PREPARED FOR

Marlborough District Council

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AIR QUALITY EVALUATION
BLENHEIM

AIR QUALITY SPECIALISTS
ENVIRONET

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Envirolink Report - 2508-MLDC175

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EXECUTIVE SUMMARY

This report evaluates air quality monitoring data for Blenheim. It includes an assessment of concentrations of PM_{10} and $PM_{2.5}$ for the period 2017 to 2024 including trend evaluation and characterisation by time of day, season, day of week and by wind speed and direction. The 2017 to 2024 period was selected to provide an indication of current patterns and trends and because it enabled comparison of $PM_{2.5}$ and PM_{10}.

The analysis shows PM_{10} and $PM_{2.5}$ concentrations are highest in Blenheim during the winter months, that peak daily concentrations during these months occur in the evening/nighttime and that at this time the majority of the PM_{10} is in the $PM_{2.5}$ size fraction. These variables are all consistent with urban air quality issues with elevated PM_{10} and $PM_{2.5}$ concentrations as a result of solid fuel burning for domestic heating.

In Blenheim the predominant wind is from the west including during the winter months when PM_{10} and $PM_{2.5}$ concentrations are elevated. High concentrations under these conditions occur with wind speeds less than around 1.5 m/s but highest when the wind speed is less than 0.8 m/s.

Analysis also shows some contribution to PM_{10} and $PM_{2.5}$ concentrations under higher wind speeds. Marine aerosol (PM_{10} and $PM_{2.5}$) and fugitive dusts (primarily PM_{10}) are likely to be contributing sources. An additional source to the WNW, potentially dust from the Wairua river bed was also found to be a significant contributor during the summer months.

A statistically significant decrease in PM_{10} concentrations was found across both the winter and non-winter periods for 2017 to 2024. This downward trend appears to occur across all wind speeds and directions. The greatest magnitude of impact (size of decreasing concentration) is during the winter months, for wind speeds of less than 0.8 m/s and when the wind is blowing from the W and SW wind directions.

A statistically significant decrease in winter $PM_{2.5}$ concentrations was found for the 2017 to 2024 period but any trend in annual $PM_{2.5}$ concentrations is not currently significant. The decrease in winter $PM_{2.5}$ relates to concentrations occurring when the wind is from the W, SW directions and for wind speeds less than 1.45 m/s. This trend also appears in the shoulder season data (April and September) for these wind directions. A slight, but statistically significant, increase in high wind speed $PM_{2.5}$ is observed during the non-winter months.

Data for PM_{10} for the period June 2021 to around April 2022 was found to be inconsistent with trends and not coherent with other data (e.g., $PM_{2.5}$ concentrations). It is considered likely that concentrations of PM_{10} are impacted by instrument calibration issues over this period and we recommend that consideration be given to removing or flagging the PM_{10} data.

Overall data are indicative of improvements in PM_{10} and $PM_{2.5}$ concentrations over the 2017 to 2024 period and data are consistent with improvements in concentrations as a result of regulatory methods to reduce emissions from domestic home heating within the MEP.

TABLE OF CONTENTS

TABLE OF FIGURES

1 INTRODUCTION

Air quality in Blenheim has been monitored since 2002 with the focus being concentrations of particulate matter including PM_{10} (particles in the air less than 10 microns in diameter) and more recently (since 2017) $PM_{2.5}$ (particles in the air less than 2.5 microns). Particles in the air (PM_{10} and $PM_{2.5}$) result in adverse health impacts. The nature of the impacts varies from minor throat and eye irritations in relatively healthy people to more serious impacts including hospitalisations for respiratory and cardiopulmonary illness and premature mortality (Health Canada, 2016).

The National Environmental Standards for Air Quality (NESAQ) include a limit of 50 µg/m^3 (24-hour average) for PM_{10} which can be exceeded on one occasion per year. In 2020 the Ministry proposed updates to the particulate NESAQ including two $PM_{2.5}$ standards for 24-hour and annual average exposures (Ministry for the Environment, 2020). The values included in the proposed NESAQ for $PM_{2.5}$ were 25 µg/m^3 and 10 µg/m^3 respectively. The National Environmental Standards aim to improve the health of the New Zealand population by requiring minimum levels for air quality (Ministry for Environment, 2004). In 2021 the World Health Organisation released new guidelines including an annual average $PM_{2.5}$ concentration of 5 µg/m^3 and a daily guideline of 15 µg/m^3.

The NESAQ requires the gazetting of Airsheds. The Blenheim airshed has been gazetted under the NESAQ and is currently considered polluted for PM_{10} concentrations. An airshed must not breach the NESAQ for five consecutive years before it is no longer considered polluted. In Blenheim PM_{10} concentrations during 2022 and 2023 exceeded the 50 µg/m^3 threshold on one occasion per calendar year but because the 2022 exceedance was within 365 days of the 2022 exceedance the 2023 exceedance is considered a breach. The earliest that Blenheim could no longer be considered polluted under the current NESAQ would be in July 2028.

Air quality in Blenheim is managed by the Wairau Awatere Resource Management Plan (WARMP) and Proposed Marlborough Environment Plan (PMEP). These include measures aiming to reduce PM_{10} and $PM_{2.5}$ from domestic solid fuel burning and outdoor rubbish burning. The measures included in the MEP are:

- A ban on the use of open fires.
- The requirement that the emission limits specified for wood burners apply to all solid fuel burners.
- The staged phase out of older burners 15 years after installation.
- Outdoor burning only be a permitted activity in the Blenheim Airshed outside of May to August.

These measures appear to have been effective in significantly reducing daily winter PM_{10} concentrations with air quality monitoring reports indicating that annual exceedances of 50 µg/m^3 have reduced from up to 16 per year prior to 2022 to one or fewer over the last three years. Historically, however the trend in PM_{10} concentrations has been inconsistent. This report evaluates PM_{10} and $PM_{2.5}$ concentrations from 2017 to provide insights into changes in concentrations and to identify potential sources that may impact on future air quality management should annual average standards be introduced.

2 METHODOLOGY

2.1 Monitoring of PM_{10} and $PM_{2.5}$

Monitoring of PM_{10} and $PM_{2.5}$ is carried out in Blenheim using two 5014i beta attenuation monitors (BAM). Monitoring for $PM_{2.5}$ commenced in 2017 and monitoring for PM_{10} has been carried out since 2002. The equipment is operated by Marlborough District Council (MDC) staff. Ten-minute data is recorded by the instruments and logged by an iQuest iRIS 350 datalogger. Results are telemetered hourly to MDC and stored in the hilltop database. Annual calibrations for particulate monitors are carried out by Mote Limited but were carried out by MDC staff during the 2020 – 2022 period owing to covid travel restrictions and prior to this by Lears Seigler.

2.2 Air quality monitoring site

Figure 2.1 shows the Redwoodtown Bowling Club site which has been operational since 2002. Since 2016 all PM_{10}, $PM_{2.5}$ and meteorological data has been collected at this site. Prior to 2016 meteorological data from a NIWA air quality monitoring site in north Blenheim was used. All meteorological data used in this evaluation is from the Redwoodtown Bowling Club air quality monitoring site.

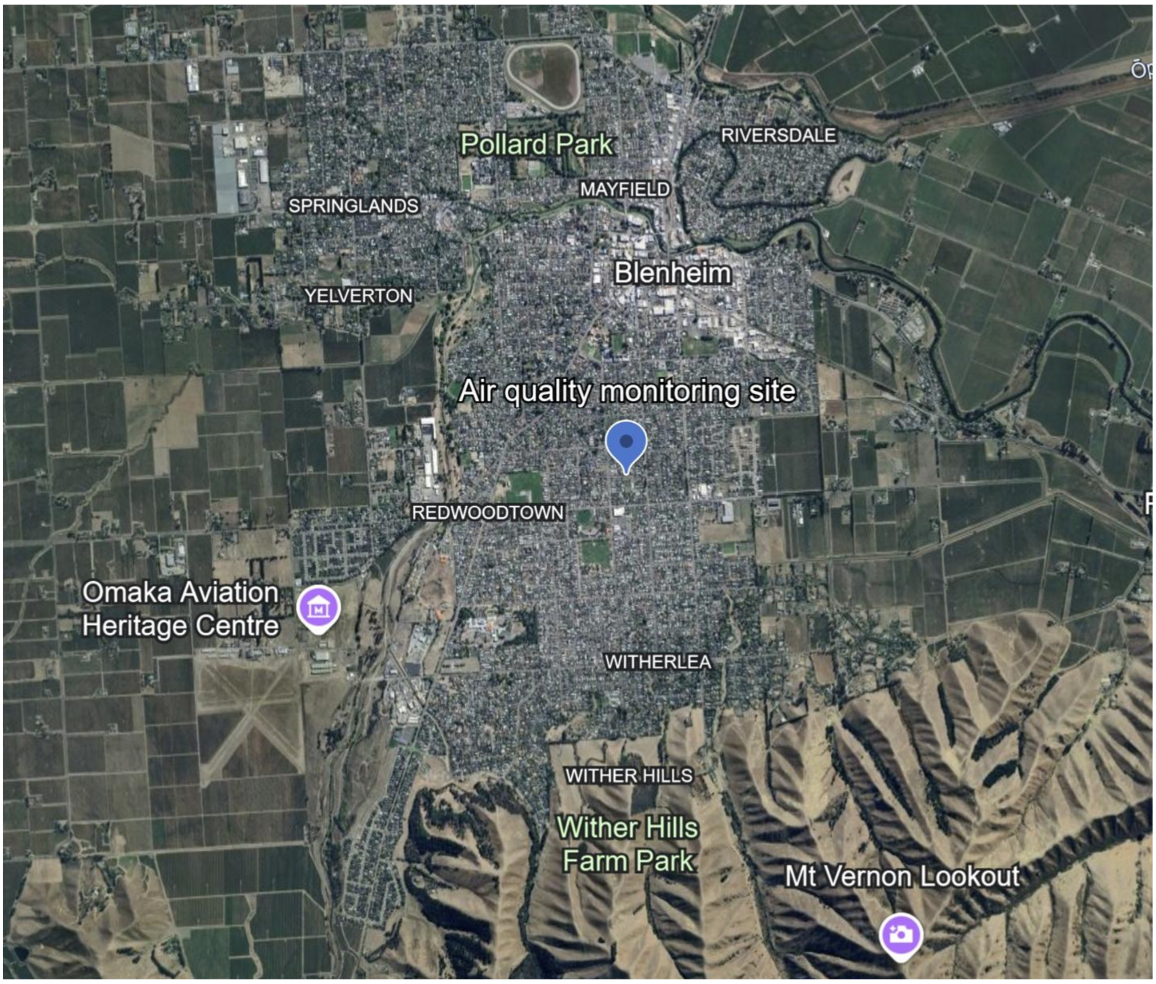


Figure 2.1: Location of air quality monitoring site in Blenheim

Figure 2.2: PM_{10} and $PM_{2.5}$ monitors at the Blenheim air quality monitoring site.

2.3 Analytical method

Data are analysed in this report for the period 2017 to September 2024. This period was selected to provide an indication of current patterns and trends and because it enabled coincidental comparison of $PM_{2.5}$ and PM_{10} concentrations.

Data were analysed using the open air r package (Carslaw & Ropkins, 2012) using 10 minute average PM_{10}, $PM_{2.5}$, wind speed and wind direction data provided by MDC. A range of graphics from this software were used to characterise PM_{10} and $PM_{2.5}$ concentrations by time of day, season, day of week and by wind speed and direction.

3 DIRECTIONAL ANALYSIS - PM_{10}

The seasonal pollution rose (Figure 3.1) for Blenheim shows the prevalence of different wind directions and the distribution of PM_{10} concentrations within those for each season. This indicates highest concentrations of PM_{10} occur during the winter and under the predominant west (W) to south west (SW) winds. Winds from the north (N), east (E) and south (S) are very low in prevalence during the autumn, spring and winter and increase slightly during the summer months.

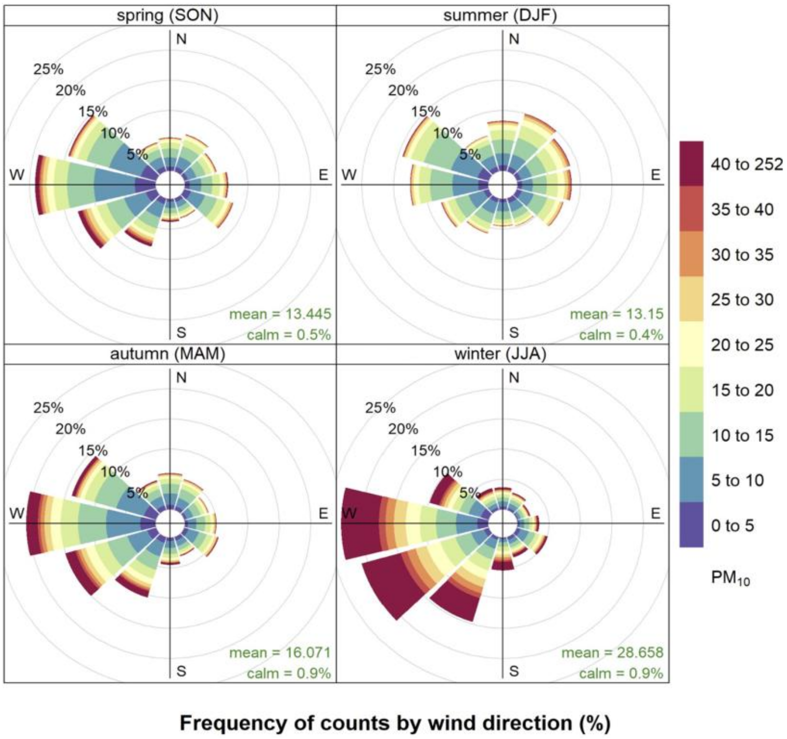


Figure 3-1: Pollution rose by season for PM_{10}

Figure 3.2 illustrates the average PM_{10} concentrations for each wind direction and speed by season. This shows that PM_{10} are consistently high when the wind speeds are low during the winter months. Additionally, average PM_{10} concentrations are elevated under very high wind speeds (around 10 m/s) from the southeast (SE). Further investigation found high concentrations from this direction were only apparent during 2022 and 2023 and may be associated with a short-term construction site or potentially fugitive dust from the Wither Hills.

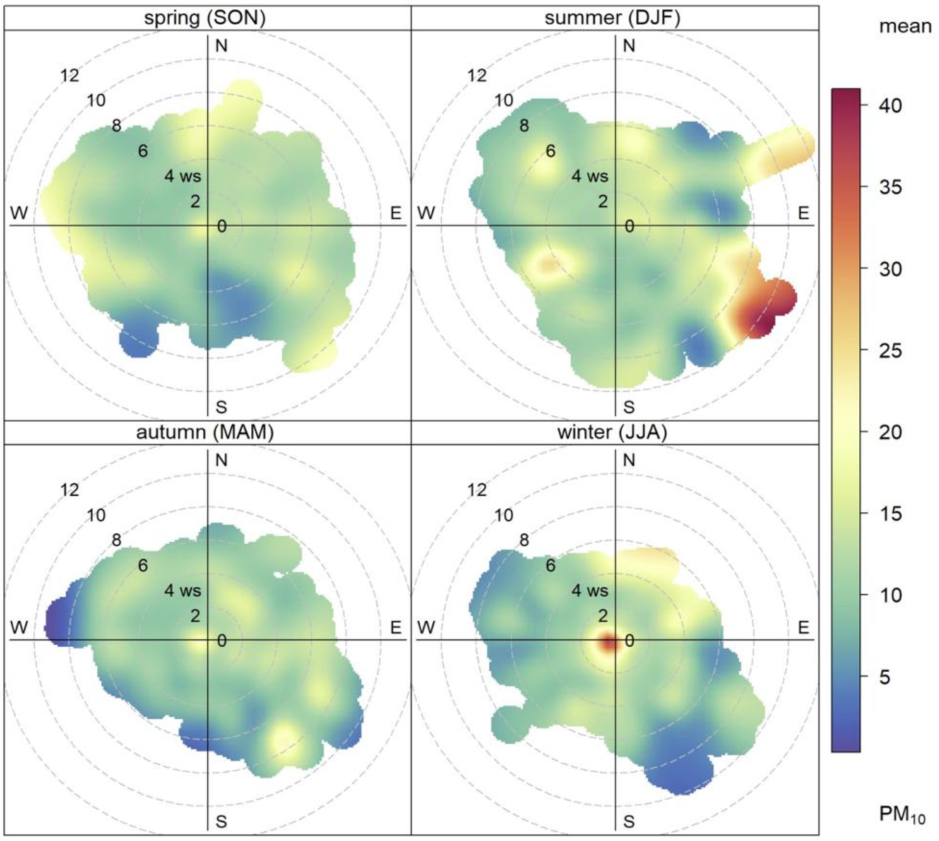


Figure 3-2: Seasonal polar plot of average PM_{10} concentrations by wind direction and speed

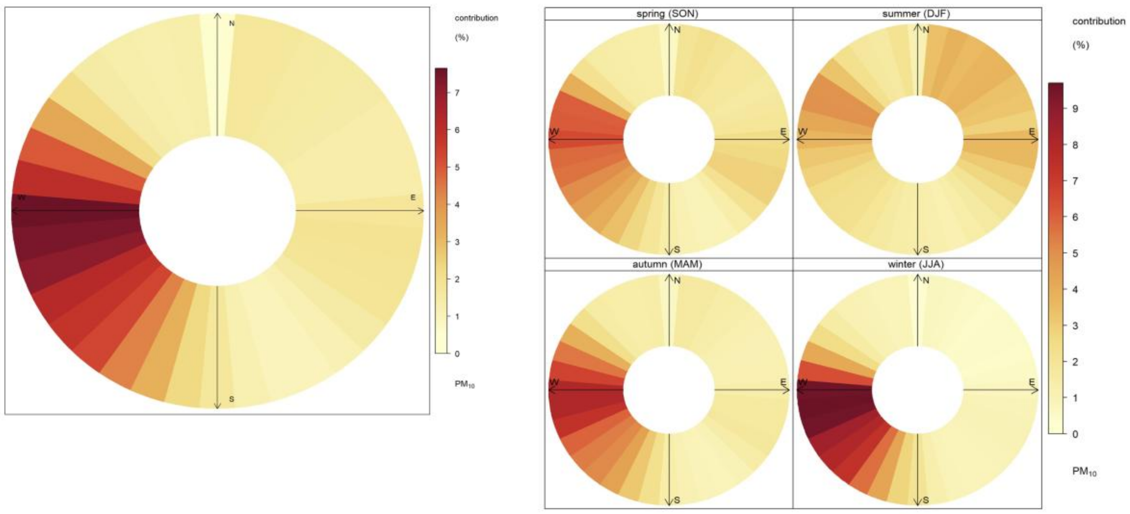


Figure 3-3: Directional relative contribution to PM_{10} concentrations annually (left) and by season (right)

Figure 3.3 shows that the direction of the greatest contribution to PM_{10} concentrations at the monitoring site during the winter months and overall is from the west (W) and south west (SW) directions. During the summer the north east (NE) and east (E) are the predominant contributors and this may be indicative of a marine aerosol source. An additional source to the west north west (WNW) which could be wind blown dust from the Wairau river bed also contributes during the summer months. Spring and autumn PM_{10} appear similar in contribution to the winter months likely indicating the influence of domestic home heating during the shoulder seasons (months of April and September).

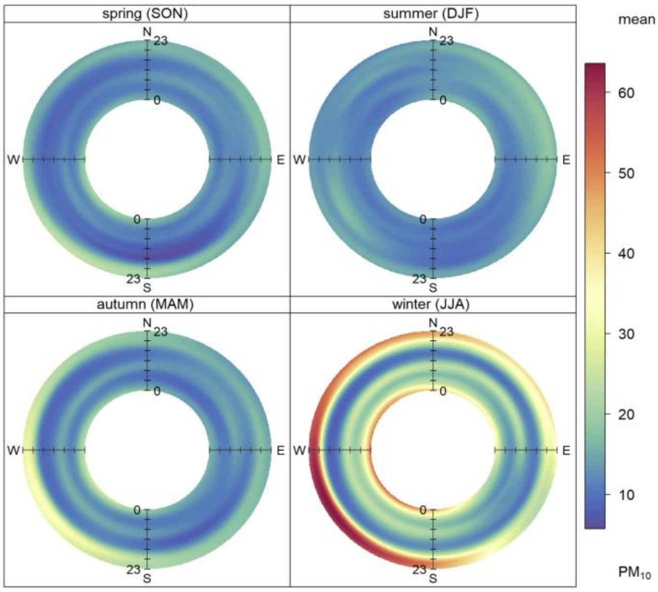


Figure 3-4: Seasonal polar annulus showing average PM_{10} concentrations by time of day and wind direction

The winter season average PM_{10} concentrations are the most variable by time of day with highest concentrations in the evening and nightlight periods (Figure 3.4).

4 TREND ANALYSIS – PM_{10}

Trend analysis of PM_{10} data (illustrated as monthly averages) indicates a statistically significant downward trend in concentrations of around 0.6 µg/m³ per year (Figure 4.1). This suggests peak monthly concentrations have decreased from around 30-40 µg/m³ prior to 2022 to around 20-30 µg/m³. Figure 4.2 shows that this trend is significant across all wind directions and greatest in magnitude for the south west (SW), west (W) and easterly (E) wind directions.

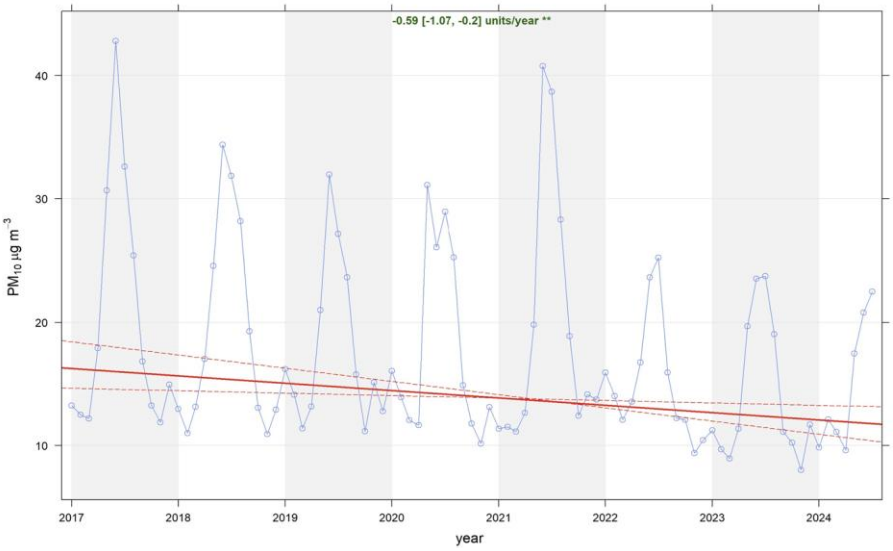


Figure 4-1: Trend analysis of PM_{10} concentrations in Blenheim (denotes $p < 0.01$)**

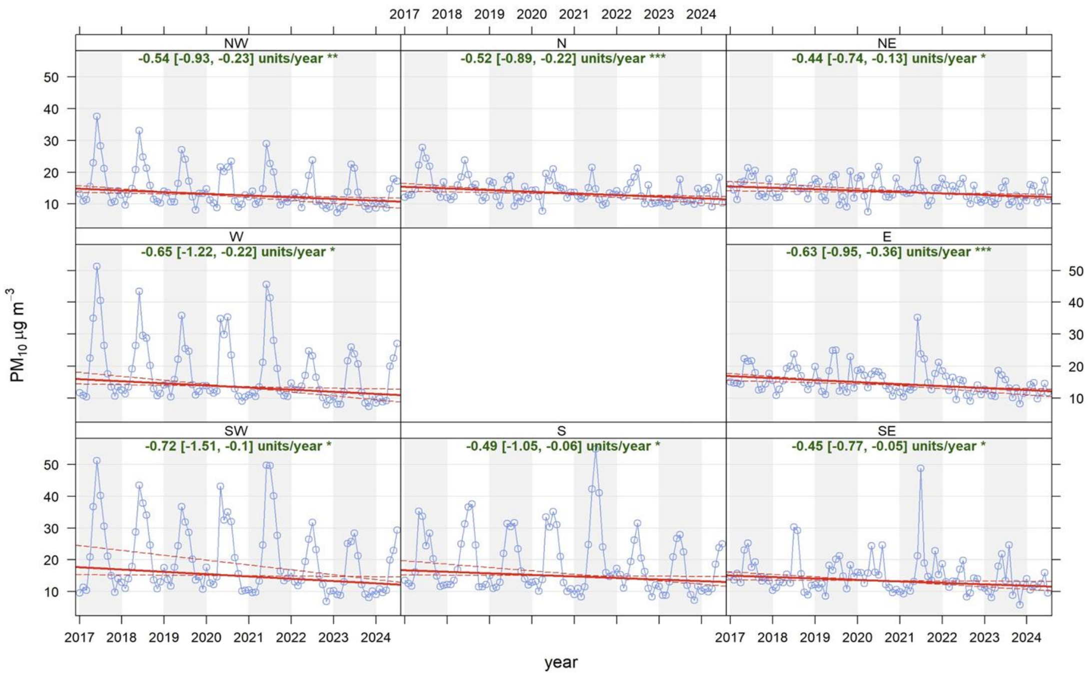


Figure 4-2: Trend analysis of PM_{10} concentrations by wind direction (*$p < 0.05$, ***$p<0.001$)

Figure 4.3 shows the trend in PM_{10} concentrations in Blenheim by wind speed. The + denotes a trend that is significant at the 90% confidence level. Typically, a 95% confidence level is selected for statistical significance however, and reporting here is based on the 95% confidence level. Figure 4.3 also illustrates that the highest winter PM_{10} concentrations occur with wind speeds less than 1.08 m/s. It is also apparent that higher average PM_{10} concentrations measured during 2021 occur for wind speeds less than 2.2 m/s and may not therefore reflect a fugitive dust source as previously thought.

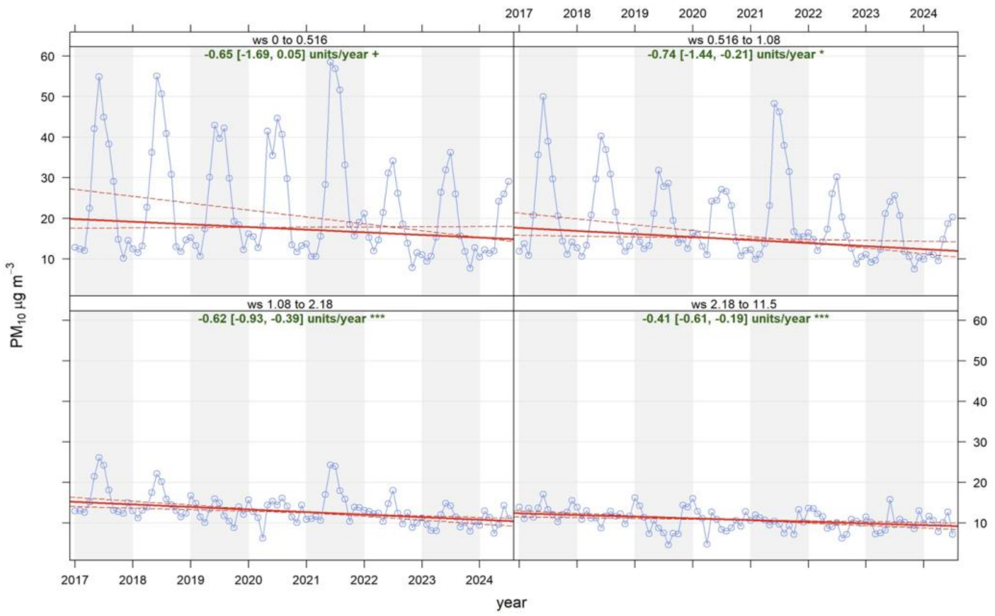


Figure 4-3: Trend analysis of PM_{10} concentrations by wind speed

4.1 Winter trend

An analysis of trend for the winter months plus May (referred to henceforth as winter) for the 2017 to 2024 period is shown in Figure 4.4. The downward trend in the winter PM_{10} is highly significant and averages around 1.7 µg/m^3 per year across these months. Figure 4.5 shows that the downward trend occurs across all wind directions and that the N, NW and NE wind directions do not appear to be contributing to the elevated PM_{10} concentrations during the winter of 2021.

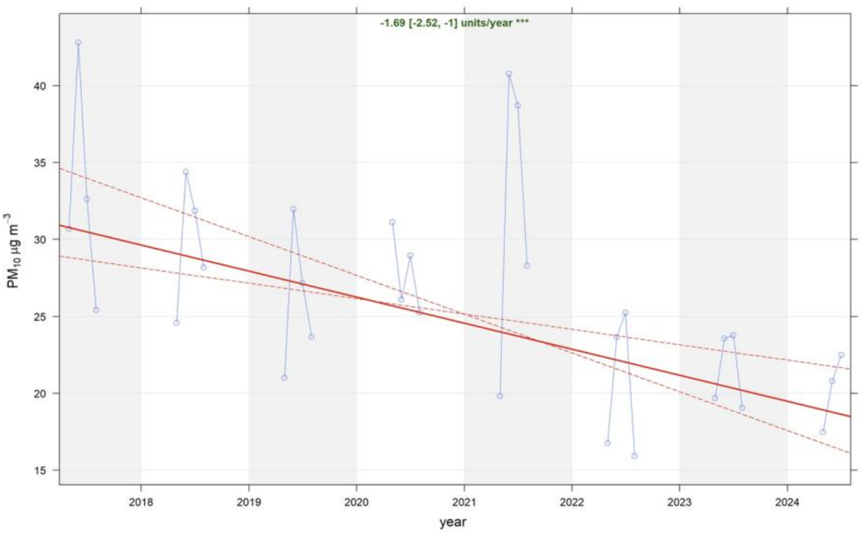


Figure 4-4: Trend analysis of PM_{10} concentrations for winter months

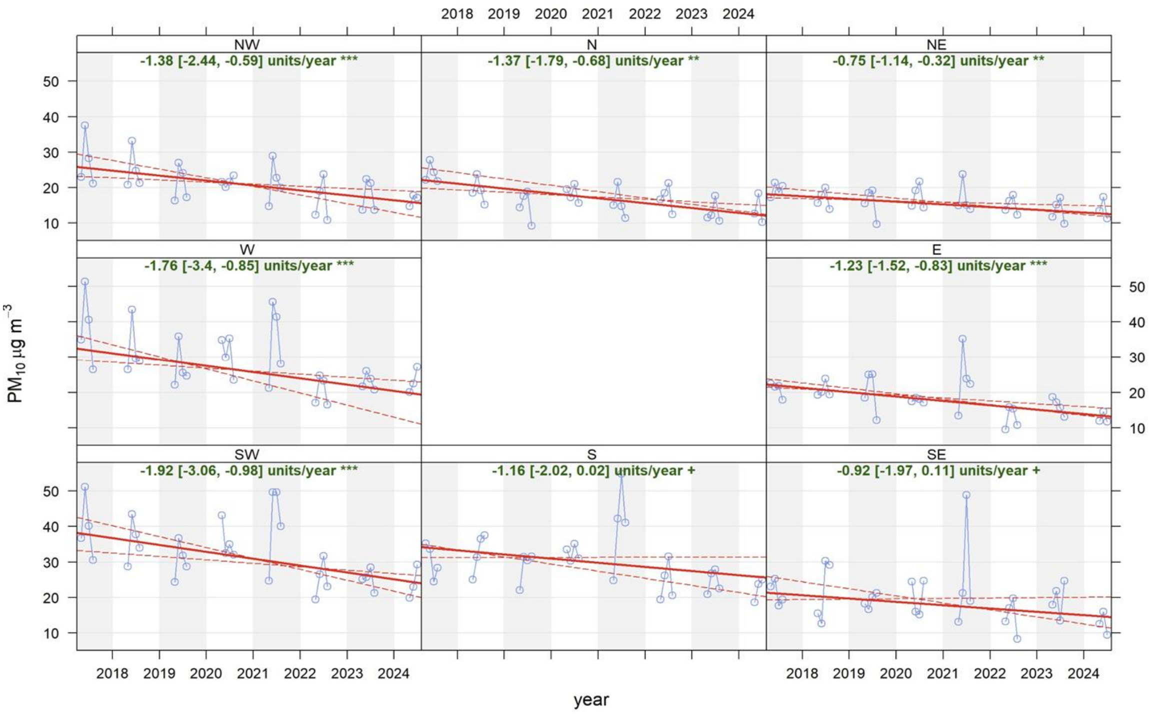


Figure 4-5: Trend analysis of PM_{10} concentrations for winter months by wind direction

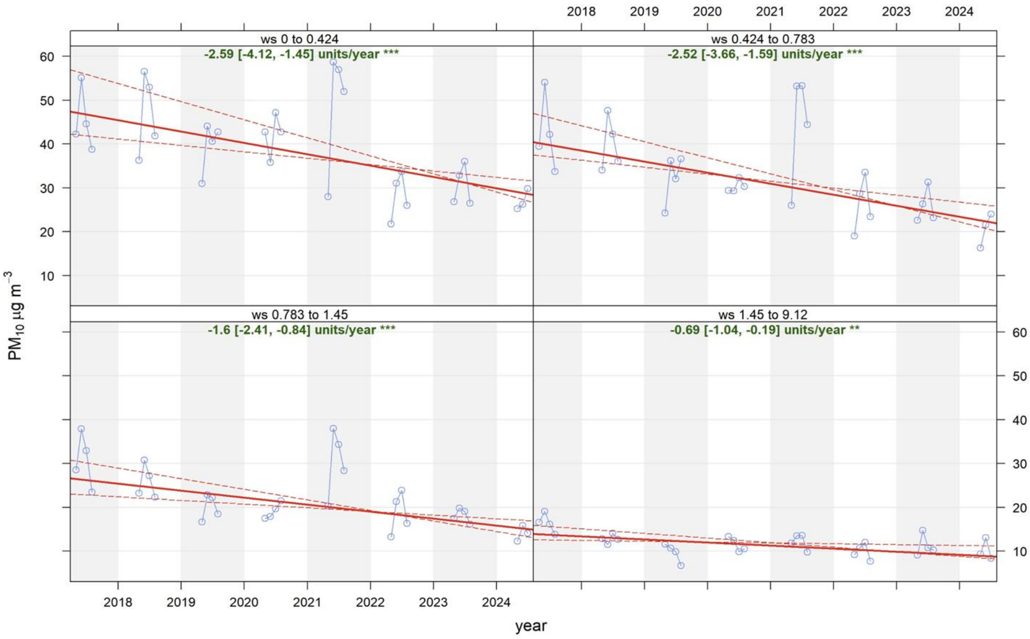


Figure 4-6: Trend analysis of PM_{10} concentrations for winter months by wind speed

Figure 4.6 shows the trend in winter PM_{10} concentrations in Blenheim by wind speed. This shows that the decrease is statistically significant across all wind speeds and of greatest magnitude for very low winds (less than around 0.8 m/s). Figure 4.6 also shows that the elevated PM_{10} concentrations during 2021 occurred only for wind speeds less than 1.5 m/s.

A comparison of the relative contributions of wind directions to annual PM_{10} in Figure 4.7 suggests an increase in the relative contribution of the W to WSW wind directions during 2021. This in part can be explained by increased prevalence of this wind direction in 2021 when compared with 2017 – 2022 but a similar prevalence occurred during 2023 and did not result in increased PM_{10} concentrations.

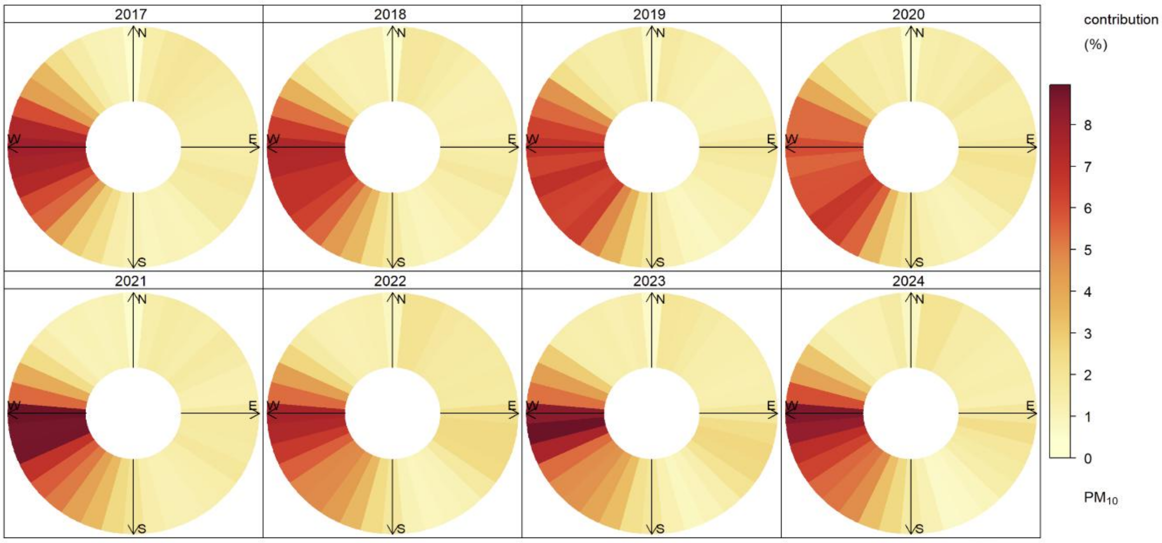


Figure 4-7: Relative contribution of wind direction to annual PM_{10} by year

4.2 Non winter trend

An analysis of trend for the months September, October, November, December, January, February, March and April (referred to henceforth as non-winter) for the 2017 to 2024 period is shown in Figure 4.8. The downward trend in the non-winter PM_{10} is highly significant and averages around 0.5 µg/m^3 per year. Data for the period September 2021 to April 2022 appear to sit outside of the trend. Figure 4.9 shows that the downward trend occurs across all wind directions and is of greatest magnitude when the wind is blowing from the W and SW directions. It also illustrates that high PM_{10} concentrations during September arise from PM_{10} concentrations from the SW and S directions.

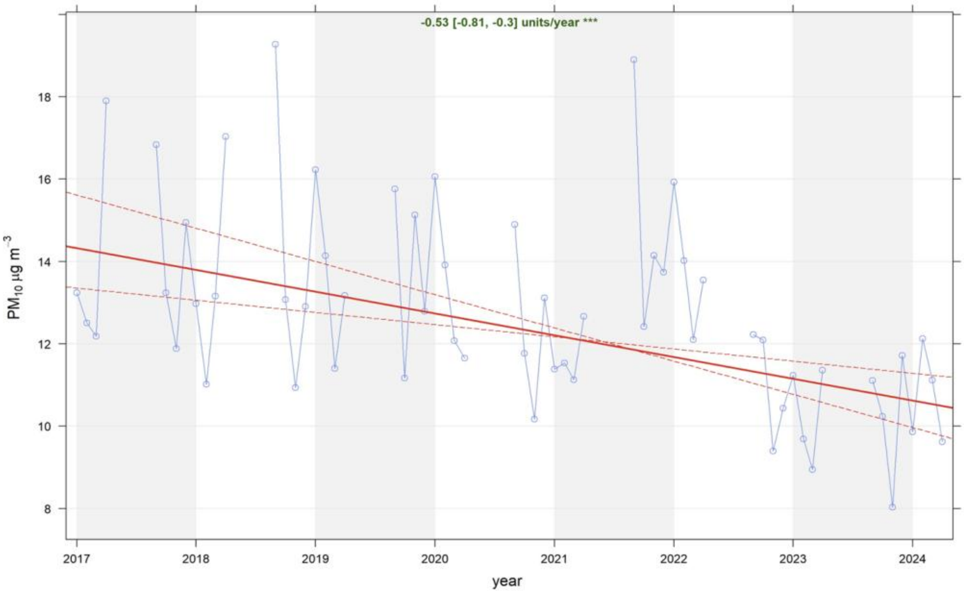


Figure 4-8: Trend analysis of PM_{10} concentrations for non-winter months

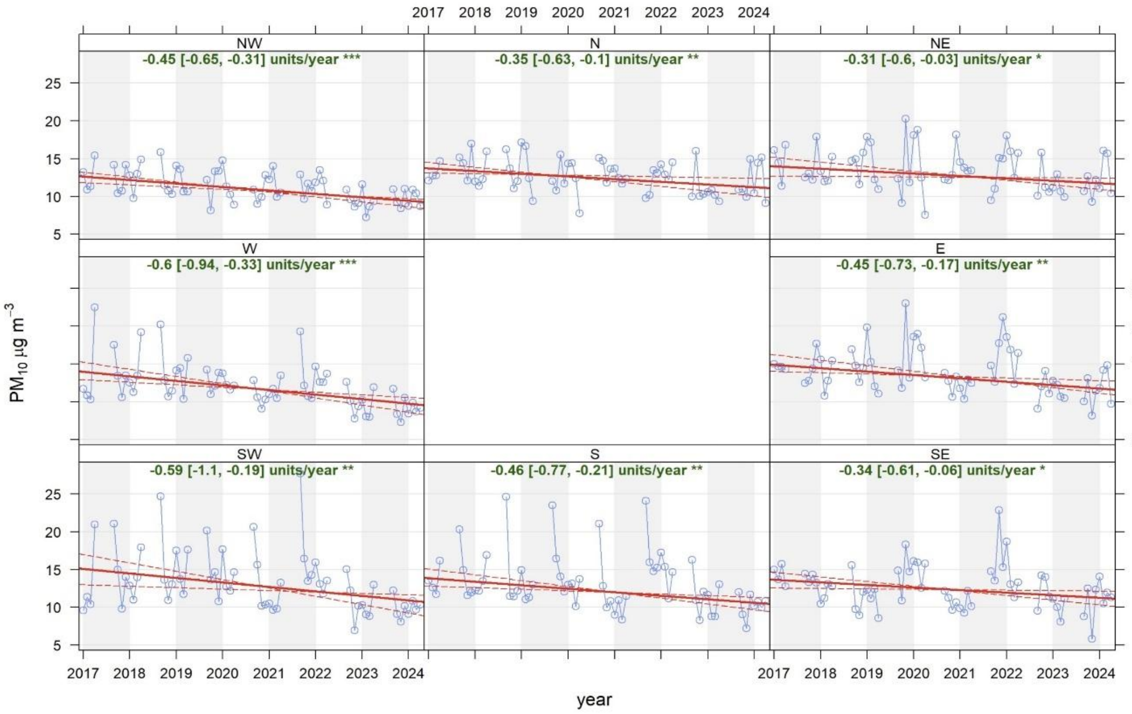


Figure 4-9: Trend analysis of PM_{10} concentrations for non-winter months by wind direction

Figure 4.10 shows the trend in non-winter PM_{10} concentrations in Blenheim occurs across all wind speeds. It also illustrates that highest average PM_{10} concentrations during the non-winter months, including the high September peaks (shoulder season for domestic heating) occur when the winds are low.

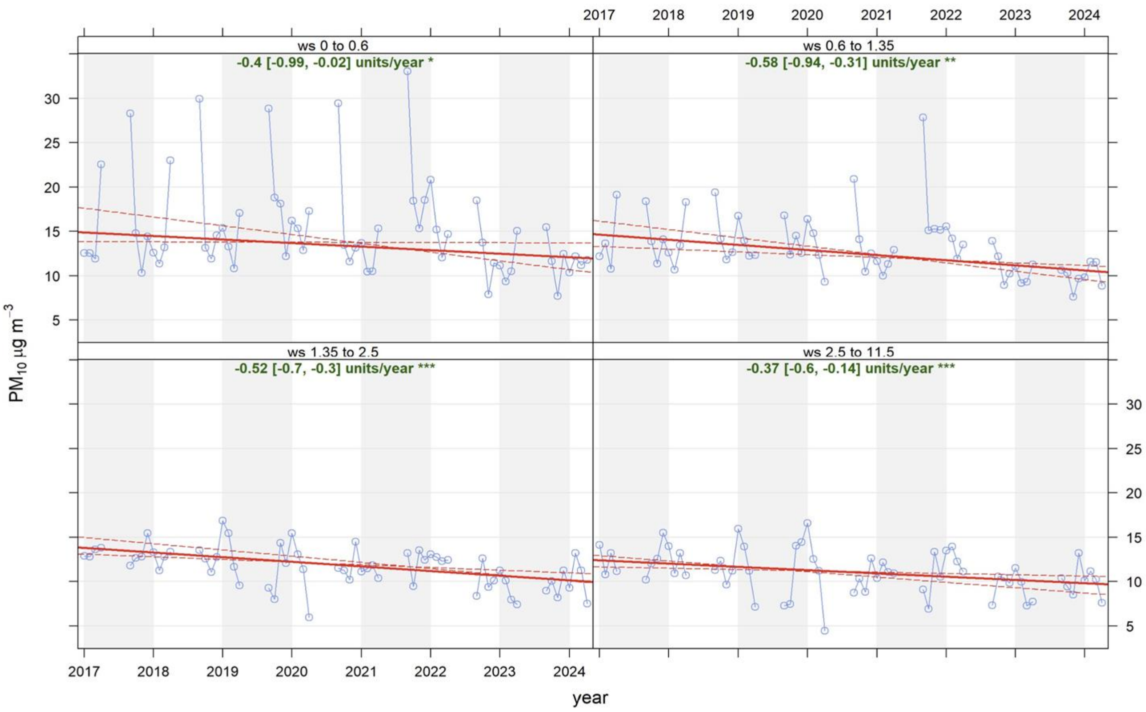


Figure 4-10: Trend analysis of PM_{10} concentrations for non-winter months by wind speed

4.3 Trend evaluation

Trend analysis of PM_{10} from 2017 to 2024 shows a statistically significant decrease in PM_{10} concentrations that exists across both the winter and non-winter periods. This downward trend appears to occur across all wind speeds and directions. The greatest magnitude of impact (size of decreasing concentration) is during the winter months, for wind speeds of less than 0.8 m/s and when the wind is blowing from the W and SW wind directions.

Seasonal analysis of trends in PM_{10} concentrations in Blenheim suggests two occurrences of note:

- Winter 2021 data for June, July and August are elevated relative to other years
- Non-winter data from September 2021 to April 2022 are elevated relative to other years.

The winter 2021 PM_{10} concentrations are only elevated when the wind is blowing between the angles of 70 and 290 degrees (i.e., not when the wind is blowing from the NW, N or NE directions). The concentrations are only elevated for wind speeds less than 1.5 m/s and with highest concentrations occurring with wind speeds less than around 0.5 m/s. This is not typical of a fugitive dust source which tend to have higher concentrations when winds are elevated.

The higher non-winter concentrations for the period from September 2021 to April 2022 also occur for wind speeds less than 1.4 m/s and with highest concentrations occurring for wind speeds less than 0.5 m/s. These also appear to occur across the same wind direction as for the elevated winter PM_{10} concentrations.

Data shows that the measured PM_{10} concentrations have increased above the normal trend from June 2021 to around April 2022. The increase in concentrations appears related to the wind speed and direction typically associated with high PM_{10} concentrations. Put another way, the abnormally elevated concentrations occur under the same meteorological conditions as typically high PM_{10} concentration in Blenheim (i.e., the high concentrations are just higher). Thus, the associations observed with meteorology may occur because those directions and speeds are associated with higher PM_{10} concentrations and the real cause might be instrumental – e.g., a percentage increase in measured concentrations owing to a calibration issue.

5 DIRECTIONAL ANALYSIS – $PM_{2.5}$

The seasonal pollution rose (Figure 5.1) for $PM_{2.5}$ shows a similar pattern to that for PM_{10} with the majority of the high concentrations occurring during the winter months and from a W and NW wind direction.

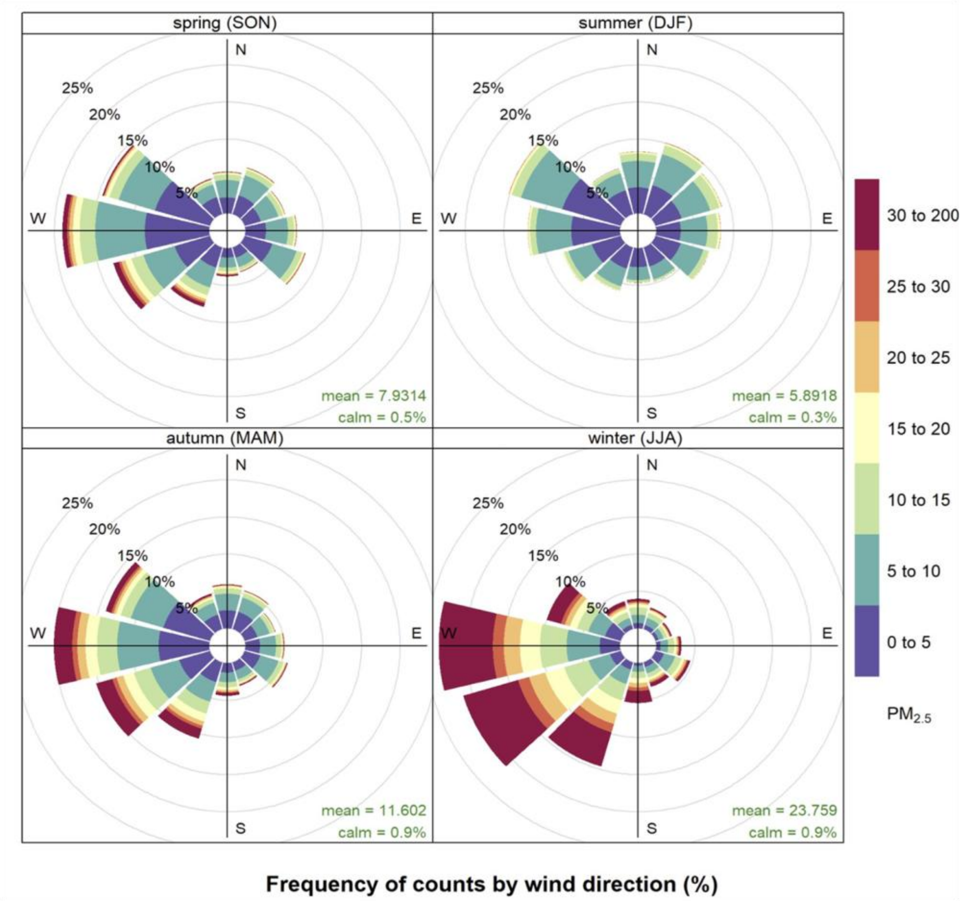


Figure 5-1: Pollution rose by season for $PM_{2.5}$

The average $PM_{2.5}$ concentrations for each wind direction and speed by each season of the year are shown in Figure 5.2. Like PM_{10}, concentrations of $PM_{2.5}$ are consistently high when the wind speeds are low during the winter months. Additionally, average $PM_{2.5}$ concentrations can be elevated under higher wind speeds from a range of wind directions. Potential sources include marine aerosol and potentially outdoor burning although the latter is likely to result in higher concentrations typically under lower wind speeds. Typically, wind blown dusts are in the coarse mode size fraction (greater than 2.5 µm) but it may be possible that this is also a contributing source of small amounts of $PM_{2.5}$.

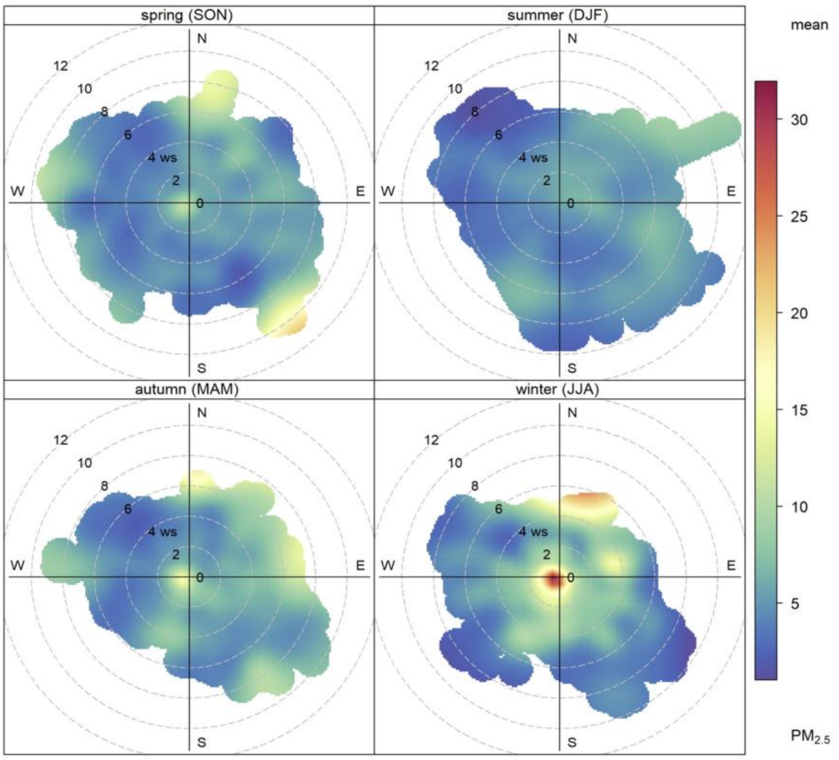


Figure 5-2: Seasonal polar plot of average $PM_{2.5}$ concentrations by wind direction and speed

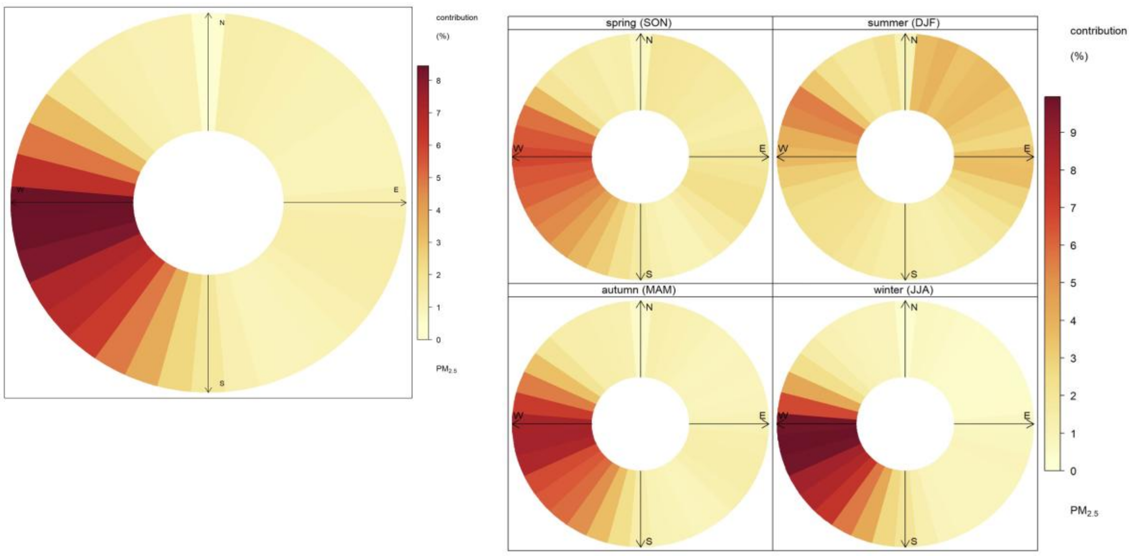


Figure 5-3: Directional relative contribution to PM_{10} concentrations annually (left) and by season (right)

Figure 5.3 shows that the greatest contribution to $PM_{2.5}$ concentrations during the winter months and overall comes from air moving from the west (W) and south west (SW) directions. During the summer, air flows from the NE and E directions are the predominant contributors to $PM_{2.5}$. This may be indicative of marine aerosol contribution which occurs in both the fine ($PM_{2.5}$) and coarse (PM_{10}-$PM_{2.5}$) size fractions(Davy & Trompetter, 2018). An additional source to the WNW of the monitoring site also contributes during the summer months as it did with PM_{10}. Figure 5.4 shows the annual directional contribution illustrated at the monitoring site. The westerly contribution is dominant during the winter months and likely reflects the contribution of domestic heating. The winter season average $PM_{2.5}$ concentrations are the most variable by time of day with highest concentrations in the evening and nightlight periods (Figure 5.5) and increases in the mid morning.

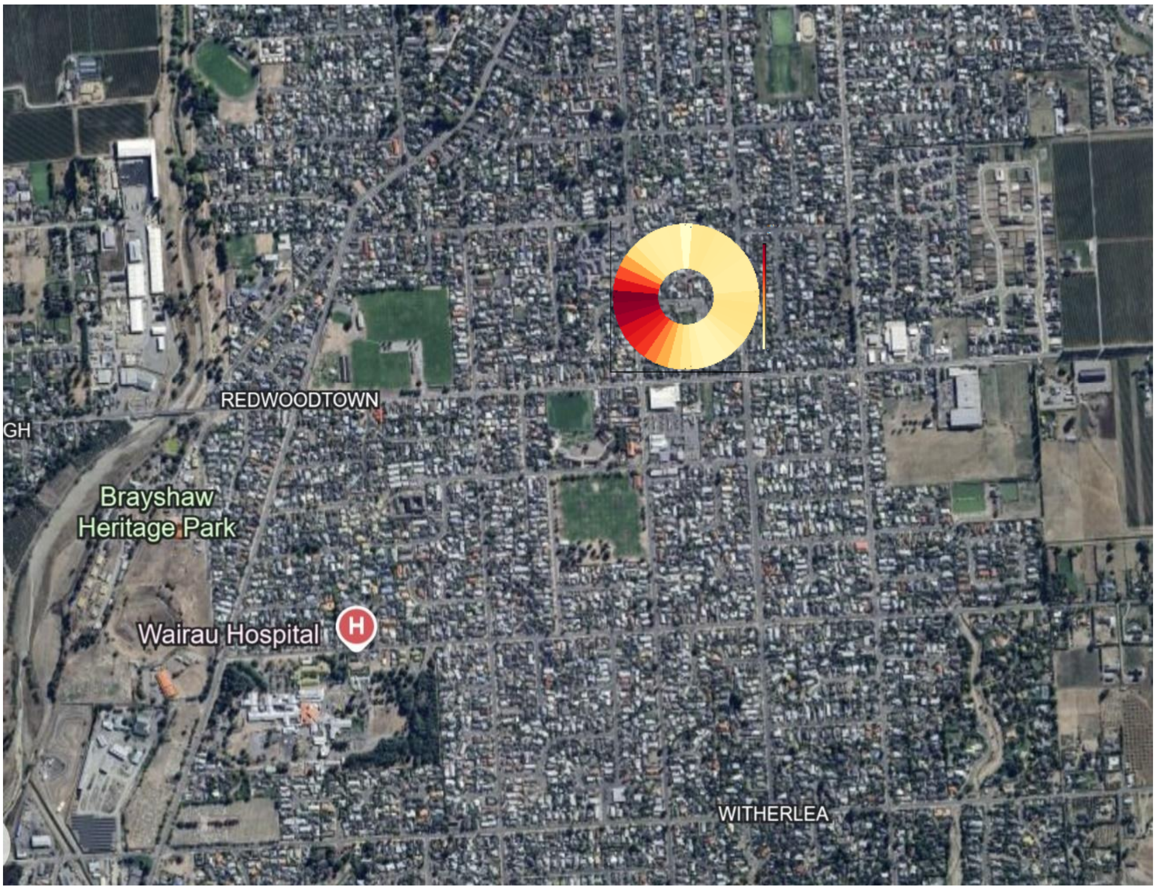


Figure 5-4: Mapped frequency contribution to annual PM_{10} for Blenheim

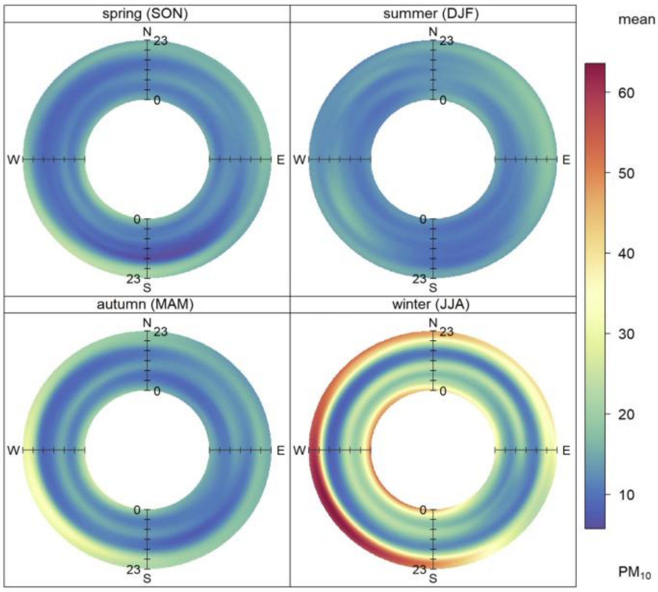


Figure 5-5: Seasonal polar annulus showing average PM_{10} concentrations by time of day and wind direction

6 TREND ANALYSIS $PM_{2.5}$

Figure 6.1 shows no significant downward trend in overall $PM_{2.5}$ concentrations measured from 2017 to 2024. Peak monthly concentrations appear to have improved over this period and this is examined in more detail in the winter trend analysis. Figure 6.2 shows no significant trends in $PM_{2.5}$ concentrations across any wind directions.

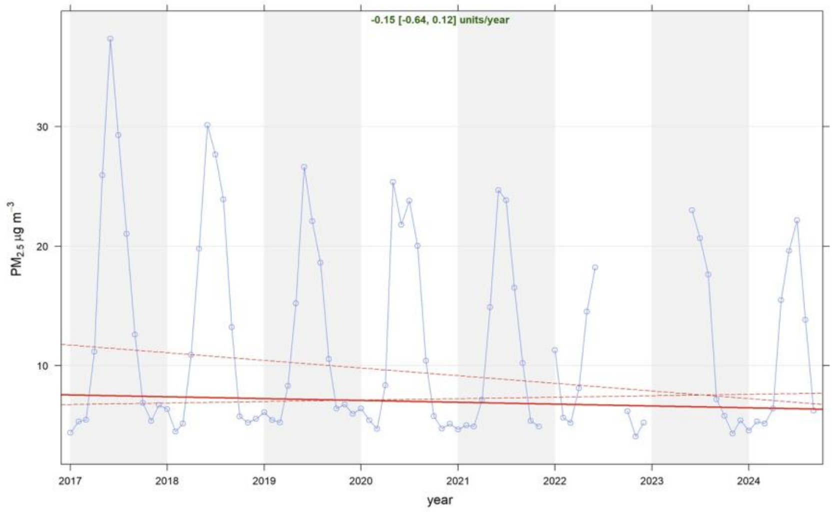


Figure 6-1: Trend analysis of $PM_{2.5}$ concentrations

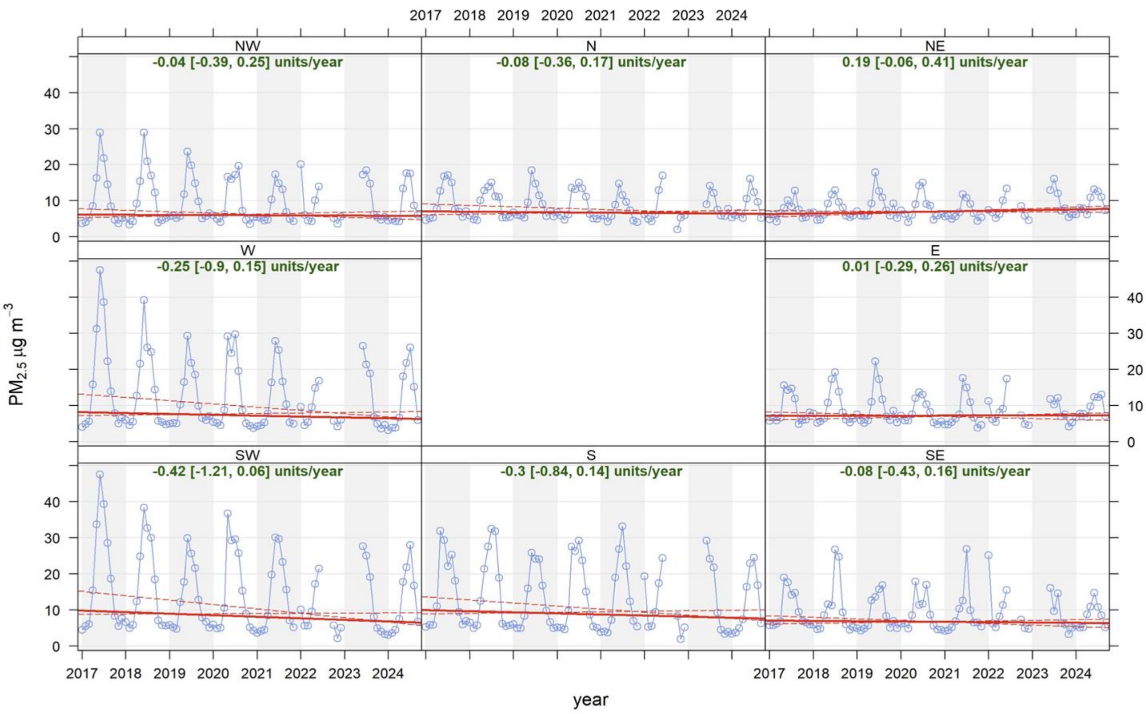


Figure 6-2: Trend analysis of $PM_{2.5}$ concentrations by wind direction

Figure 6.3 shows the trend in $PM_{2.5}$ concentrations in Blenheim by wind speed. Data suggest a slight increase in $PM_{2.5}$ concentrations under higher wind speeds (>2 m/s). This may reflect an increase in $PM_{2.5}$ concentrations from marine aerosol or other wind affected sources.

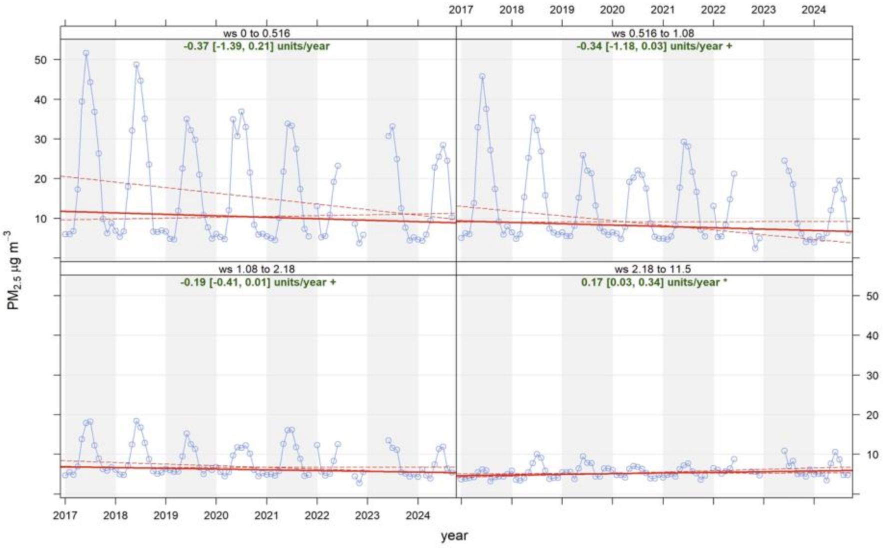


Figure 6-3: Trend analysis of $PM_{2.5}$ concentrations by wind speed

6.1 Winter trend

An analysis of trend for the winter months for the 2017 to 2024 period is shown in Figure 6.4. This indicates a significant downward trend during the winter months of around 1.4 µg/m^3 per year. Figure 6.5 shows that the downward trend occurs predominantly across the W and SW wind directions. It is also noted that there is no corresponding peak $PM_{2.5}$ concentrations to match the elevated PM_{10} for 2021 discussed previously.

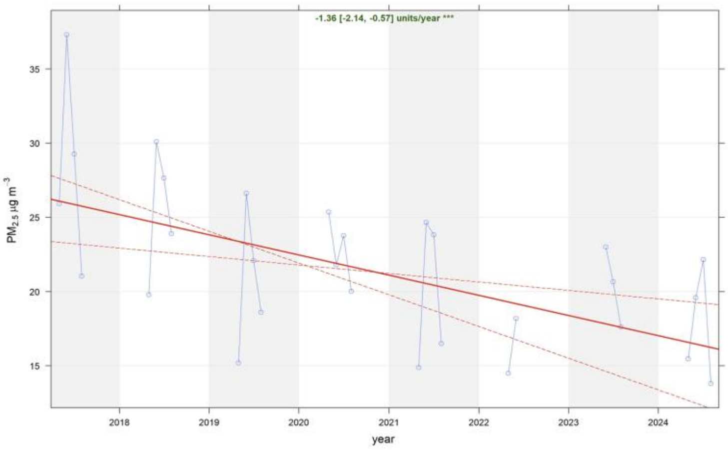


Figure 6-4: Trend analysis of $PM_{2.5}$ concentrations for winter months

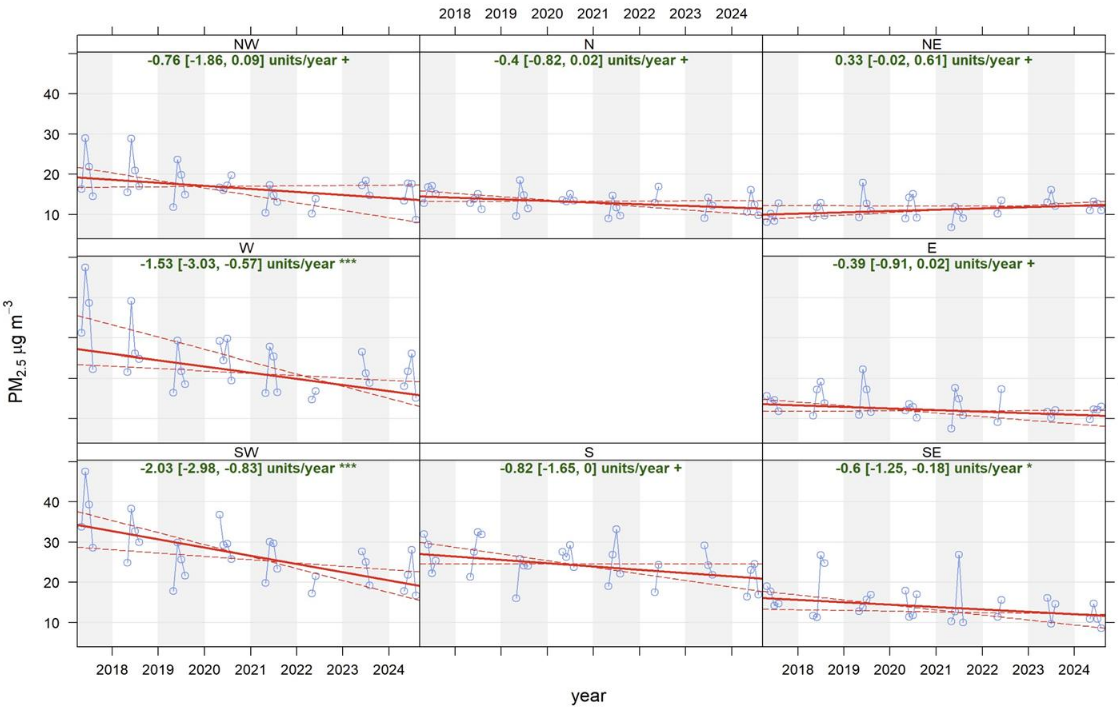


Figure 6-5: Trend analysis of $PM_{2.5}$ concentrations for winter months by wind direction

Figure 6.6 shows the trend in winter $PM_{2.5}$ concentrations by wind speed. This shows that the decrease is statistically significant across all wind speeds less than 1.45 m/s and of greatest magnitude for very low winds (less than around 0.8 m/s).

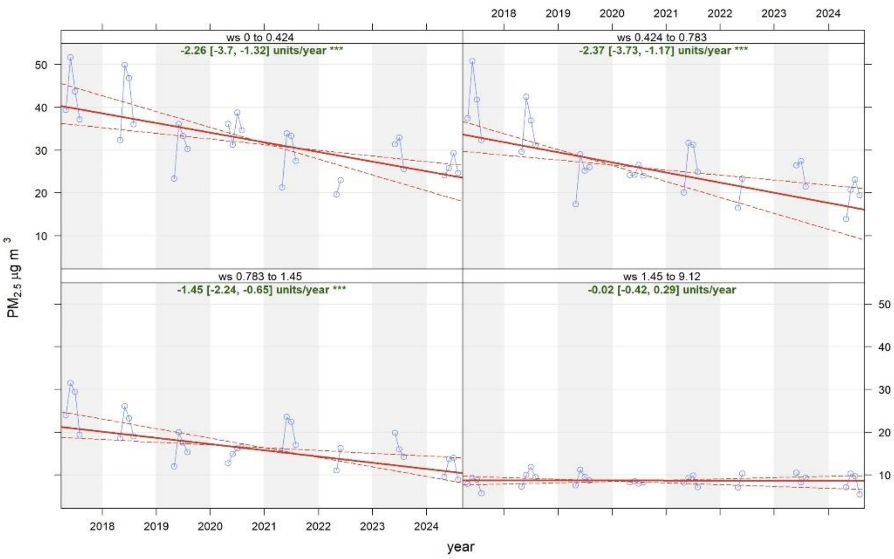


Figure 6-6: Trend analysis of $PM_{2.5}$ concentrations for winter months by wind speed

6.2 Non winter trend

An analysis of trend for the non-winter months for the 2017 to 2024 period is shown in Figure 6.7. This shows no trend in $PM_{2.5}$ concentrations for the non-winter months. However, Figure 6.8 shows that $PM_{2.5}$ from the W, SW and S quadrants decrease in concentration over the monitoring period. This likely reflects improvements in sources of winter time $PM_{2.5}$ (domestic home heating emissions) as these directions show the highest shoulder season (April and September) concentrations.

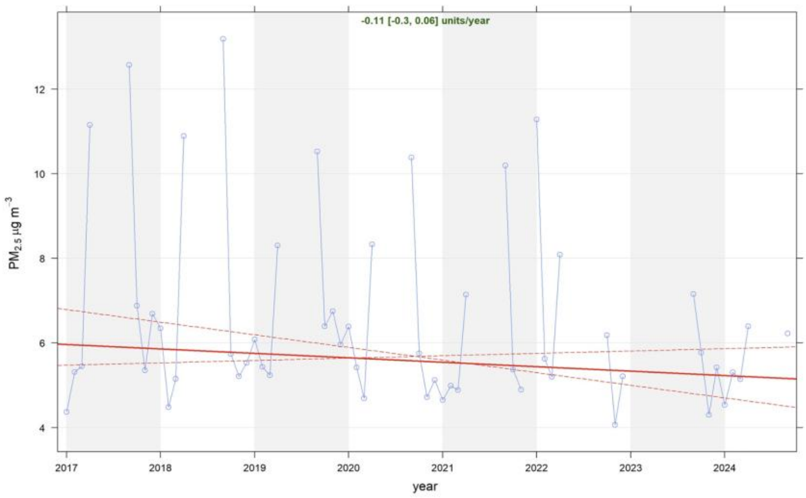


Figure 6-7: Trend analysis of $PM_{2.5}$ concentrations for non-winter months

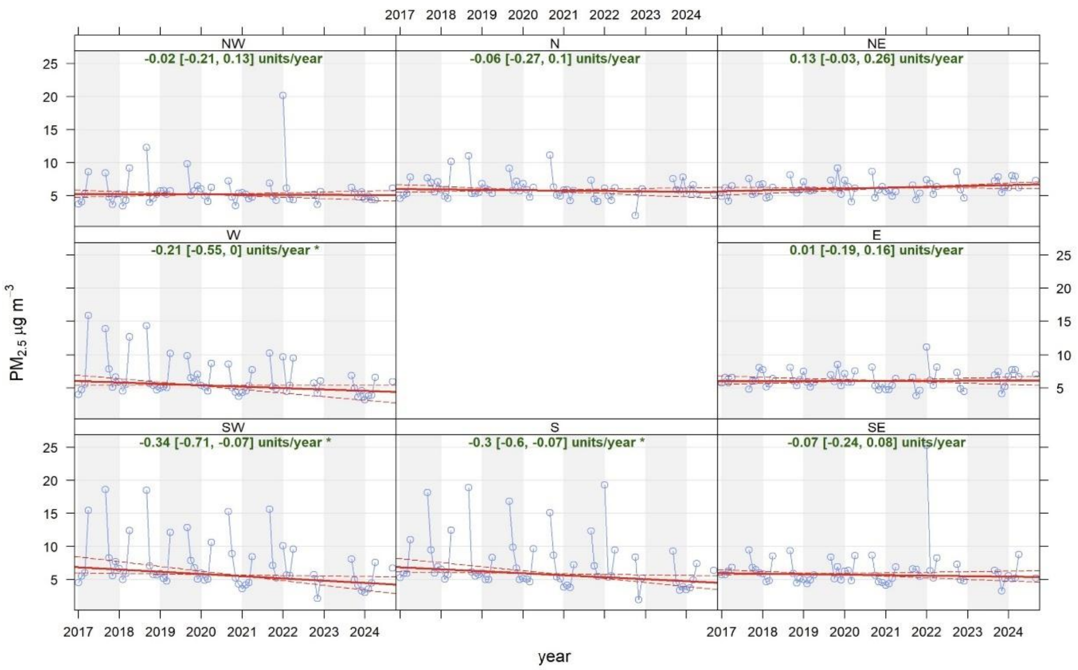


Figure 6-8: Trend analysis of $PM_{2.5}$ concentrations for non-winter months by wind direction

Figure 6.9 shows a slight decreasing trend in non-winter $PM_{2.5}$ concentrations for wind speeds greater than 0.4 and less than 2.5 m/s. For winds greater than 2.5 m/s there is a significant trend for increasing $PM_{2.5}$ concentrations.

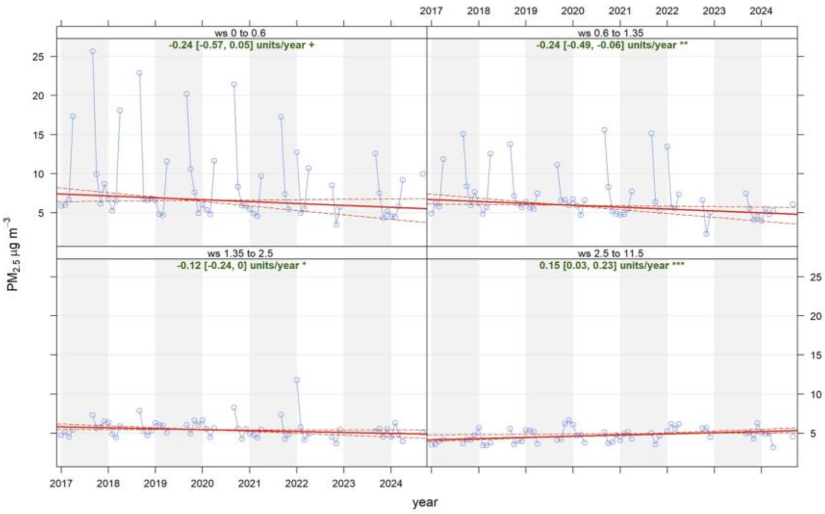


Figure 6-9: Trend analysis of $PM_{2.5}$ concentrations for non-winter months by wind speed

6.3 Trend evaluation

Trend analysis of $PM_{2.5}$ concentrations in Blenheim from 2017 to 2024 shows no overall trend but a statistically significant decrease in winter $PM_{2.5}$ concentrations. The decrease relates to be $PM_{2.5}$ concentrations when the wind is from the W, SW directions and for wind speeds less than 1.45 m/s. There is no overall trend in non winter $PM_{2.5}$ concentrations over the same period although significant decreases are noted for winds from the W, SW and S wind quadrants. This is driven by a reduction in concentrations in the shoulder season as noted by changes in the April and September average $PM_{2.5}$ concentrations. An increase in high wind speed $PM_{2.5}$ is observed during the non-winter months although the magnitude of this is small.

7 TEMPORAL VARIATIONS IN $PM_{2.5}$ AND PM_{10}

Figure 7.1 compares the daily and seasonal variations in PM_{10} and $PM_{2.5}$ concentrations for the period prior to the 2021 PM_{10} peak and for the year 2021. This shows average hourly and monthly peak $PM_{2.5}$ concentrations during 2021 were slightly lower than for the previous years and the peak hourly and monthly PM_{10} concentrations were higher. As a result the difference between the $PM_{2.5}$ and PM_{10} concentrations was much higher than typical for 2021. Figure 7.2 shows that the $PM_{2.5}$ concentrations for the subsequent years (2022 to 2024) are similar to 2021 but that the relationship is more consistent with the pre 2021 period with the majority of the PM_{10} being in the $PM_{2.5}$ size fraction.

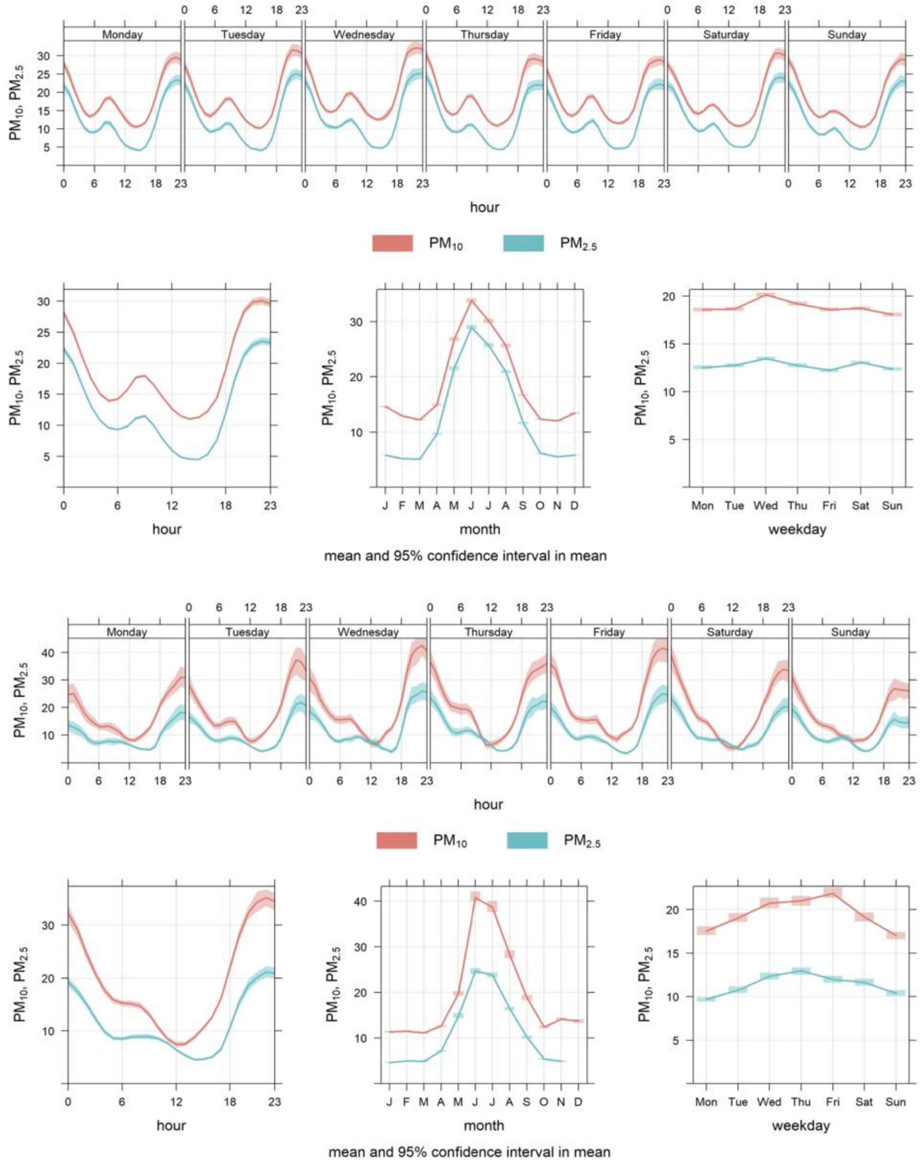


Figure 7-1: Diurnal and seasonal variations in PM_{10} and $PM_{2.5}$ concentrations from 2017 to 2020 (top) and for 2021 (bottom

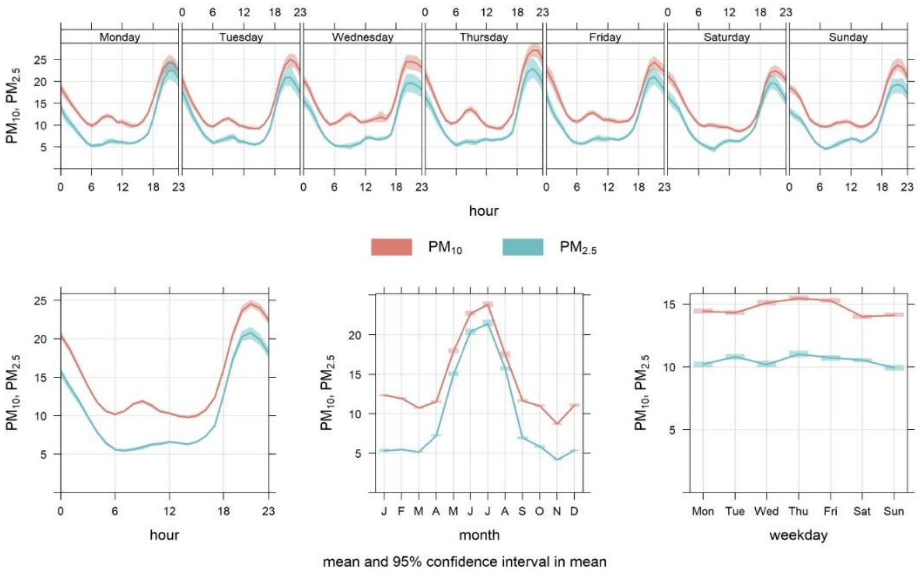


Figure 7-2: Diurnal and seasonal variations in PM_{10} and $PM_{2.5}$ concentrations from 2022 to 2024

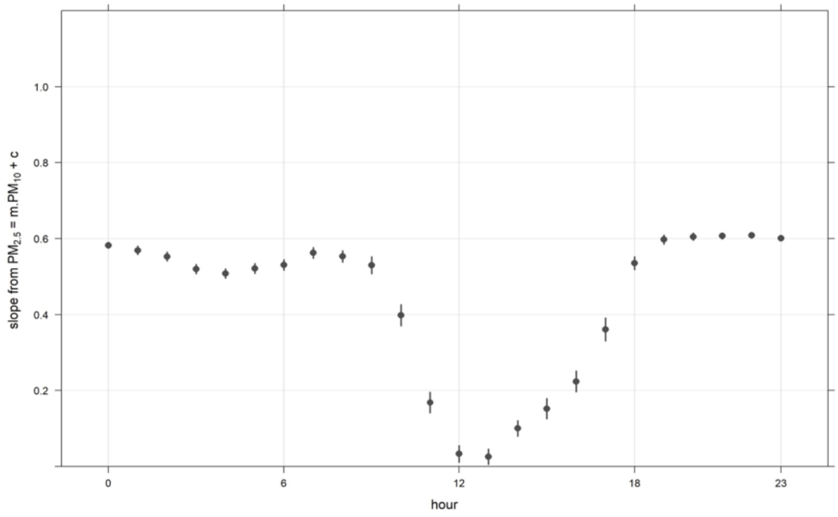
An illustration of the hourly slope of $PM_{2.5}$ to PM_{10} concentrations for 2021 (top) compared with the years excluding 2021 (bottom) is shown in Figure 7.3. This shows that during the evening/ nighttime period the majority of the PM_{10} is in the $PM_{2.5}$ size fraction for the years excluding 2021. This is typical when solid fuel burning (in particular wood) for domestic heating is the main source of PM_{10}. For 2021 only around 60% of the PM_{10} is estimated to be in the $PM_{2.5}$ size fraction during this period.

Typically, and as illustrated in the bottom graph (Figure 7.3), the $PM_{2.5}$ to PM_{10} slope decreases during the afternoon period as winds increase, dispersing the combustion related particulate and potentially increasing the coarse mode contribution which can increase with increased wind speeds. However, ordinarily there remains a small proportion of PM_{10} that is in the $PM_{2.5}$ size fraction as illustrated by a slope of around 0.2 during the afternoon period (Figure 7.3 (bottom)).

The average diurnal variations in concentrations for 2021 to 2022 (which also includes higher PM_{10} during January to April) and 2023 is shown in Figure 7.4. This shows PM_{10} concentrations during the early afternoon period for 2021 are lower than for the subsequent years and suggests some differences in the PM_{10} sampler performance during this time of day in 2021.

Overall the combination of observations for the 2021 data likely points to the PM_{10} sampler having calibration issues for the period June 2021 to around April 2022. The mass calibration co-efficient from the calibrations conducted in June 2021 and March 2022 were both outside of the typical range. The likely impact of this is a concentration multiplier which impacts more on higher concentrations, as was observed in the data. It is however, unlikely to have resulted in the lower than typical daytime concentrations. The cause of this remains unknown but appears rectified by 2022. The 2023 annual air quality monitoring report (Wilton, 2024) shows the number of breaches of the NESAQ for PM_{10} in 2021 was 15 (16 exceedances) and compares with only one exceedance for the calendar years 2022 and 2023. It is recommended that consideration be given to flagging issues with the PM_{10} data for the period June 2021 to April 2022, or deleting the PM_{10} data for winter 2021 to ensure air quality in Blenheim is not misrepresented over this period.

Slope of linear relationship between PM_{10} and $PM_{2.5}$ for 2021



Slope of linear relationship between PM_{10} and $PM_{2.5}$ for all other years

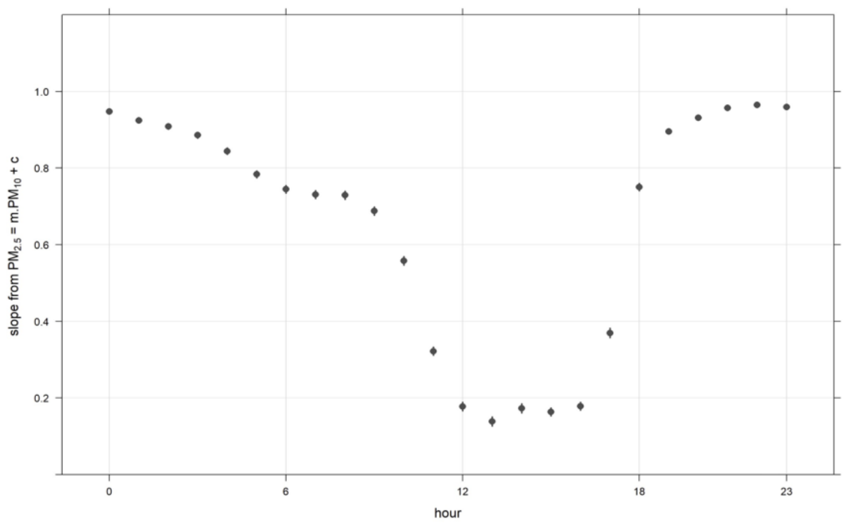


Figure 7-3: Linear Regression of slope of PM_{10} and $PM_{2.5}$ relationship for 2021 (top) and 2017 to 2024 excluding 2021 (bottom)

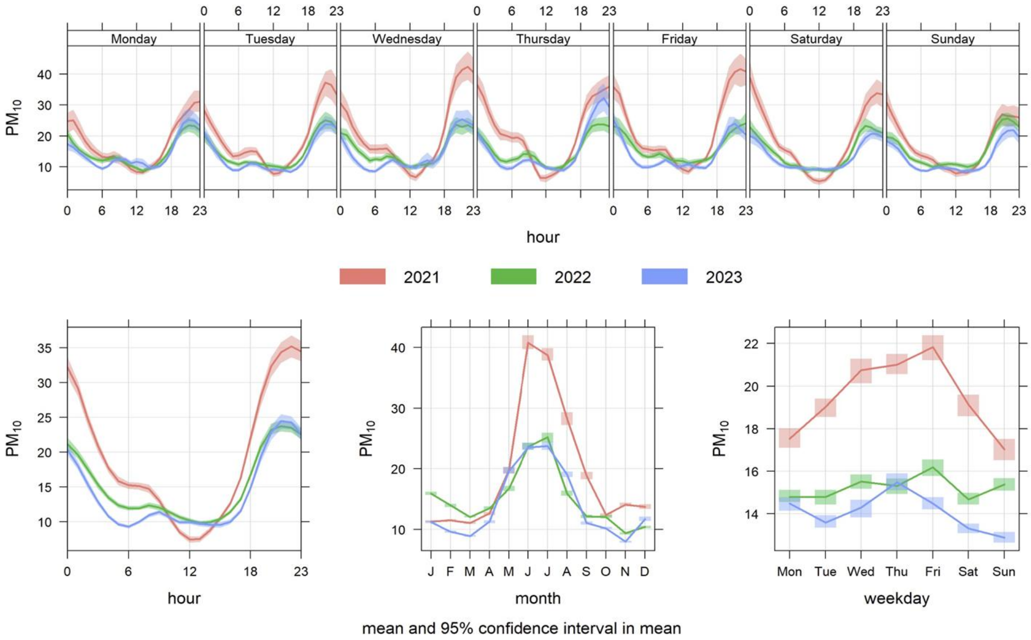


Figure 7-4: Diurnal and seasonal variations in PM_{10} concentrations during 2021, 2022 and 2023

Data indicates that concentrations of PM_{10} during the non-winter months are typically around 10 µg/m^3 and concentrations of $PM_{2.5}$ during these months are around 5 µg/m^3. Peak winter monthly PM_{10} concentrations have reduced from around 35 µg/m^3 prior to 2021 to less than 25 µg/m^3 post 2021. Reductions in peak winter monthly $PM_{2.5}$ concentrations are also evident.

These background concentrations may increase in significance with the introduction of annual average $PM_{2.5}$ standard. Management of non-winter sources may be required for example if the WHO (2021) guideline level of 5 µg/m^3 for $PM_{2.5}$ were introduced.

8 CONCLUSIONS

Concentrations of PM_{10} and $PM_{2.5}$ in Blenheim are highest over the winter period with the greatest contribution to both daily and annual average concentrations occurring when the wind is blowing from the W to SW and under low wind speeds. On the whole data are generally consistent and coherent and are indicative of significant contributions from solid fuel burning for domestic heating. The exception is PM_{10} data for the period June 2021 to around April 2022 which was found to be anomalous and likely to occur as a result of instrument calibration issues. It is recommended that consideration be given to flagging the PM_{10} data for this period as likely anomalous.

The relationship between PM_{10} and $PM_{2.5}$ concentrations varies by time of day with high $PM_{2.5}$ to PM_{10} ratios during the evening/ nighttime peaks (slope > 0.9 indicating >90% of PM_{10} is $PM_{2.5}$) and much lower ratios (slope <0.02) from midday to early evening. This is consistent with evening concentrations dominated by solid fuel burning for domestic heating and afternoon concentrations having a higher coarse mode particulate contribution (e.g., marine aerosol, fugitive dusts).

Non-winter sources of PM_{10} and $PM_{2.5}$ are likely to include marine aerosol and additionally a source to the WNW of the site makes a reasonable contribution during the non-winter months. This may reflect outdoor burning, motor vehicles or an industrial source. Whilst non-winter monthly average concentrations are significantly less than current winter averages, at around 10 $\mu g/m^3$ compared with up to 25 $\mu g/m^3$ for PM_{10} and 5 $\mu g/m^3$ compared with around 20 $\mu g/m^3$ for $PM_{2.5}$, consideration should be given to potential manageable sources, particularly of $PM_{2.5}$ during these months.

Trend analysis of PM_{10} from 2017 to 2024 shows a statistically significant decrease in PM_{10} concentrations that exists across both the winter and non-winter periods. This downward trend appears to occur across all wind speeds and directions. The greatest magnitude of impact (size of decreasing concentration) is during the winter months, for wind speeds of less than 0.8 m/s and when the wind is blowing from the W and SW wind directions.

Trend analysis of $PM_{2.5}$ concentrations in Blenheim from 2017 to 2024 shows a statistically significant decrease in winter $PM_{2.5}$ concentrations but no significant trend in annual concentrations at this stage. The decrease in winter $PM_{2.5}$ relates to concentrations occurring when the wind is from the W, SW directions and for wind speeds less than 1.45 m/s. This trend also appears in the shoulder season data (April and September) for these wind directions. A slight, but statistically significant, increase in high wind speed $PM_{2.5}$ is observed during the non-winter months.

Overall data are indicative of improvements in PM_{10} and $PM_{2.5}$ concentrations over the 2017 to 2024 period and are consistent with improvements in concentrations as a result of regulatory methods to improve emissions from domestic home heating within the WARMP.

REFERENCES

Carslaw, D. C., & Ropkins, K. (2012). openair—An R package for air quality data analysis. *Environmental Modelling & Software*, *27–28*, 52–61. https://doi.org/10.1016/j.envsoft.2011.09.008

Davy, P., & Trompetter, B. (2018). *Heavy metals, black carbon and natural sources of particulate matter in New Zealand*. GNS Science Consultancy.

Ministry for the Environment. (2020). *Proposed amendments to the National Environmental Standards for Air Quality, particulate matter and mercury emissions*. Ministry for Environment.

Ministry for Environment. (2004). *Resource Management (National Environmental Standards for Air Quality) Regulations 2004*. New Zealand Government. http://www.legislation.govt.nz/regulation/public/2004/0309/latest/DLM286835.html?search=ts_regulation_air+quality_resel&p=1&sr=1

Wilton, E. (2024). *Annual Air Quality Monitoring Report – Blenheim 2023*. Marlborough District Council Report.