# Seasonal $PM_{10}$ variations and links to climate in Invercargill and Gore

environment SOUTHLAND REGIONAL COUNCIL
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## Introduction

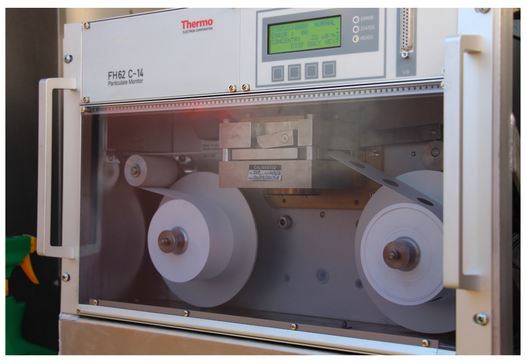
Particulate matter smaller than 10 microns in diameter ($PM_{10}$) presents a significant health risk worldwide. It can travel deep into the lungs and has been linked to a range of respiratory and cardiovascular diseases (Kuschel et al., 2012).

$PM_{10}$ comes from a variety of sources including those caused by humans, such as domestic heating, vehicle emissions and industrial processes. Natural sources are also present and include sea spray, dust, pollens and volcanic activity. Understanding the seasonal variations in particulate matter enables people to make more informed decisions about their heating choices and outdoor activities.

Environment Southland has explored the seasonal variation in particulate air pollution ($PM_{10}$) and links to meteorology at two sites in Southland. $PM_{10}$ is monitored in Invercargill at Fernworth Primary on Pomona Street, and in Gore at Resthaven Village on Main Street. The Invercargill monitoring site has been in use since April 2009, while the Gore site has been in use since May 2006.

## Methods

We used data from the Invercargill and Gore sites for the period of 2010-2017. $PM_{10}$ data was collected using a Thermo Scientific FH62 C-14 Beta Attenuation Monitor (BAM) and telemetry system. The data was then extracted from Environment Southland's Hilltop database. The 'Openair' package in the statistical software R was used to visualise the data and present it for analysis (Carslaw & Ropkins, 2012).

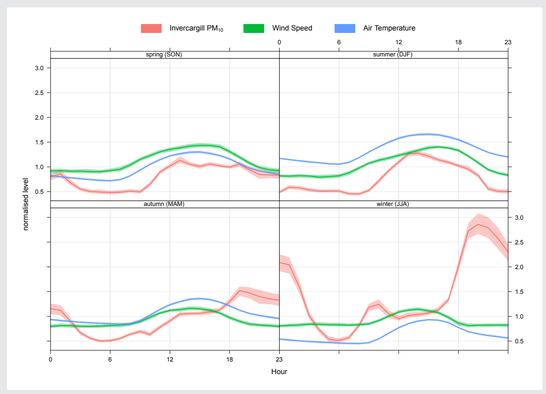



▲ **Beta Attenuation Monitor (BAM)**

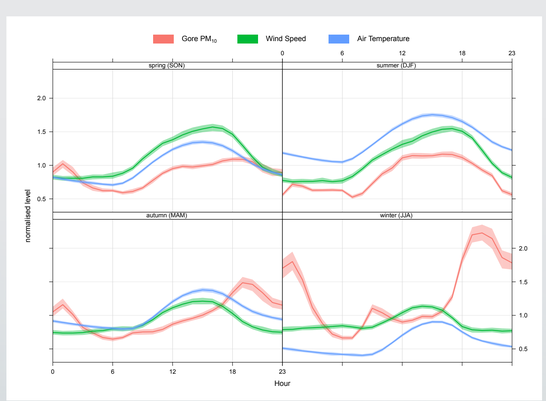
The 'timeVariation' function was first used to compare the temporal variation in $PM_{10}$ at each of the two sites. The same function was then used to display normalised diurnal cycles of $PM_{10}$, wind speed and air temperature over each of the seasons. Finally, the 'polarPlot' function was used to plot mean hourly $PM_{10}$ concentrations according to wind speed and direction. The weighted mean statistic has been used as it highlights the wind speed and direction conditions that dominate the overall mean (Carslaw, 2018).

## Results

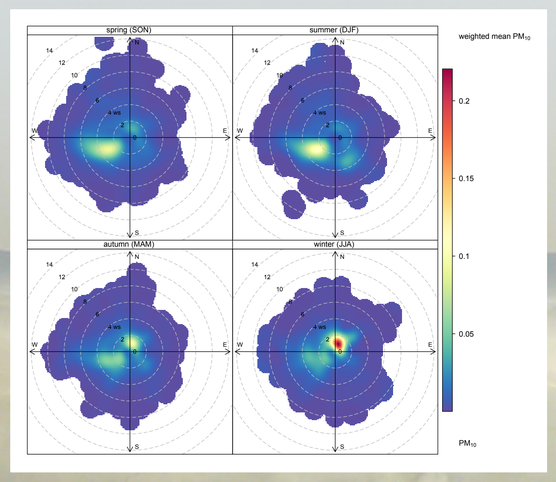

▲ **Figure 1: Time variation plot of hourly $PM_{10}$ concentration data for Invercargill and Gore, 2010-2017.**



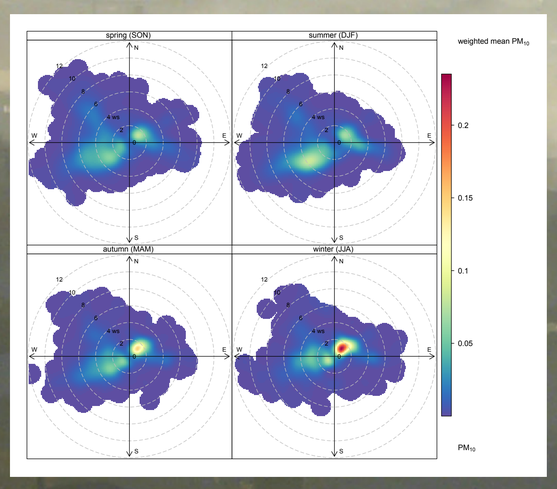

▲ **Figure 2: Seasonal normalised diurnal patterns in $PM_{10}$, wind speed and air temperature for Invercargill, 2010-2017**




▲ **Figure 3: Seasonal normalised diurnal patterns in $PM_{10}$, wind speed and air temperature for Gore, 2010-2017**




▲ **Figure 4: Seasonal polar plot using weighted mean $PM_{10}$ concentrations for Invercargill, 2010-2017.**




▲ **Figure 5: Seasonal polar plot using weighted mean $PM_{10}$ concentrations for Gore, 2010-2017.**

## Discussion

Both monitoring sites displayed distinct seasonal variations in $PM_{10}$ concentrations (Figure 1). There was a noticeable increase in $PM_{10}$ concentrations between the months of May-August. While the monthly average concentrations in Gore climbed throughout the winter period, the concentrations in Invercargill peaked in June before dropping in August.

Very similar seasonal patterns were present in both Invercargill and Gore (Figures 2 and 3). A very obvious increase in $PM_{10}$ concentrations occurred over the winter period, with a faintly similar diurnal pattern observable in autumn also.

The diurnal patterns in $PM_{10}$ across the study period were characterised by a gradual increase through the day to peak in the evening around 7pm. $PM_{10}$ concentrations appeared to be lowest around dawn and for that reason it is recommended that consideration is given to undertaking outdoor activities at that time, such as running, biking or dog walking.

It is also interesting to note that the $PM_{10}$ concentrations appeared to decrease over the weekend, particularly on Sunday. It is possible that this decrease is linked to fewer emissions occurring at that time (e.g. less burners used in homes, less vehicle traffic). Further source specific investigations are required to determine the reason for the pattern observed over the week.

The polar plots (Figures 4 and 5) also indicate a strong pollution signal during the winter period. In Invercargill the peak concentrations appear to be associated with wind speeds of less than 2 $ms^{-1}$, from a north or north-east direction. Outside of the winter, elevated $PM_{10}$ concentrations appear to originate from a south-westerly direction. Elevated $PM_{10}$ concentrations in Gore also appear to originate from a north-easterly direction in the winter and a south-westerly direction in spring and summer.

The next steps for Environment Southland are to undertake a more detailed assessment of the influence of synoptic scale weather patterns and the Southern Oscillation Index. Further source characterisation sampling is also recommended to gain more insight into the dynamic behaviour of particulate matter in the boundary layer.

## References

**Carslaw, D.C. and K. Ropkins,** (2012). openair — an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, pp. 52–61.

**Carslaw, D.C.** (2018). The openair manual – open-source tools for analysing air pollution data. Manual for version 2.2-4, University of York (p.281).

**Kuschel, G., Metcalfe, J., Wilton, E., Guria, J., Woodward, A., Hales, S., & Rolfe, K.** (2012). Updated Health and Air Pollution in New Zealand Study – Volume 1: Summary Report. Prepared for Health and Research Council of New Zealand, Ministry of Transport, Ministry for the Environment and New Zealand Transport Agency. Retrieved from www.hapinz.org.nz.