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Lower Hunter Particle Characterisation Study

4th Progress Report (Summer)

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April 2015

Prepared for
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Citation

Hibberd MF, Keywood MD, Cohen DD, Stelcer E, Scorgie Y and Thompson S (2015). Lower Hunter Particle Characterisation Study, 4th Progress Report (Summer). CSIRO, Australia.

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Acknowledgments

This project is funded by

- NSW Environment Protection Authority (EPA)
- NSW Office of Environment & Heritage
- NSW Department of Health
- CSIRO Climate & Atmosphere Theme
- ANSTO

The project is supported by the Project Management Team of Matt Riley, Yvonne Scorgie, Judy Greenwood, Ann Louise Crotty, Leanne Graham, Wayne Smith, John Kirkwood, Keith Craig, Mark Hibberd, Melita Keywood, David Cohen, and Ed Stelcer.

We acknowledge the contributions of the CSIRO project support team of Kate Boast and Paul Selleck, the ANSTO project support team of David Garton and Armand Atanacio, and OEH project support and field staff Peter Crabbe, Scott Thompson, Gareth James, Stuart Masson and Upma Dutt.

Support provided by Orica Limited for the study by facilitating sampling at Stockton Air Quality Monitoring Site and making available monitoring records from this site is gratefully acknowledged.

Support extended by CSIRO Energy Centre for the establishment of study samplers on the grounds of the centre in Mayfield is acknowledged.

1 Introduction

The Lower Hunter Particle Characterisation Study (LHPCS) was initiated in 2013 and is being undertaken to provide the EPA and communities in the Lower Hunter with scientific information about the composition and likely sources of fine airborne particles in their local environment. The study represents a collaboration between the NSW Environment Protection Authority (EPA), the NSW Office of Environment and Heritage (OEH), NSW Health, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Nuclear Science and Technology Organisation (ANSTO). Following the establishment of governance arrangements and an independently peer reviewed study design, the one year airborne particle study program commenced on 1 March 2014 with the first samples collected on 2 March.

This 4th Progress Report documents the samples collected during the final quarter from December 2014 to February 2015 (Summer period) of the one year sampling program. It also includes presentation of wind and pollution roses for the sampling period.

1.1 Study Objectives

The Lower Hunter Particle Characterisation Study aims to determine the composition of $PM_{2.5}$ and PM_{10} air particles, and to identify major sources contributing to $PM_{2.5}$ and PM_{10} concentrations in the region to inform EPA's control programs[1].

Specific sub-objectives are as follows:

- Determine the composition and major sources contributing to $PM_{2.5}$ concentrations at sites representative of regional population exposures.
- Establish airborne particle composition and major sources contributing to $PM_{2.5}$ and PM_{10} concentrations at sites indicative of population exposures in areas near to the Newcastle Port.

1.2 Study Scope and Overview

The study comprises $PM_{2.5}$ sampling at four sites in the Lower Hunter region over a one year period, including two sites representative of wider community exposures in the region (Newcastle and Beresfield) and two sites indicative of public exposures in areas neighbouring the Newcastle Port (Stockton and Mayfield). PM_{10} sampling and analysis is also being undertaken for the Stockton and Mayfield sites in response to community requests that PM_{10} be addressed. The sampling site locations are shown in Figure 1.

Existing or planned ambient air quality monitoring sites were preferred locations since they allow timely establishment of study sampling sites. These sites also have continuous particulate matter and gaseous monitoring records and meteorological data that can be used during the source apportionment analysis. Selected study sites coincided with the existing OEH Beresfield Air Quality Monitoring (AQM) Station, the OEH Newcastle AQM Station, the Orica Fullerton Street Stockton AQM Station, and CSIRO Energy Centre in Mayfield West. Sampling is being conducted over the period 1 March 2014 to 28 February 2015. Since sampling commenced, OEH-operated AQM Stations have been commissioned at CSIRO Energy Centre in July 2014 (OEH Mayfield AQM Station) and at the Orica Fullerton Street Stockton site in October 2014 (OEH Stockton AQM Station), as part of the Newcastle Local Air Quality Monitoring Network.

[1] $PM_{2.5}$ and PM_{10} refer to airborne particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres and 10 micrometres respectively.

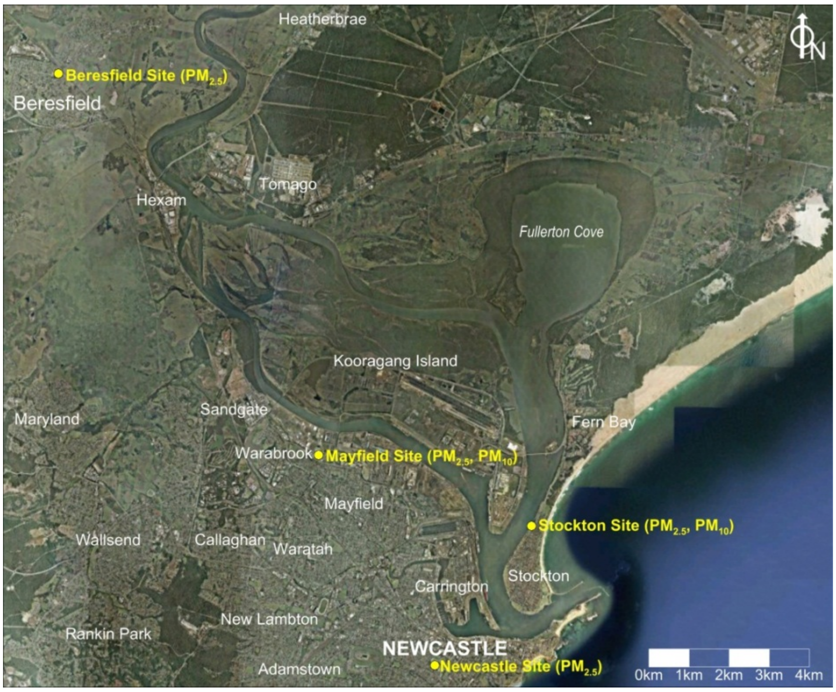

Figure 1 Overview of locations of sampling sites for Lower Hunter Particle Characterisation Study

A summary of the monitoring sites, equipment and filter types and sampling schedules for the study is given in Table 1.

Sample analysis for the $PM_{2.5}$ component will include Ion Beam Analysis (IBA) techniques and Ion Chromatography (IC) on the Teflon filters and organic and elemental carbon (OC/EC) analysis using a DRI Model 2001A Thermal-Optical Carbon Analyzer for the quartz filters.

The use of ANSTO ASP $PM_{2.5}$ cyclone samplers at each of the four sites provides the basis for gravimetric analysis to determine $PM_{2.5}$ concentrations. Combining results from the gravimetric analysis of the coarse ($PM_{2.5\text{-}10}$) and fine ($PM_{2.5}$) fractions from the GENT SFU sampling will allow PM_{10} concentrations to be determined.

Table 1 LHPCS monitoring sites, equipment, filter types and sampling schedule

MONITORING SITE:	EQUIPMENT, SIZE FRACTION AND FILTER TYPE	SAMPLING SCHEDULE
OEH Newcastle AQM Station	Two ANSTO Aerosol Sampling Program (ASP) $PM_{2.5}$ cyclone samplers – one collecting on Teflon filter and one on a quartz filter.	1-in-3 days
OEH Beresfield AQM Station	Two ANSTO ASP $PM_{2.5}$ samplers – one collecting on Teflon filter and one on a quartz filter.	1-in-3 days
OEH Mayfield AQM Station (at CSIRO Energy Centre)	One GENT Stacked Filter Unit (SFU) sampling 'coarse' ($PM_{2.5\text{-}10}$) particles on a Nuclepore filter and 'fine' ($PM_{2.5}$) particles on a quartz filter. One ANSTO ASP $PM_{2.5}$ sampler collecting fine particles on a Teflon filter has been relocated to this site from the nearby former Steel River AQM station. (Separately funded program, with sampling done by OEH, analysis by ANSTO, and funded by the EPA.)	1-in-3 days
OEH Stockton AQM Station (formerly Orica Fullerton Street Stockton AQM Station)	One GENT SFU sampling 'coarse' ($PM_{2.5\text{-}10}$) particles on a Nuclepore filter and 'fine' ($PM_{2.5}$) particles on a quartz filter. One ANSTO ASP $PM_{2.5}$ cyclone sampler collecting fine particles on a Teflon filter already in operation at this site. (Separately funded program with sampling and analysis undertaken by ANSTO, funded by Orica).	1-in-3 days

Chemical analysis of the $PM_{2.5-10}$ component will include IBA and IC on the Nuclepore filters in addition to black carbon (BC) being determined through the use of the Laser Integrated Plate Method (LIPM), which is a light absorption technique. Given that organic carbon is primarily in the fine fraction, the use of quartz filters to support OC/EC analysis of the coarse fraction is not required.

The chemical composition of all the samples will subsequently be input into receptor modelling using a mathematical technique called Positive Matrix Factorisation (PMF) to identify factors and the contribution of each factor to the total $PM_{2.5}$ and PM_{10} concentration. The key source of emissions in each factor will be identified using a range of information including source characteristics, wind data and the pattern of seasonal variation in the factor.

A project website (http://www.environment.nsw.gov.au/aqms/lowhunterparticle.htm) includes further information about the project including copies of the progress reports. The First Progress Report (PDF, 1.4MB - July 2014) provides more information on the study method and the sampling program commissioning phase, as well as details about the samples collected during the first quarter (autumn) sampling period. The Second Progress Report (PDF, 1.3 MB – October 2014) summarises data collected during the second quarter (winter) sampling period and presents photographs of the sampling sites, and the Third Progress report (PDF 2.4MB - January 2015) summarises data collected during the third quarter (spring) sampling period.

2 Report on September-November 2014 Sampling

2.1 Long-term Regional Air Quality Monitoring

The OEH-operated air quality monitoring stations at Beresfield, Newcastle and Wallsend characterise regional air quality and provide a framework for the detailed particle characterisation study. PM_{10}, $PM_{2.5}$, ozone (O_3), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO) and meteorology (wind speed, wind direction, air temperature and relative humidity) are continuously measured at these stations.

Long-term time series of PM_{10} and $PM_{2.5}$ for the period October 2012 – February 2015 are shown in Figure 2 and Figure 3. Data are included from the OEH monitoring stations; the Stockton station was run by Orica until 14 October 2014. Table 2 lists some key statistics of the 2013 and 2014 PM_{10} and $PM_{2.5}$ results – average, median, maximum, and number of days exceeding the criteria.

The figures show much stronger regional variations in PM_{10} than $PM_{2.5}$ concentrations. The PM_{10} levels recorded at Stockton are almost always significantly higher than at the other sites and include many peaks above 50 µg m^{-3} during October – February of the study. This pattern is similar to that seen in 2012/13 and 2013/14, and as shown later (Figure 9) is mainly associated with winds in the easterly sector. $PM_{2.5}$ levels measured at the Stockton monitoring station are comparable to levels measured at the OEH Beresfield and Wallsend stations for much of the year, with average and median levels only marginally higher.

Figure 2 shows that the PM_{10} values are lowest during both March – August periods, whereas $PM_{2.5}$ are lowest in January – April (Figure 3). A clearer picture of the relative importance of the fine and coarse fractions of PM_{10} is provided by Figure 4, which shows the smoothed 31-day running average of the $PM_{2.5}/PM_{10}$ ratio at the four sites and since August 2014 for the new Mayfield Site. The almost two years of data shows an annual trend of the $PM_{2.5}/PM_{10}$ ratio being highest in winter and lowest in summer, indicating an influence from seasonal meteorological factors. Reasons for this will be more fully explored during the final stages of the study when source apportionment modelling is undertaken.

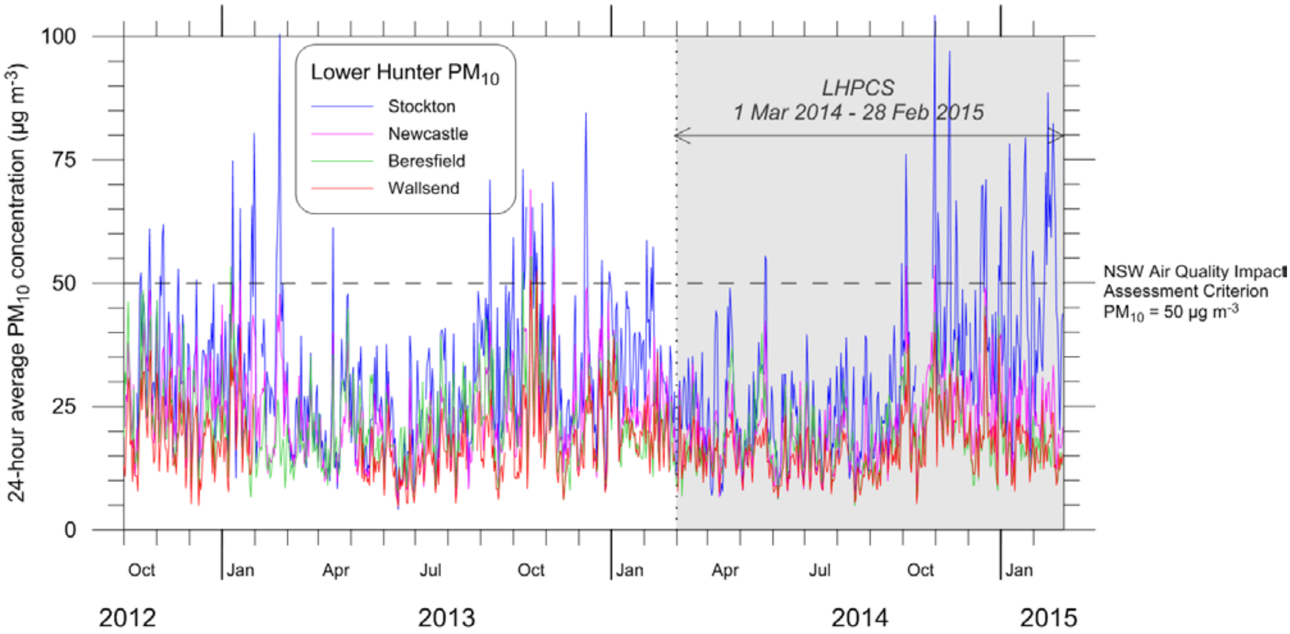

Figure 2 Long-term (Oct 2012 – Feb 2015) time series of 24-hour average PM_{10} concentrations recorded at the OEH Lower Hunter monitoring stations including the Stockton station (run by Orica until 14 October 2014)

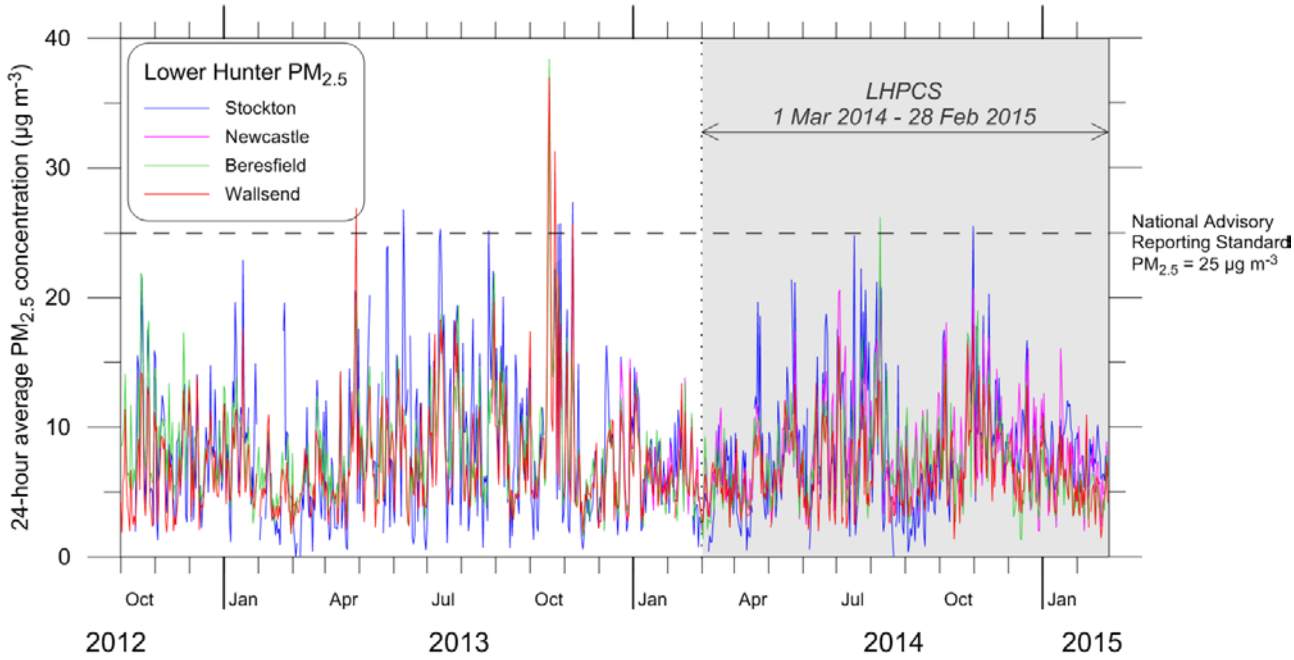

Figure 3 Long-term (Oct 2012 – Feb 2015) time series of 24-hour average $PM_{2.5}$ concentrations recorded at the OEH Lower Hunter monitoring stations including the Stockton station (run by Orica until 14 October 2014)

Table 2 Key statistics of the 2013 and 2014 24-hour averaged PM_{10} and $PM_{2.5}$ monitoring results

MONITORING SITE	BERESFIELD		NEWCASTLE		STOCKTON		WALLSEND	
	2013	2014	2013	2014	2013	2014	2013	2014
PM_{10} (µg m^{-3})								
Average	21.4	19.4	22.7	21.4	29.6	29.1	17.4	16.9
Median	19.1	18.3	20.5	20.5	26.6	27.0	15.5	16.1
Maximum	55.3	45.4	69.0	53.7	100.5	104.3	52.5	43.4
Days>50 µg m^{-3}	5	0	4	2	28	27	2	0
$PM_{2.5}$ (µg m^{-3})								
Average	8.2	7.5		8.1	8.6	8.0	7.7	6.7
Median	7.2	6.9		7.4	7.3	7.3	6.2	6.3
Maximum	40.8	26.2		21.2	32.6	25.5	37.0	18.0
Days>25 µg m^{-3}	2	1		0	7	1	6	0

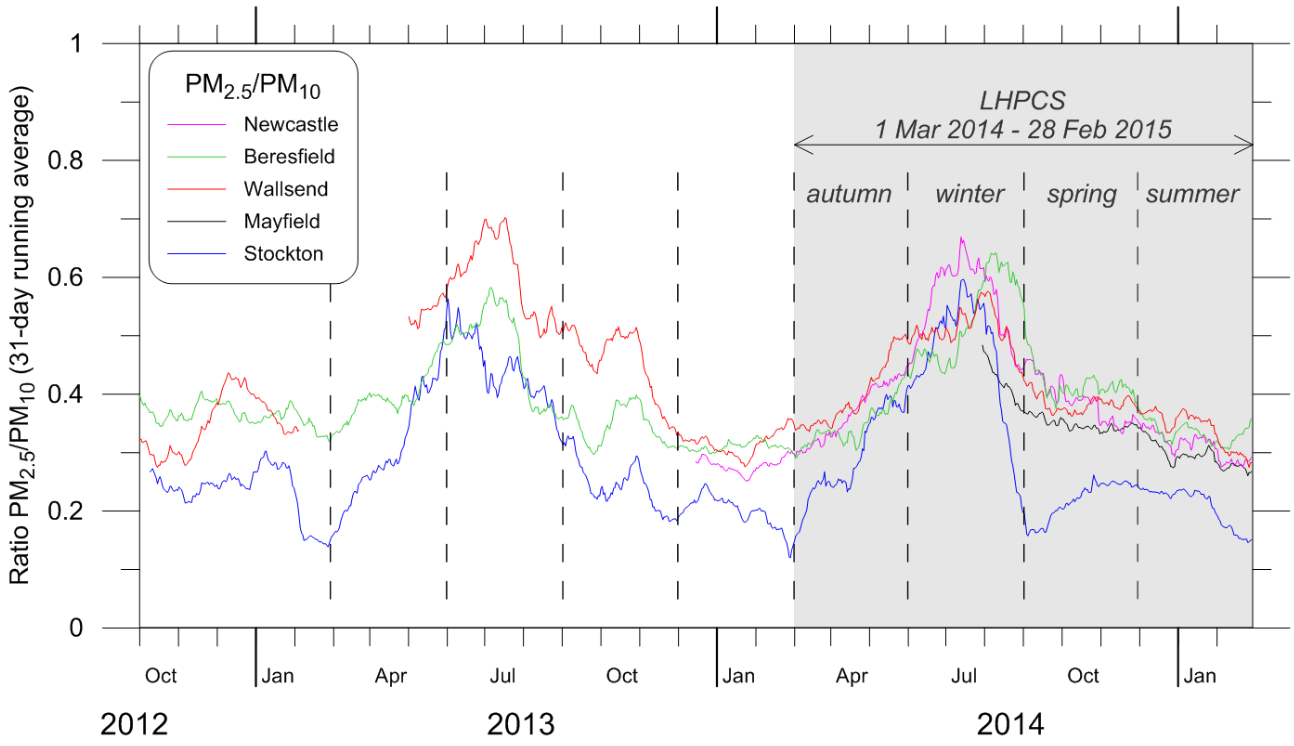

Figure 4 Long-term time series of $PM_{2.5}/PM_{10}$ ratio (31-day running average) recorded at OEH and Newcastle Local air quality monitoring stations (Oct 2012 – Feb 2015). The Stockton station was run by Orica until 14 October 2014.

2.2 Sampling Report

The overall collection rate for each sampler at each site for the whole study was excellent – the values are listed in Table 3. At Beresfield and Newcastle, where samplers were located at existing OEH AQM stations, no samples were missed so the collection the rate was 100%. During the first quarter of the sampling year, some issues were experienced at the Mayfield site resulting in a loss of samples during the first quarter. These issues were addressed resulting in the annual collection rate being higher than 97% at Mayfield. Similarly at Stockton, there was a problem with the ASP sampler in the first quarter giving a 94% return, but the annual collection rate was 98.5% for the ASP sampler and 100% for the GENT sampler.

Table 3 Overall sample collection rate for the 12 month study

SITE	BERESFIELD $PM_{2.5}$		NEWCASTLE $PM_{2.5}$		MAYFIELD PM_{COARSE} & $PM_{2.5}$			STOCKTON PM_{COARSE} & $PM_{2.5}$		
	ASP14 TEFLON	ASP15 QUARTZ	ASP12 TEFLON	ASP13 QUARTZ	ASP10 TEFLON $PM_{2.5}$	GAS44C NUCLEPORE PM_{COARSE}	GAS44Q QUARTZ $PM_{2.5}$	ASP89 TEFLON $PM_{2.5}$	GAS43C NUCLEPORE PM_{COARSE}	GAS43Q QUARTZ $PM_{2.5}$
Annual sample collection rate	100%	100%	100%	100%	97%	99%	99%	98.5%	100%	100%

Table 4 lists the status of the sample collection for the final 3 months of the study including the dates on which the control filters were deployed. Sample collection rates of 100% achieved for all samplers at all sites.

Table 4 Status of sample collection for the Summer sampling period (December 2014-February 2015)

SITE	BERESFIELD $PM_{2.5}$		NEWCASTLE $PM_{2.5}$		MAYFIELD PM_{COARSE} & $PM_{2.5}$			STOCKTON PM_{COARSE} & $PM_{2.5}$		
SAMPLE DATE	ASP14 TEFLON	ASP15 QUARTZ	ASP12 TEFLON	ASP13 QUARTZ	ASP10 TEFLON $PM_{2.5}$	GAS44C NUCLEPORE PM_{COARSE}	GAS44Q QUARTZ $PM_{2.5}$	ASP89 TEFLON $PM_{2.5}$	GAS43C NUCLEPORE PM_{COARSE}	GAS43Q QUARTZ $PM_{2.5}$
03/12/2014	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓ C
06/12/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
09/12/2014	✓	✓ C	✓	✓ C	✓ C	✓	✓ C	✓	✓	✓
12/12/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15/12/2014	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓	✓ C	✓ C	✓
18/12/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
21/12/2014	✓ C	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓ C
24/12/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
27/12/2014	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓
30/12/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
02/01/2015	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓
05/01/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
08/01/2015	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓ C	✓
11/01/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
14/01/2015	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓	✓ C	✓	✓ C
17/01/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
20/01/2015	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
23/01/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
26/01/2015	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓ C
29/01/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
01/02/2015	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓ C
04/02/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
07/02/2015	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓ C
10/02/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13/02/2015	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓	✓	✓ C	✓
16/02/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19/02/2015	✓ C	✓ C	✓	✓ C	✓ C	✓ C	✓	✓ C	✓ C	✓
22/02/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
25/02/2015	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
28/02/2015	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sample collection rate	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Notes:

✓ - Filter sample collected;

C – control (unexposed) filter included;

2.3 Daily PM Results from the Monitoring Sites

Figure 5 shows the time series of 24-hour average PM_{10} concentrations measured at the Newcastle, Beresfield, Stockton and Mayfield monitoring sites using the standard TEOM and BAM equipment for the Summer period (December 2014 – February 2015) of the study. The green bars highlight the days when 1-in-3-day sampling was carried out for the current study. It shows that these are representative of the full period, including days with both low and high concentrations. The most striking feature is the much higher concentrations at Stockton than at other sites, particularly in January and February. The 50 µg m^{-3} guideline is exceeded on one third of the days in the three month period.

The average PM_{10} concentrations for September–November were 24.4 µg m^{-3} at Newcastle, 17.3 µg m^{-3} at Beresfield, 24.4 µg m^{-3} at Mayfield, and 44.0 µg m^{-3} at Stockton. These Summer averages are similar to the Spring averages at Newcastle and Mayfield, but 20% lower at Beresfield and 20% higher at Stockton. The seasonal wind roses from Stockton in Figure 8 show that summer is also a period with the majority of the winds from the easterly sector (NE–SE). Thus the samples are likely to contain a significant proportion of sea salt. The chemical analysis of the samples collected during this study will identify the source of the particles and should provide a definitive explanation for the differences between sites.

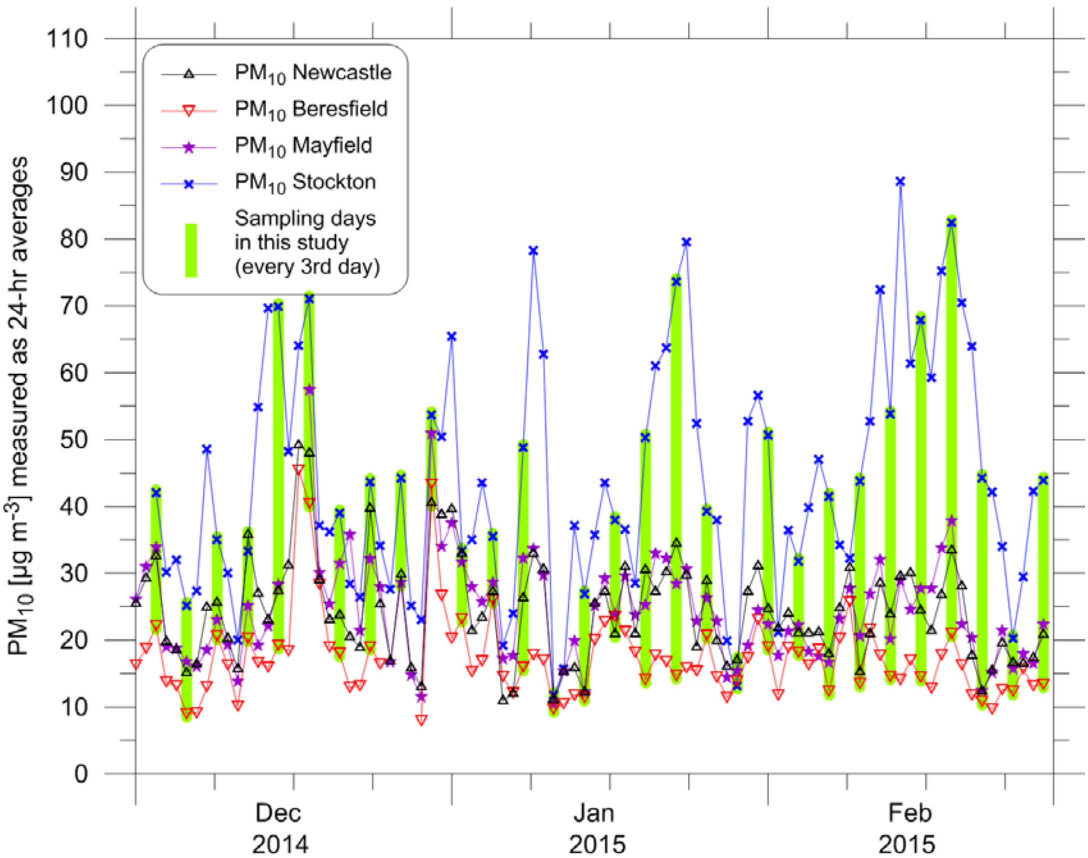

Figure 5 Summer time series of 24-hour average PM_{10} concentrations measured at the Newcastle, Beresfield, Mayfield, and Stockton sites using the standard TEOM (Tapered Element Oscillating Microbalance) equipment. The green bars show the days when sampling for the current study was carried out.

Figure 6 shows the equivalent results for $PM_{2.5}$ concentrations. As above, the green bars highlight the days when 1-in-3-day sampling was carried out for the current study, and show that these are generally representative of the full period, including days with both high and low concentrations, and including the days with the highest concentrations: 16 January at Newcastle and 18 December at the other three sites.

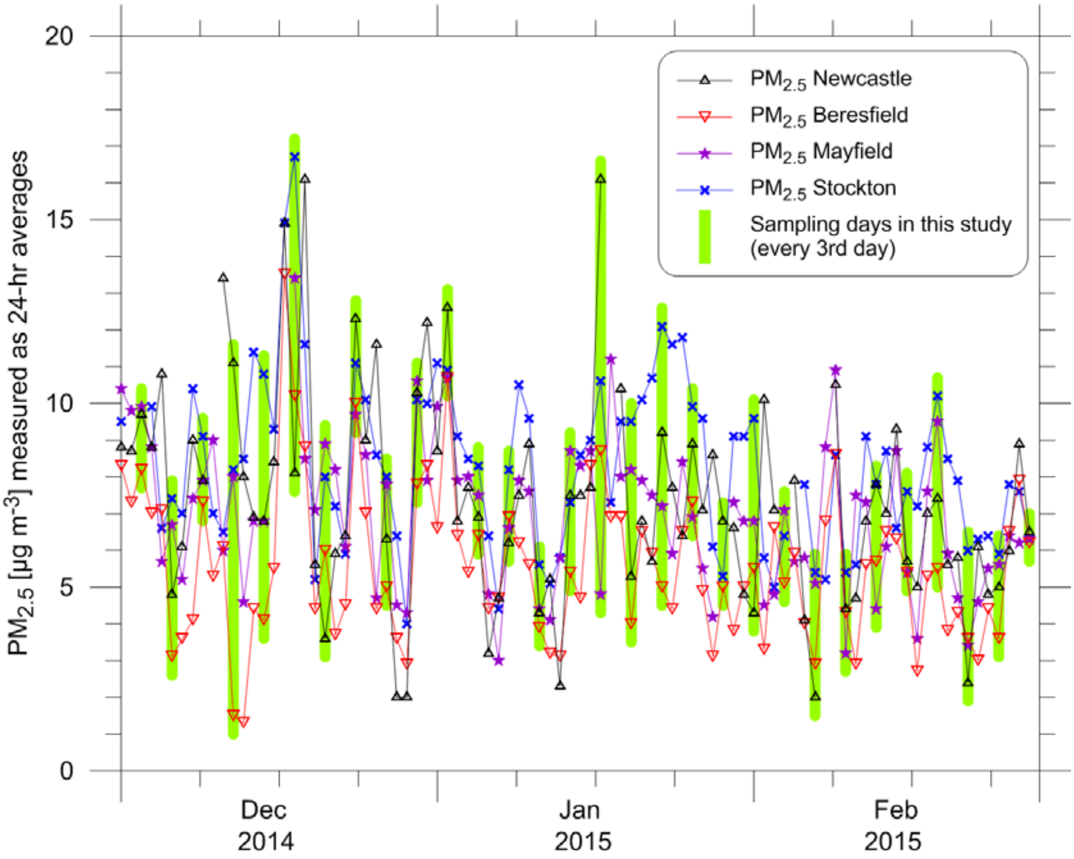

Figure 6 Summer time series of 24-hour average $PM_{2.5}$ concentrations measured at the Newcastle, Beresfield, Mayfield and Stockton sites using the standard BAM (Beta Attenuation Monitor) equipment. The green bars show the days when sampling for the current study was carried out.

The average $PM_{2.5}$ concentrations for the December – February period were 7.4 µg m^{-3} at Newcastle, 5.6 µg m^{-3} at Beresfield, 7.0 µg m^{-3} at Mayfield, and 8.3 µg m^{-3} at Stockton. These averages are about 30% lower than the Spring averages, except at Stockton where there is little difference.

2.4 Wind and pollution roses

Figure 7 presents the wind roses at the sampling sites for the Summer sampling period. Compared to the Spring period, there are far fewer few north-westerly winds at all sites. The wind roses at Stockton and Mayfield are fairly similar and dominated by easterlies whereas at Newcastle the winds are principally from the north-east and south. Beresfield has far fewer winds with a northerly component than the other three sites, as well as more frequent light wind conditions.

There are only small differences between the wind roses computed for the 1-day-in-3 sampling days (right-hand side of each pair) and those for the full 90 days of Summer (left-hand side), which confirms the representativeness of the sampling days.

Figure 8 compares the four seasonal wind roses for Stockton, showing the strong seasonal variation. North-westerlies are dominant during autumn and winter. During spring, the frequency of north-westerlies decreases with more easterlies from a wider range of wind directions. The summer pattern is similar but with almost no north-westerlies.

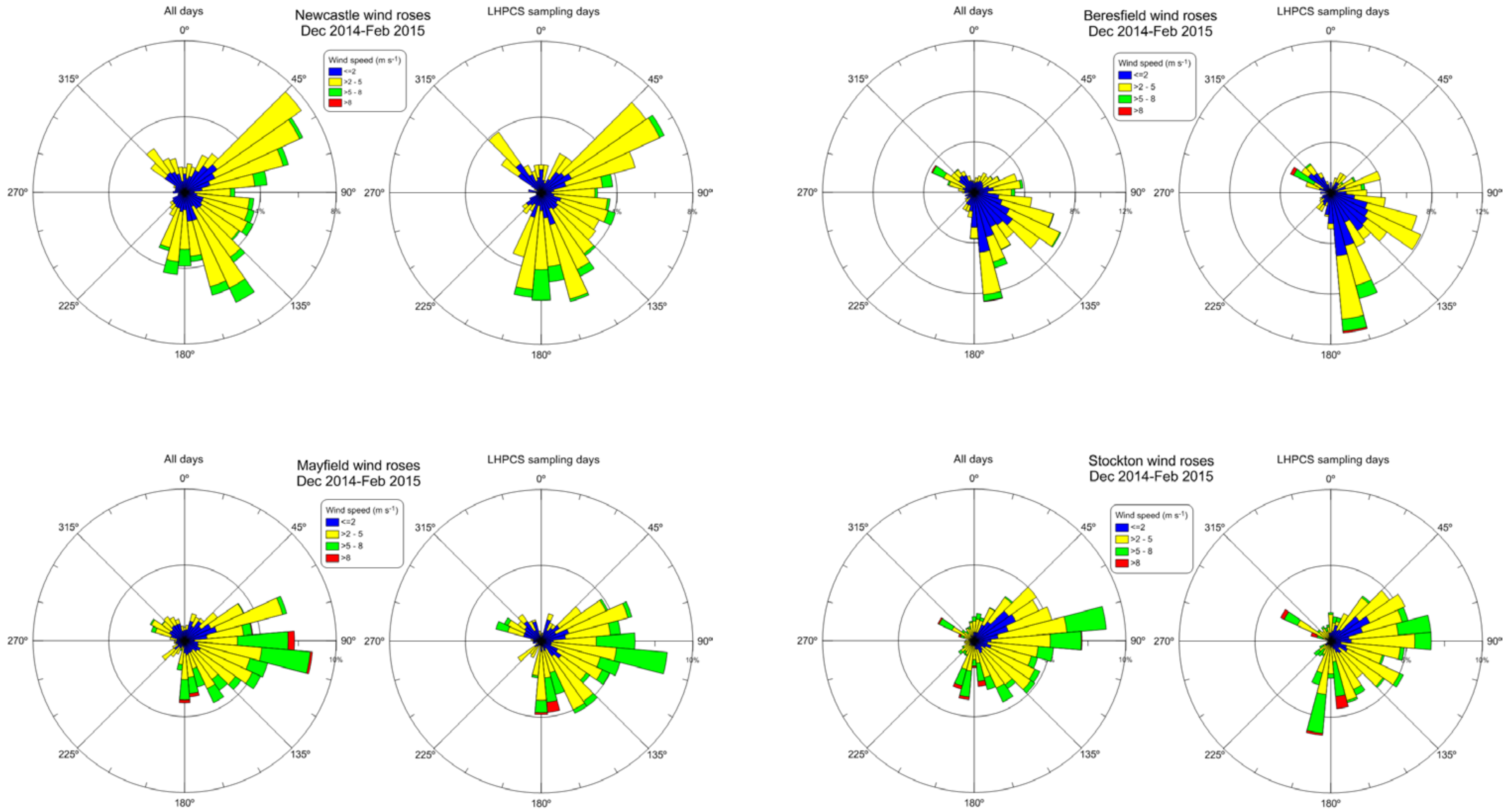

Figure 7 Wind roses for the Summer period at Newcastle, Beresfield, Mayfield, and Stockton showing close agreement between all days (left-hand side) and the 1-day-in-3 sampling days (right-hand side). [Note: a wind rose shows the frequency of winds plotted by wind direction, with colour bands showing wind ranges. The length of each band is proportional to the frequency of wind from that direction.]

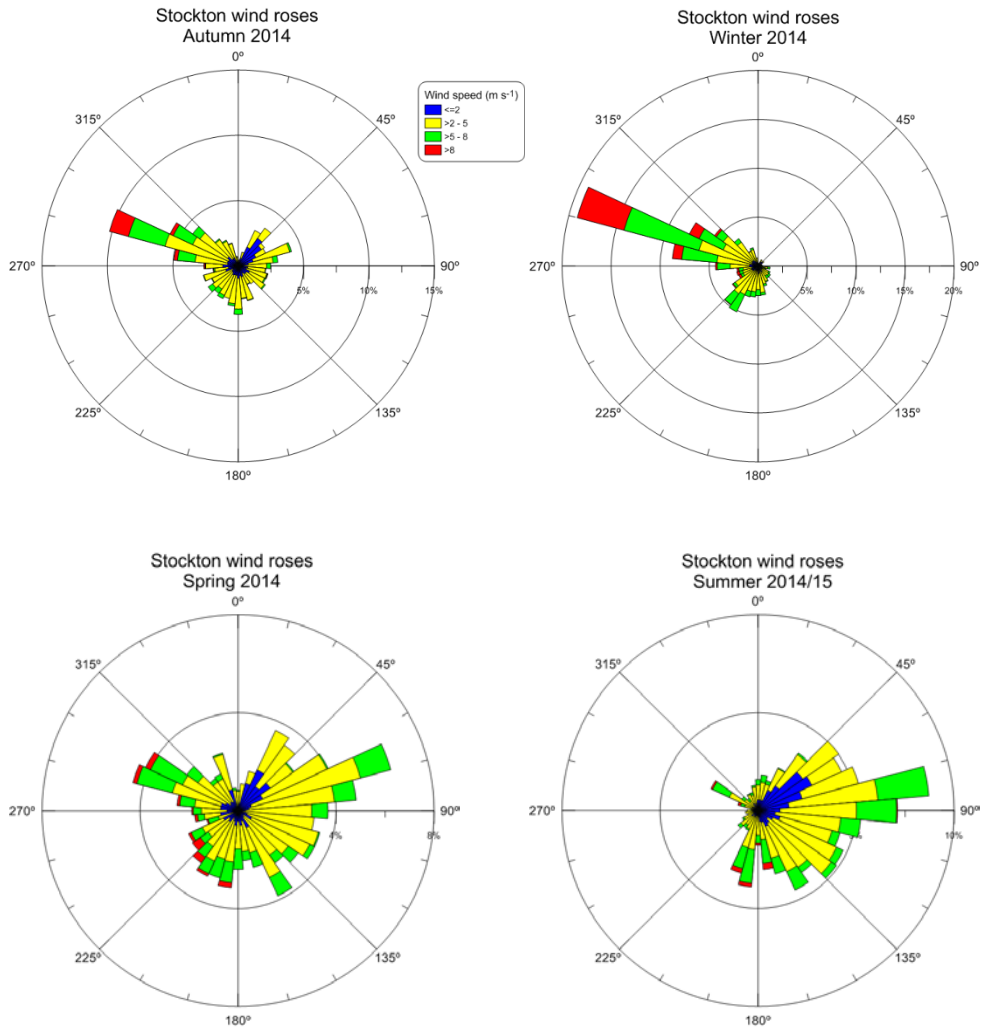

Figure 8 Seasonal wind roses at Stockton for the study period, showing the strong seasonal variation.

In the same way that a wind rose depicts the distribution of wind speeds at each wind direction, a pollution rose depicts the distribution of pollution concentrations at each wind direction. It is an easily understood means of showing which wind directions are associated with the various pollution concentrations.

Figure 9 and Figure 10 show the PM_{10} and $PM_{2.5}$ pollution roses computed using the hourly-averaged continuous monitoring data from the sampling sites but restricted to above average concentrations, namely $PM_{10} > 20$ µg m^{-3} and $PM_{2.5} > 10$ µg m^{-3}. This shows the high concentration results more clearly.

For PM_{10}, the Newcastle site shows some elevated levels for ENE and S winds, whereas at Mayfield and Stockton the elevated concentrations occur for winds from the easterly sector. As mentioned earlier the Stockton concentration above 50 µg m^{-3} almost all occur for on-shore NE–SE winds. At Beresfield there are very few days above 30 µg m^{-3} and these occur for NW and SE winds.

At most sites, the $PM_{2.5}$ pollution roses show similar patterns to those for PM_{10} but unlike PM_{10}, the $PM_{2.5}$ concentrations are much more similar across all four sites, as was seen in Figure 3. In all cases, there is suitably close agreement between the results for the 1-day-in-3 sampling days (right-hand side of each pair) and those for the full 90 days of summer (left-hand side), which confirms the representativeness of the sampling days.

2.5 Summary

The sampling conducted during the December 2014 to February 2015 period was undertaken successfully and will support chemical analysis and source apportionment for the Summer season. An excellent overall sample collection rate of 100% was achieved, and sampling days generally coinciding with low, high and average ambient particle concentration measurements across all sampling sites. There have been no significant issues with filter shipping and analysis of filter samples is ongoing. Study results will be presented in the Final Study Report due for publication early in 2016.

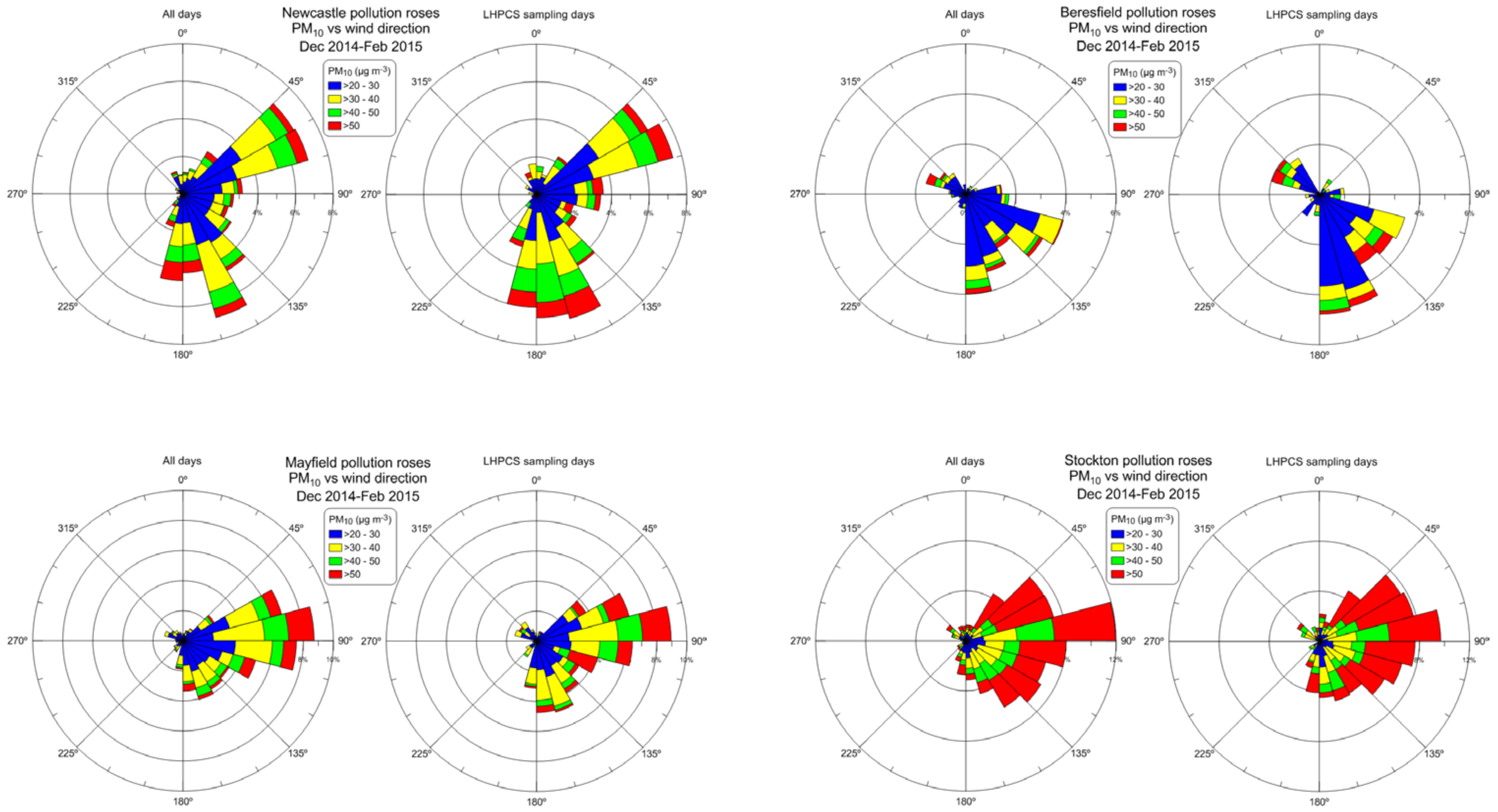

Figure 9 PM_{10} pollution roses for PM_{10} > 20 µg m^{-3} for the Summer period at Newcastle, Beresfield and Stockton showing close agreement between all days (left-hand side) and the 1-day-in-3 sampling days (right-hand side). [Note: these pollution roses depict the distribution of PM_{10} concentrations at each wind direction.]

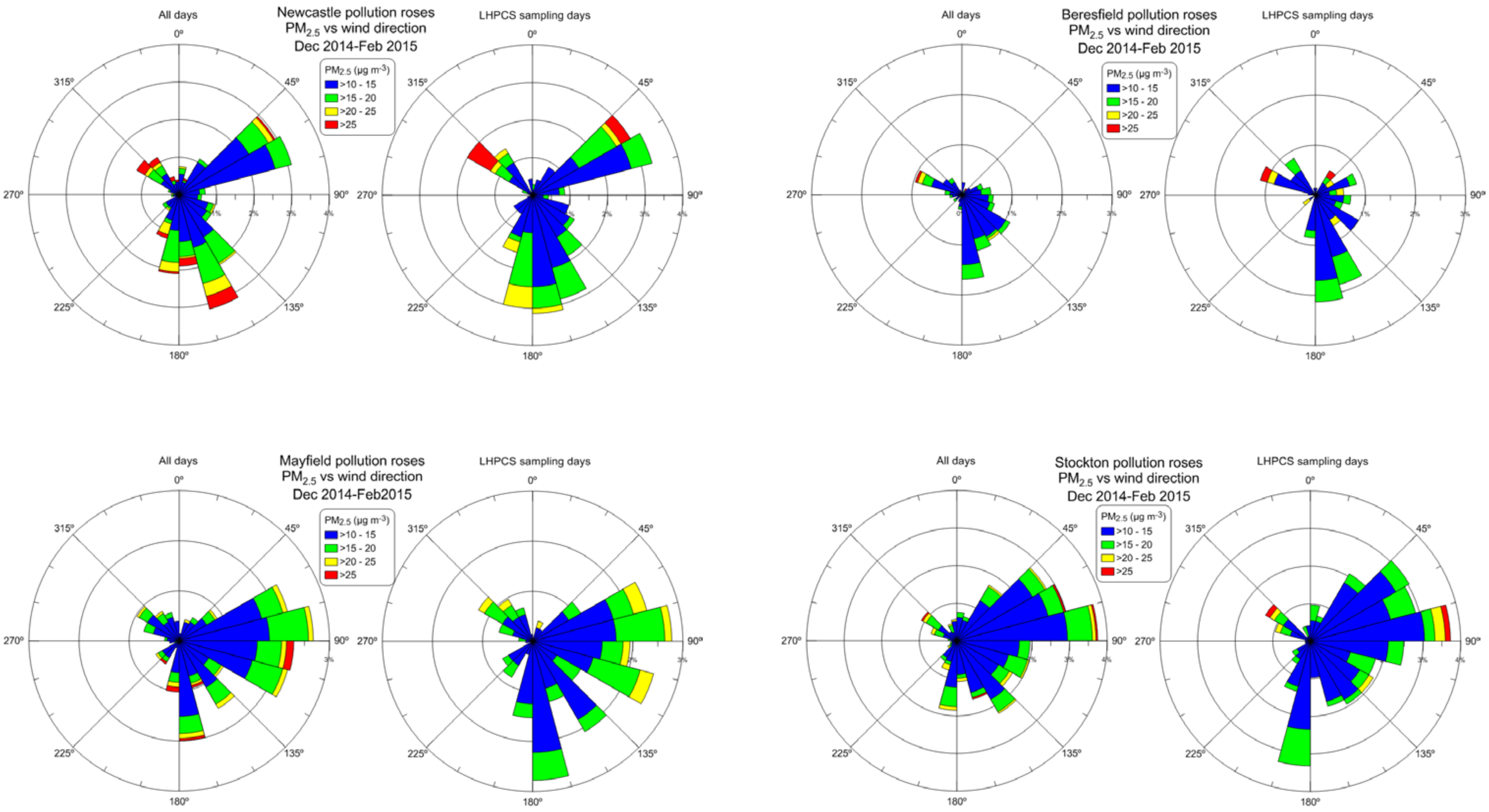

Figure 10 $PM_{2.5}$ pollution roses for $PM_{2.5}$ > 10 µg m^{-3} for the Summer period at Newcastle, Beresfield and Stockton showing close agreement between all days (left-hand side) and the 1-day-in-3 sampling days (right-hand side). [Note: these pollution roses depict the distribution of $PM_{2.5}$ concentrations at each wind direction.]

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