulting from long range transport of pollution from the continent as seen for $PM_{2.5}$. The UK-wide pollution/trans-boundary episodes previously mentioned on this report and some agricultural activity related to harvesting may also help explain high PM_{10} concentrations at higher wind speeds originating from several wind directions.

Figure 39: NO_2 polar plot for Stansted 3, 4 and 5 during 2022 (µg m^{-3})

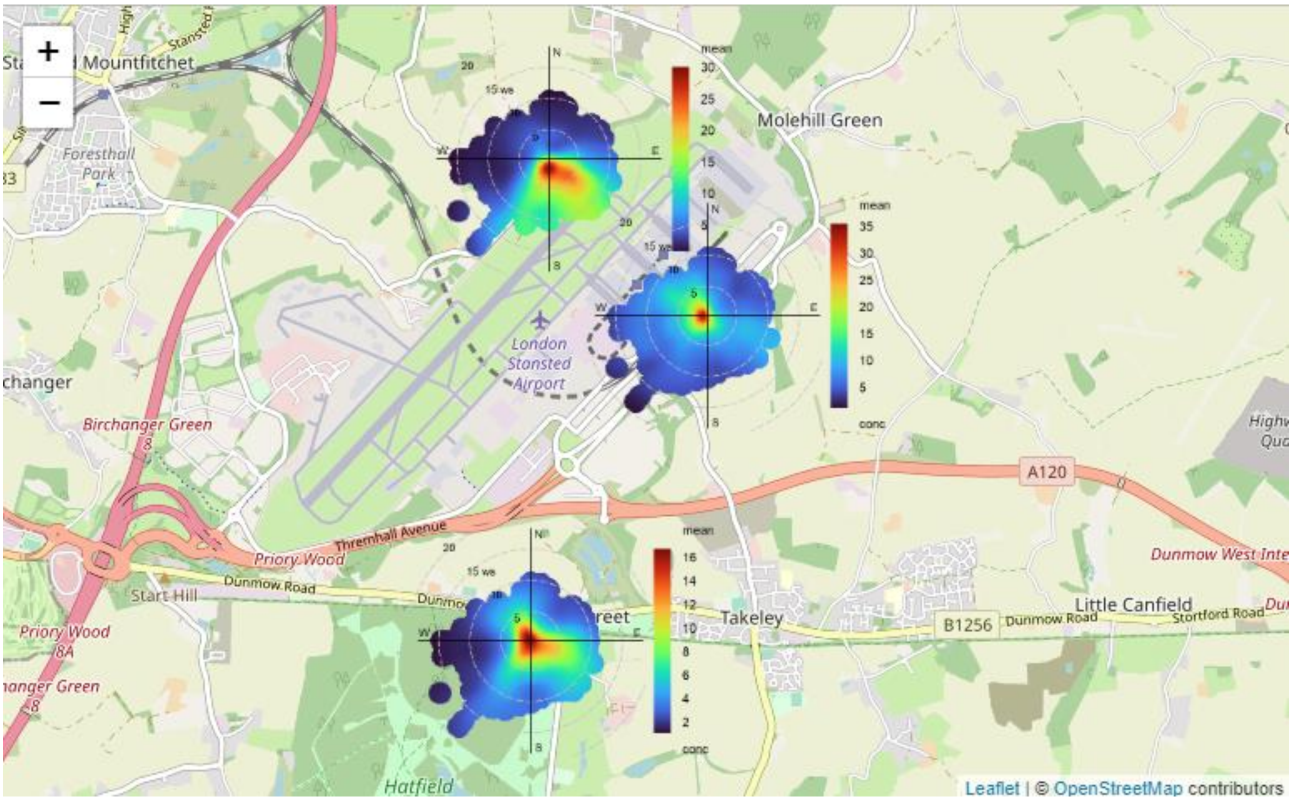


Figure 40: $PM_{2.5}$ polar plot for Stansted 3, 4 and 5 during 2022 (µg m^{-3})

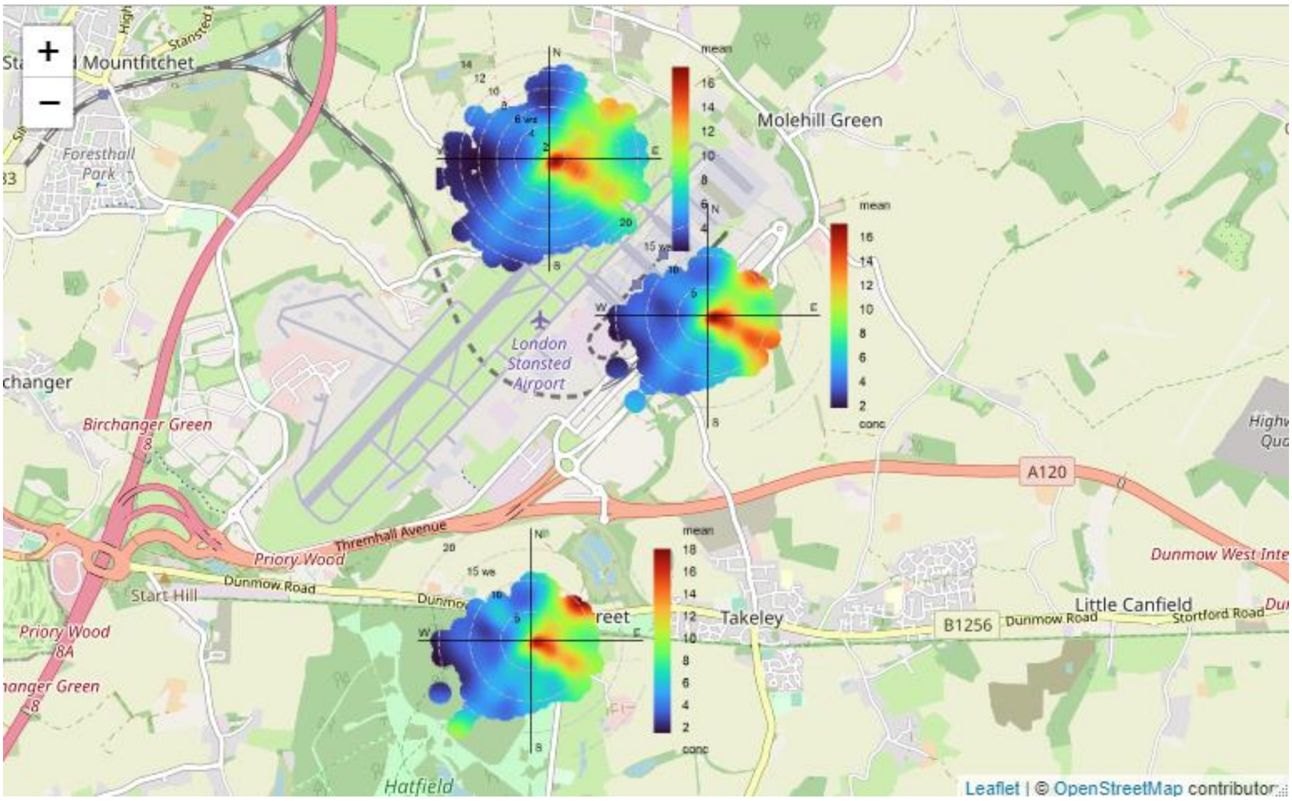
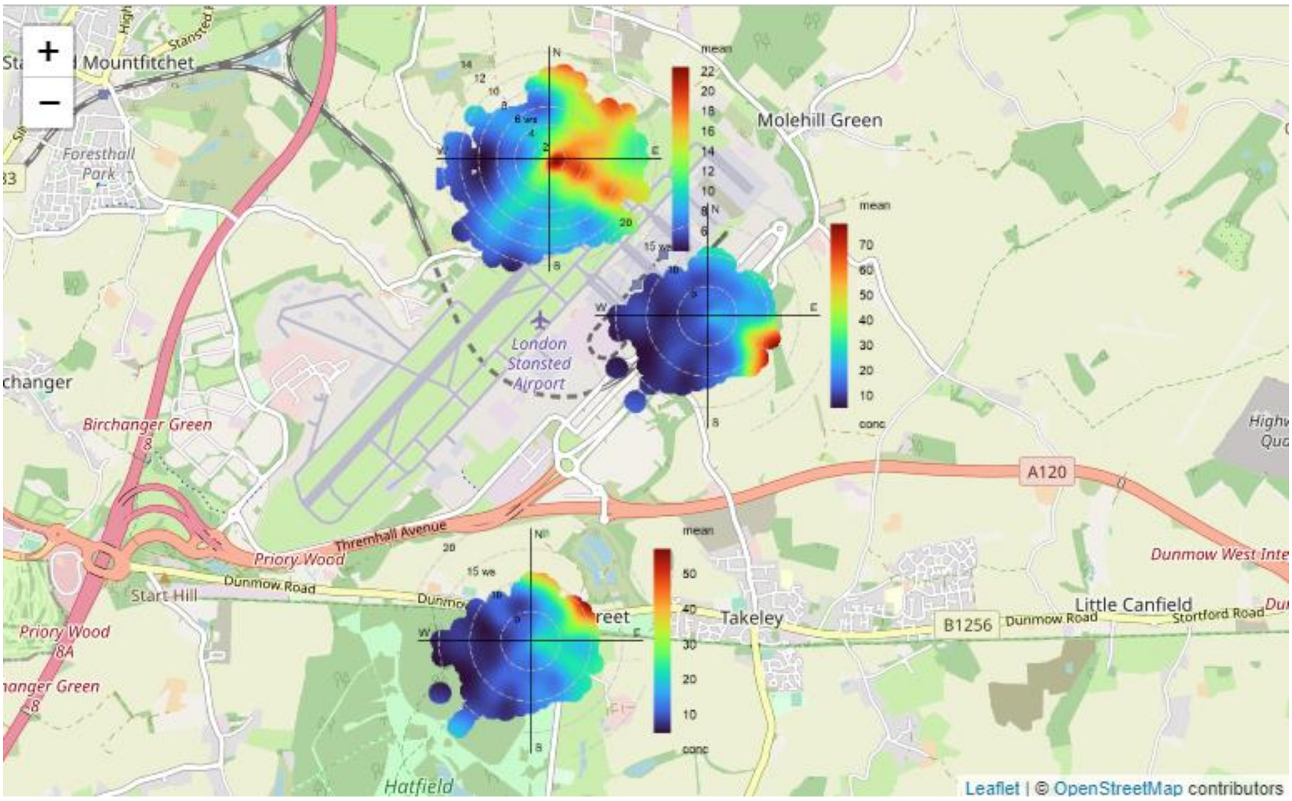


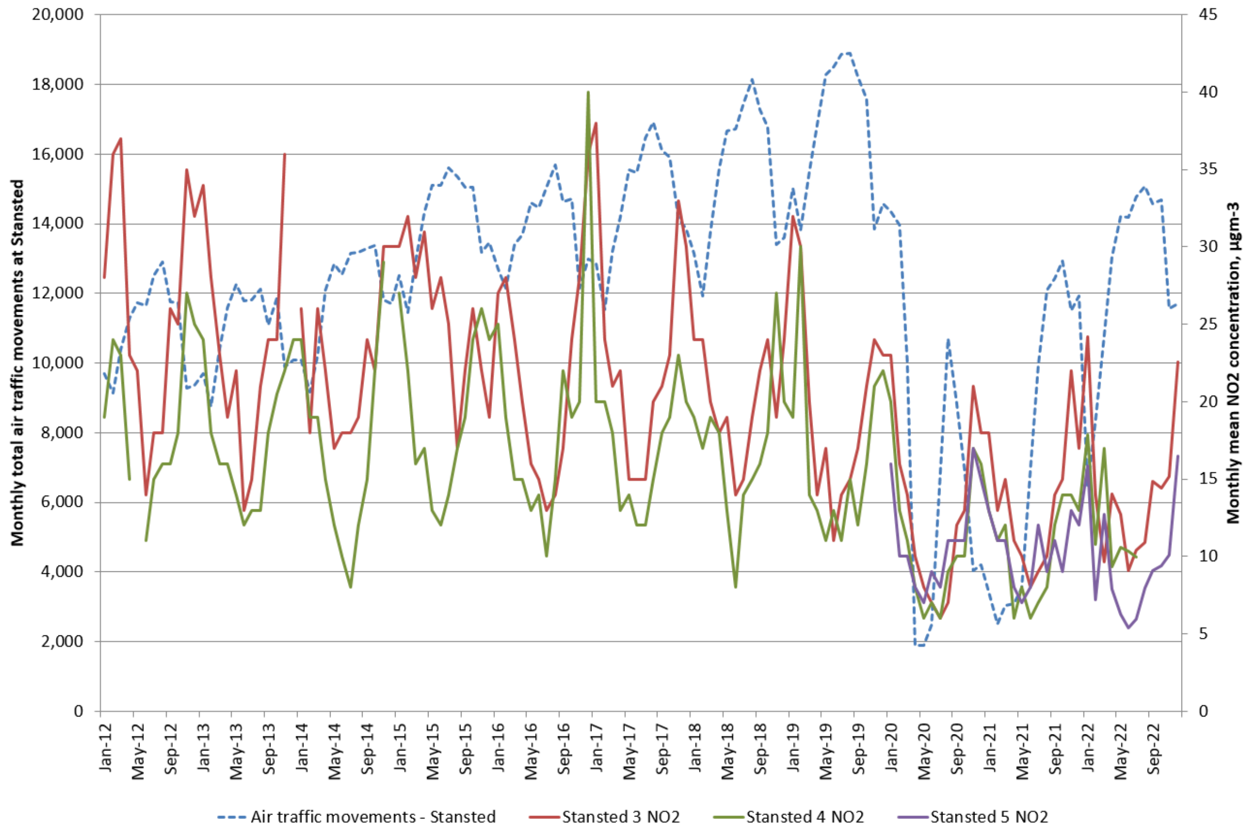
Figure 41: PM_{10} polar plot for Stansted 3, 4 and 5 during 2022 ($\mu g\ m^{-3}$)



4.11 RELATIONSHIP WITH AIRPORT ACTIVITY

Figure 42 shows monthly total aircraft movement at Stansted Airport, compared to monthly mean concentrations of NO_2 at Stansted 3, Stansted 4 and Stansted 5 between January 2013 and December 2022. At Stansted airport, air movement numbers exhibit a clear seasonal pattern showing higher numbers in summer months and lower numbers in winter months. Comparatively, NO_2 concentrations are generally shown to be highest in winter months and lowest in summer months. In 2022, air traffic movements increased by 60% when compared to those documented for 2021, which is expected following the lifting of travel restrictions during the Coronavirus pandemic. In comparison, average NO_2 concentrations at Stansted 4 increased by 16% between 2021 and 2022. Although airport emissions can be an important contributor to local NO_2 concentrations, it is also important to note that ambient pollution concentrations vary seasonally due to widespread factors such as meteorological conditions.

Figure 42: Monthly total aircraft movements compared with monthly mean pollutant concentrations 2012 - 2022

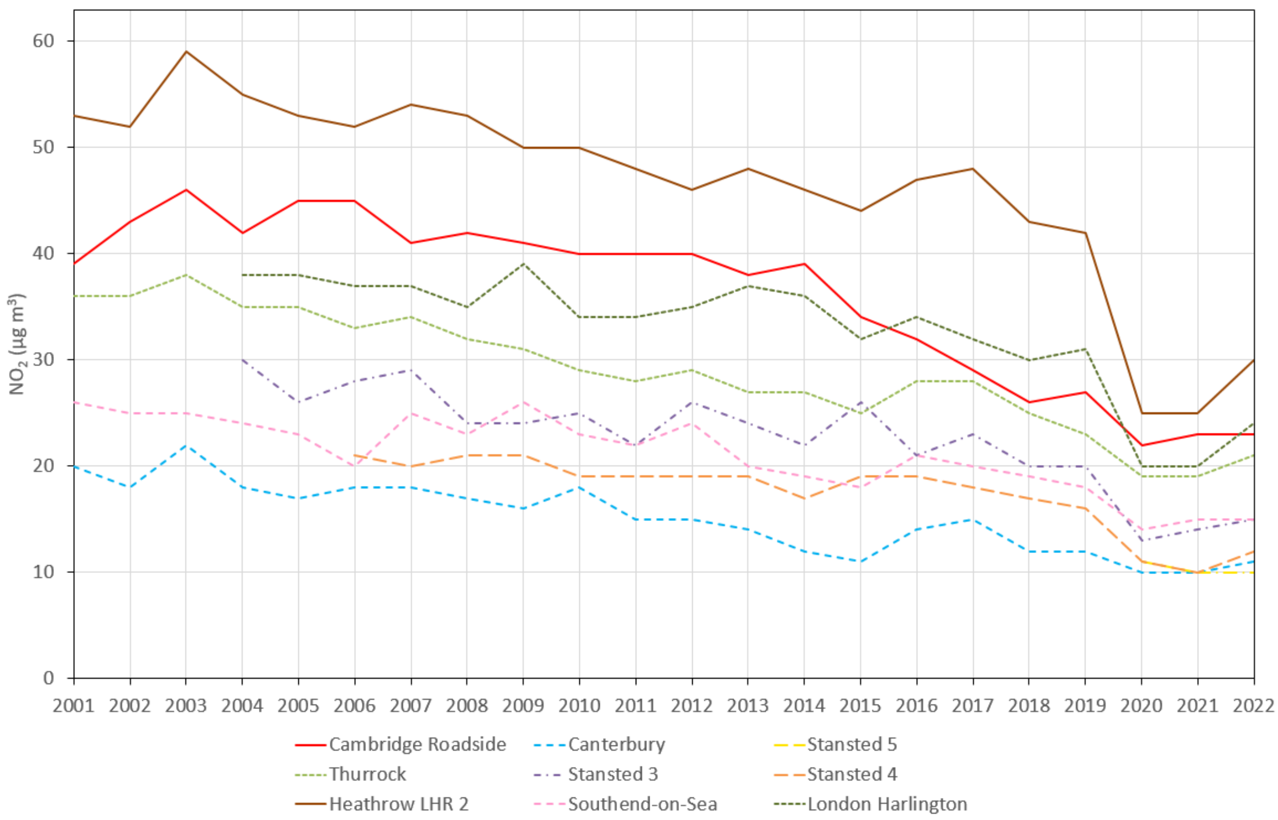


4.12 COMPARISON WITH OTHER UK SITES

Figure 43 compares annual mean NO_2 concentrations at the three Stansted sites and measurements recorded at six other monitoring sites. Five of these are other AURN monitoring sites in the south and east of England and the sixth is in the vicinity of a major airport. These sites are listed below:

- Canterbury - an urban background site approximately 1.5 kilometres from the centre of Canterbury.
- Thurrock - an urban background site in the town of Thurrock, Essex, approximately 35 metres from the kerb of a busy road.
- Cambridge Roadside - roadside site in the city of Cambridge, where vehicle emissions are the major pollution source.
- Southend-on-Sea - an urban background site situated in an urban public park in a residential area.
- London Harlington - a background monitoring station approximately 1 km northeast of the perimeter of Heathrow airport.
- LHR2 - a long-term airside monitoring station at Heathrow, 180 metres north of runway 27R and northeast of the central terminal area. This site is not part of the AURN, but data are made available to the public through the Heathrow Airwatch website.

Figure 43: Time series of annual mean NO_2 concentrations at nearby sites, 2001 onwards

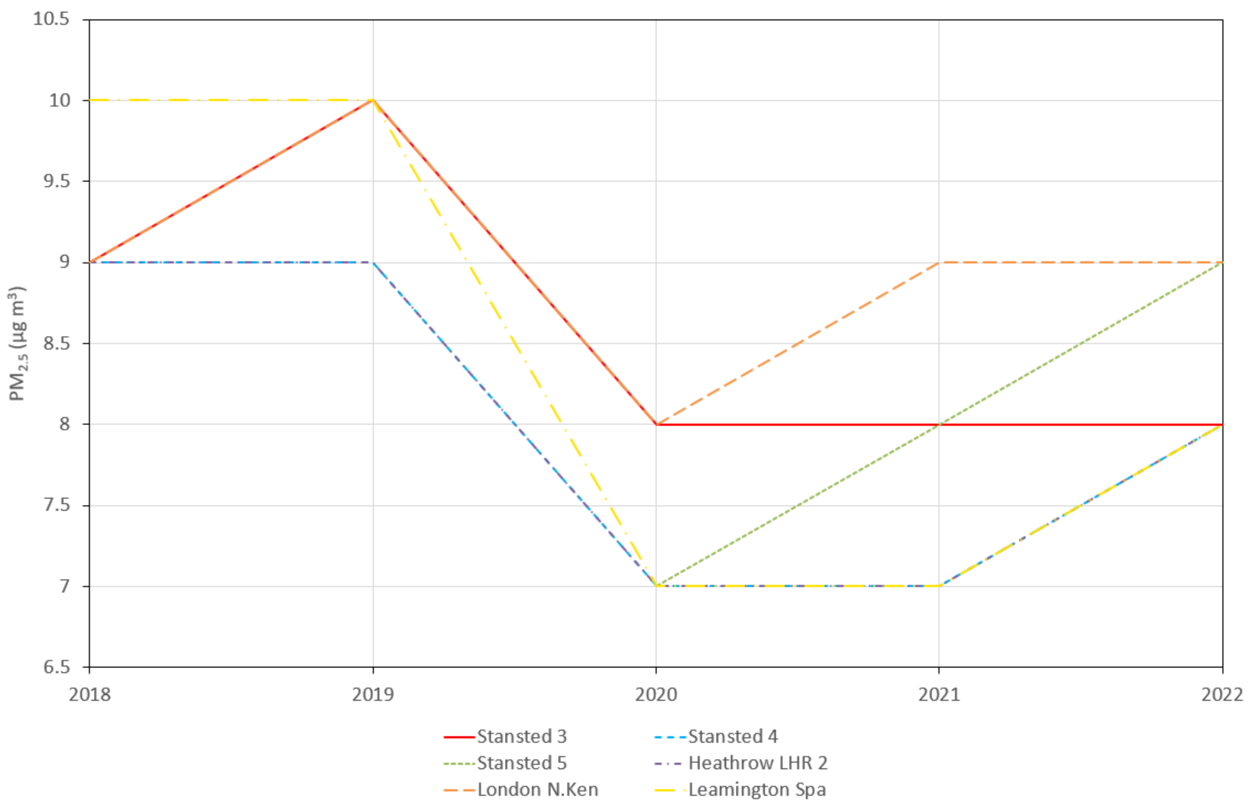


Annual mean concentrations at Stansted 3, Stansted 4 and Stansted 5 have resembled urban background concentrations to similar sites in recent years. For example, concentrations measured at Stansted 3 and Southend-on-Sea are comparable. Furthermore, Stansted 4, Stansted 5 and Canterbury are similar in the concentrations reported, especially in the last two years.

When compared to concentrations recorded at London Harlington, Heathrow LHR2, and Cambridge Roadside, Stansted 3 and Stansted 4 have consistently recorded lower concentrations. Similarly, Stansted 5 has also reported lower concentrations than these sites since its operation began in 2020. Overall Stansted 3, Stansted 4 and Stansted 5 show a general decreasing trend of 50%, 42% and 9% respectively, since first year of operation. Stansted 3 and Stansted 4 show a noticeable decrease between 2019 and 2020, which is most likely due to the reduction in motor vehicle use as a result of the Coronavirus pandemic.

Cambridge Roadside is an example of a site showing constant high annual mean NO_2 concentrations due to the proximity of the site to a busy road in Cambridge. The site (like many other urban roadside sites in the UK) has consistently recorded annual mean NO_2 concentrations in excess of 26 µg m^{-3} (except for 2020 and 2021), substantially higher than those observed at either of the Stansted sites.

Figure 44: Time series of annual mean $PM_{2.5}$ concentrations at nearby sites, 2001 onwards



Figures 44 and 45 compare annual mean $PM_{2.5}$ and PM_{10} concentrations recorded at each Stansted site and three other monitoring stations. The additional two monitoring sites used to supplement this are listed below:

- Leamington Spa – an urban background site located approximately 50 meters from a busy road
- London North Kensington – an urban background site, located in the grounds of a school, situated in a mostly residential area

Figure 44 shows a comparison of annual mean $PM_{2.5}$ concentrations at the three Stansted sites and concentrations recorded at three other monitoring stations. Between 2018 and 2022, Stansted 4 and Heathrow LHR2 have very similar recorded annual mean concentrations. All sites showed a noticeable decrease in $PM_{2.5}$ concentrations between 2019 and 2020, which is likely a result of reduced activity due to the Coronavirus pandemic. $PM_{2.5}$ concentration decreased by 11% at Stansted 3 and Stansted 4 between 2018 and 2022. Stansted 5 showed an increase of 26% between 2020 and 2022 that is likely caused by the reuptake in activity since the pandemic. $PM_{2.5}$ is a widely dispersed pollutant; this can therefore offer a possible explanation to the similarities in averages seen between all sites.

Figure 45: Time series of annual mean PM_{10} concentrations at nearby sites, 2018 onwards.

Figure 45 shows annual mean PM_{10} concentrations at Stansted 3, Stansted 4, Stansted 5 and other local sites. Stansted 3 data is “as measured” without VCM correction for data until the end of 2016. Since 2004, Stansted 3 and Heathrow (LHR2) have displayed a consistent pattern from year to year until 2013. Following this LHR2 experienced a reduction in concentrations whereas Stansted 3 shows a steady increase until 2016. Stansted 3 and 4 exhibit a similar pattern to LHR2 between 2019 and 2022. There is shown to be decrease in PM_{10} concentrations at these sites between 2019 and 2020 followed by a plateau in concentrations through 2020-2021. Given that Stansted 4 may not be influenced by as many local factors as Stansted 3 and it is situated closer to the runway (like LHR2), a comparison between Stansted 4 and LHR2 may be more suitable. Annual mean PM_{10} concentrations are shown to increase by 1 µg m^{-3} at all three Stansted sites between 2021 and 2022 whereas LHR2 experienced an increase of 2 µg m^{-3}. This is likely due to an increase in activity since the lifting of restrictions during the pandemic.

5. CONCLUSIONS

The following conclusions have been drawn from the results of air quality monitoring at Stansted Airport during 2022.

1. The data capture target of least 85 % was achieved for all the measured pollutants at Stansted 3 and Stansted 5. However, at Stansted 4 data capture for NO_2 was 57.3%, and data capture for both PM_{10} and $PM_{2.5}$ was 72.3%.

2. Stansted 3 and Stansted 5 met the AQS objectives for 1 hour mean NO_2 concentrations. As Stansted 4 only had a data capture rate of 57.3%, it was not possible to sufficiently assess the AQS objective for 1 hour mean NO_2 concentrations at this site.

3. All fourteen NO_2 diffusion tube sites met the AQS annual mean objective for this pollutant.

4. Stansted 3 and Stansted 5 met the AQS objectives for daily mean and annual mean PM_{10} concentration. Stansted 4 met the AQS objective for annual mean PM_{10} concentration based on the calculated annualised mean, however it was not possible to sufficiently assess the AQS objective for daily mean PM_{10} concentrations at this site.

5. Stansted 3 and Stansted 5 met the AQS objectives for annual mean $PM_{2.5}$ concentrations. Stansted 4 met the AQS objectives for annual mean $PM_{2.5}$ concentrations based on the calculated annualised mean.

6. NO_2 concentrations were higher during the winter months at Stansted 3, Stansted 4 and Stansted 5, an annual profile that is in contrast to that of the annual air traffic movement profile. This is a typical pattern for urban sites. PM_{10} and $PM_{2.5}$ levels showed peaks in, March 2022.

7. Concentrations of NO_2 followed a characteristic diurnal pattern, with peaks coinciding with the morning and evening rush hour periods. PM_{10} and $PM_{2.5}$ concentrations showed less pronounced morning and evening peaks.

8. Bivariate plots of pollutant concentrations against meteorological data indicated that sources of NO_2 were located close to the monitoring sites and were probably associated with the airport.

9. $PM_{2.5}$ analysis shows that in general higher concentrations are associated with calmer conditions that are possibly associated with local vehicle emissions, there are also some periods where elevated concentrations coincide with more unsettled conditions.

10. PM_{10} analysis seems to indicate the presence of several sources for this pollutant (both local and regional), with peaks occurring under both calm and unsettled conditions.

11. Annual mean concentrations of NO_2 at Stansted 3, Stansted 4 and Stansted 5 showed a small increase compared to 2021, and this was most likely due to a reuptake in activity following the Coronavirus pandemic.

12. Annual mean concentrations of $PM_{2.5}$ at Stansted 3 remained similar to 2021. Stansted 4 and Stansted 5 showed a small increase compared to 2021, which could be due to a reuptake in activity following the Coronavirus pandemic.

13. Annual mean concentrations of PM_{10} at Stansted 3, Stansted 4 and Stansted 5 showed a small increase compared to 2021, and this was likely due to an increase in activity since the lifting of restrictions during the pandemic.

6. REFERENCES

1 - EC (2015) **Commission Directive (EU) 2015/1480 of 28 August 2015 amending several annexes to Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council laying down the rules concerning reference methods, data validation and location of sampling points for the assessment of ambient air quality**. [online]. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015L1480 (Accessed 14 April 2023). And **Commission Directive (EU) 2015/1480 of 28 August 2015 amending several annexes to Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council laying down the rules concerning reference methods, data validation and location of sampling points for the assessment of ambient air quality (Text with EEA relevance)**. Available from http://data.europa.eu/eli/dir/2015/1480/oj (Accessed 14 April 2023).

2 - Department for Environment, Food and Rural Affairs (2007). **The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Volume 1)**. Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland. July 2007. https://www.gov.uk/government/publications/the-air-quality-strategy-for-england-scotland-wales-and-northern-ireland-volume-1 (Accessed 14 April 2023).

3 - Air Quality Expert Group (2004) **Nitrogen dioxide in the United Kingdom** [online]. London, UK: Department for Environment, Food and Rural Affairs. Available at: https://uk-air.defra.gov.uk/library/assets/documents/reports/aqeg/nd-chapter2.pdf [Accessed 14 April 2023]

4 - National Atmospheric Emissions Inventory (2023) (online). Available at (http://www.naei.org.uk) (Accessed 14 April 2023).

5 - Department for Environment, Food and Rural Affairs (2022). **Part IV of the Environment Act 1995. Local air quality management - Technical Guidance LAQM.TG (22)** [online]. London, UK: Department for Environment, Food and Rural Affairs in partnership with the Scottish Executive, Welsh Assembly Government and Department of the Environment Northern Ireland. Available from: https://laqm.defra.gov.uk/wp-content/uploads/2022/08/LAQM-TG22-August-22-v1.0.pdf [Accessed 14 April 2023].

6 - Department for Environment, Food and Rural Affairs (2009). **QA/QC procedures for the UK Automatic and Urban Rural Air Quality Monitoring Network (AURN)** [online]. London, UK: Department for Environment, Food and Rural Affairs and the Devolved Administrations. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat13/0910081142_AURN_QA_QC_Manual_Sep_09_FINAL.pdf (Accessed 14 April 2023).

7 – Department for Transport (2021) **Transport use during the coronavirus (COVID-19) pandemic** [online]. Available at: https://www.gov.uk/government/statistics/transport-use-during-the-coronavirus-covid-19-pandemic (Accessed 14 April 2023).

8 - Department for Environment, Food and Rural Affairs (2023) (online). Available at https://uk-air.defra.gov.uk/ (Accessed 14 April 2023)

7. ACKNOWLEDGEMENTS

Ricardo Energy & Environment would like to thank Stansted Airport for their assistance with this work and for providing air traffic movement and passenger number data for this report.

8. APPENDICES

Appendix 1: Air Quality objectives and index bands

Table A1: UK air quality objectives for protection of human health, July 2007

Pollutant	Air Quality objective	Date do be achieved by	Pollutant
	Concentration	Measured as	
Benzene All authorities	16.25 µg m^{-3}	Running annual mean	**Benzene** All authorities
England and Wales only	5.00 µg m^{-3}	Annual mean	England and Wales only
Scotland and Northern Ireland	3.25 µg m^{-3}	Running annual mean	Scotland and Northern Ireland
1,3-Butadiene	2.25 µg m^{-3}	Running annual mean	**1,3-Butadiene**
Carbon monoxide England, Wales and Northern Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	**Carbon monoxide** England, Wales and Northern Ireland
Scotland	10.0 mg m^{-3}	Running 8-hour mean	Scotland
Lead	0.5 µg m^{-3}	Annual mean	**Lead**
	0.25 µg m^{-3}	Annual mean	
Nitrogen dioxide	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	**Nitrogen dioxide**
	40 µg m^{-3}	Annual mean	
Particles (PM_{10}) (gravimetric) All authorities	50 µg m^{-3}, not to be exceeded more than 35 times a year	24-hour mean	**Particles (PM_{10}) (gravimetric)** All authorities
	40 µg m^{-3}	Annual mean	
Scotland	50 µg m^{-3}, not to be exceeded more than 7 times a year	24-hour mean	Scotland
	18 µg m^{-3}	Annual mean	
Particles ($PM_{2.5}$) (gravimetric)* All authorities	25 µg m^{-3} (target)	Annual mean	**Particles ($PM_{2.5}$) (gravimetric)*** All authorities
	15% cut in urban background exposure	Annual mean	
Scotland only	12 µg m^{-3} (limit)	Annual mean	Scotland only
Sulphur dioxide	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	**Sulphur dioxide**
	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	

Pollutant	Air Quality objective	Date do be achieved by	Pollutant
	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	
PAH*	0.25 ng m^{-3}	Annual mean	**PAH***
Ozone*	100 µg m^{-3} not to be exceeded more than 10 times a year	8-hour mean	**Ozone***

** Not included in regulations.*

Table A2: UK air quality objective for protection of vegetation and ecosystems, July 2007

Pollutant	Air Quality objective		Date do be achieved by
	Concentration	Measured as	
Nitrogen oxides measured as NO_2	30 µg m^{-3}	Annual mean	31st December 2000
Sulphur dioxide	20 µg m^{-3}	Annual mean	31st December 2000
	20 µg m^{-3}	Winter average (October to March)	31st December 2000
Ozone	18 µg m^{-3}	AOT40^{+}, calculated from 1-hour values May to July. Mean of 5 years, starting 2010	1st January 2010

+ AOT40 is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (= 40 ppb) and 80 µg m^{-3} over a given period using only 1-hour averages measured between 08:00 and 20:00.

Table A3: Air pollution bandings and descriptions

Band	Index	Health descriptor
Low	1 to 3	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants.
Moderate	4 to 6	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
High	7 to 9	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
Very High	10	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

Table A4: Air pollution bandings and descriptions

Band	Index	O_3	NO_2	SO_2	$PM_{2.5}$	PM_{10}
		Daily max 8-hour mean (µg m-3)*	Hourly mean (µg m 3)	15 minute mean (µg m 3)	24 hour mean (µg m-3)	24 hour mean (µg m 3)
Low	1	0-33	0-67	0-88	0-11	0-16

Band	Index	O_3	NO_2	SO_2	$PM_{2.5}$	PM_{10}
	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

Appendix 2 Monitoring apparatus and techniques

The following continuous monitoring methods were used at the Stansted air quality monitoring stations:

- NO, NO_2: chemiluminescence with ozone.
- PM_{10} and $PM_{2.5}$: Fine Dust Analysis Systems (FIDAS).

These methods were selected in order to provide real-time data. The chemiluminescence analyser is the European reference method for ambient NO_2 monitoring.

Each analyser provides a continuous output, proportional to the pollutant concentration. This output is recorded and stored every 10 seconds, and averaged to 15 minute averages by the instrument onboard loggers. The on-site web logger sends the data to a web server every hour, Ricardo Energy & Environment contact the server and download data hourly. The data are then converted to concentration units and averaged to hourly mean concentrations.

The chemiluminescence analysers for NO_x are equipped with an automatic calibration system, which is triggered daily under the control of the data logger. Fully certificated calibration gas cylinders are also used at each site for manual calibration.

The FIDAS unit employs a white light LED light scatter method that offers additional information on both particle size distribution from 0.18 to 30 microns (PM_1, $PM_{2.5}$, PM_4, PM_{10} and Total Suspended Particles (TSP).

All of the air quality monitoring equipment at both sites are housed in purpose-built enclosures. The native units of the analysers are volumetric (e.g. ppb). Conversion factors from volumetric to mass concentration measurement for gaseous pollutants are provided below:

- NO 1 ppb = 1.25 $\mu g\ m^{-3}$
- NO_2 1 ppb = 1.91 $\mu g\ m^{-3}$

In this report, the mass concentration of NO_x has been calculated as follows:

NO_x $\mu g\ m^{-3}$ = (NO ppb + NO_2 ppb) x 1.91.

This complies with the requirements of the Air Quality Directive3 and is also the convention generally adopted in air quality modelling.

Appendix 3 Quality assurance and quality control

Ricardo Energy & Environment operates air quality monitoring stations within a tightly controlled and documented quality assurance and quality control (QA/QC) system. These procedures are documented in the AURN QA/QC manual[8].

Elements covered within this system include: definition of monitoring objectives, equipment selection, site selection, protocols for instrument operation calibration, service and maintenance, integrity of calibration gas standards, data review, scrutiny and validation.

All gas calibration standards used for routine analyser calibration are certified against traceable primary gas calibration standards at the Gas Standards Calibration Laboratory at Ricardo Energy & Environment. The calibration laboratory operates within a specific and documented quality system and has UKAS accreditation for calibration of the gas standards used in this survey.

An important aspect of QA/QC procedures is the regular six-monthly intercalibration and audit check undertaken at every monitoring site. This audit has two principal functions: firstly to check the instruments and the site infrastructure, and secondly to recalibrate the transfer gas standards routinely used on-site, using standards recently checked in the calibration laboratory. Ricardo Energy & Environment's audit calibration procedures are UKAS accredited to ISO 17025.

In line with current operational procedures within the Defra AURN, full intercalibration audits take place at the end of winter and summer. At these visits, the essential functional parameters of the monitors such as noise, linearity and, for the NO_x monitor, the efficiency of the NO_2 to NO converter are fully tested. In addition, the on-site transfer calibration standards are checked and re-calibrated if necessary, the air intake sampling system is cleaned and checked and all other aspects of site infrastructure are checked.

All air pollution measurements are reviewed daily by experienced staff at Ricardo Energy & Environment. Data are compared with corresponding results from AURN monitoring stations and with expected air pollutant concentrations under the prevailing meteorological conditions. This review process rapidly highlights any unusual or unexpected measurements, which may require further investigation. When such data are identified, attempts are made to reconcile the data against known or possible local air pollution sources or local meteorology, and to confirm the correct operation of all monitors. In addition, the results of the daily automatic instrument calibrations (see Appendix 2) are examined to identify any possible instrument faults. Should any faults be identified or suspected, arrangements are made for Ricardo Energy & Environment personnel or equipment service contractors to visit the site as soon as possible.

At the end of every quarter, the data for that period are reviewed to check for any spurious values and to apply the best daily zero and sensitivity factors, and to account for information which only became available after the initial daily processing. At this time, any data gaps are filled with data from the data logger back-up memory to produce as complete a data record as possible.

Finally, the data are re-examined on an annual basis, when information from the six-monthly intercalibration audits can be incorporated. After completion of this process, the data are fully validated and finalised, for compilation in the annual report. Following these three-stage data checking and review procedures allows the overall accuracy and precision of the data to be calculated. The accuracy and precision figures for the pollutants monitored at Stansted are summarised in Table A5.

Table A4: Estimated accuracy and precision of the data presented

Pollutant	Precision	Accuracy
NO	± 2.5	± 15 %
NO_2	± 6.9	± 15 %
PM_{10}	± 4	Estimated* accuracy of a TEOM □ 30% or better. With VCM correction, estimated as □ 25 %.

T: +44 (0) 1235 75 3000
E: enquiry@ricardo.com
W: ee.ricardo.com