INTERANNUAL METEOROLOGICAL DRIVERS OF TASMANIAN WINTER-TIME AIR QUALITY

John Innis[1]

[1]EPA Tasmania, GPO Box 1550 Hobart TAS 7001 Australia

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1. Summary

The time-series of Tasmanian $PM_{2.5}$ measurements is currently just over one decade in extent for Launceston (Ti Tree Bend station) and Hobart (Prince of Wales Bay/New Town stations). In winter, wood smoke from residential heating is the dominant source of $PM_{2.5}$. The relocation of the Hobart monitoring site during this interval complicates data interpretation, but the Launceston data form a homogeneous set. These time-series can be used, in a preliminary sense, to look for trends and longer-term behaviour.

There is interannual variability in mean winter $PM_{2.5}$ at Launceston. Previous analyses searching for meteorological determinants such as mean ambient temperature, wind speed and number of frosty nights did not show clear correlations.

In this study, we have found good correlation between the mean barometric pressure and mean winter $PM_{2.5}$ concentrations at Launceston. This paper will present the analysis and attempt to frame the work in the context of climate change.

2. Launceston, Tasmania – 2006-2016

Tasmania's second largest city of Launceston is knonw for its winter woodsmoke issues. Significant effort has been expended in earlier decades to reduce woodsmoke emissions and concentrations through programs such as woodheater buy-backs and education. Probably the most significant influence was the the National Heritage Trust buy-back program, which was largely completed by the mid 2000s. Since then Launceston's winter air quality has been reasonably consistent from year to year, with typically around 10 winter-time exceedences of the National Environmental Protection Measure 24-hour $PM_{2.5}$ standard of 25 μg/m^3, and with a winter (1st May-31 Aug) mean PM2.5 usually in the range from 12 to 16 μg/m^3. Notable exceptions were the winters of 2011 (mean PM2.5 of 11 μg/m^3) and 2016 (mean of 9.7 μg/m^3), as can be seen in Figure 1.

Anectodally, it was apparent that winter 2016 was much windier and wetter than usual. A succession of cold fronts moved across Tasmania, particularly in early winter, with relatively few instances of settled anti-cyclonic conditions that result in cold, calm and smoke-filled nights.

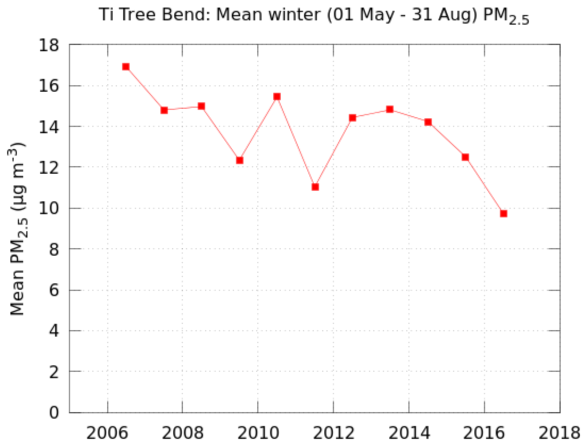

Illustration 1: Mean winter (1st May-31st Aug) $PM_{2.5}$ measured at Ti Tree Bend reference level air station, 2006-2016.

The mean winter barometric pressure measured at Ti Tree Bend over the 2006-2016 interval is shown in Figure 2. A similar variation is apparent. This is confirmed by the scatter plot of mean pressure against mean PM2.5 shown in Figure 3. The data are highly correlated. The nominal slope is that a 1 hPa increase in mean winter barometric pressure leads to a 1 μg/m^3 *increase* in mean winter $PM_{2.5}$. Winter 2016 clearly shows as an atypical point in Figure 3.

Figure 4 shows the monthly-averaged pressure history at Ti Tree Bend from 2003. The thicker symbols denote May (i.e. the start of winter). Itis seen that not only was May 2016 anomalously low for that month, but it was one of the lowest monthly mean pressures in this time series. The Bureau of Meteorology reported that the mean pressure for Hobart in May 2016 was the fourth lowest since records began in 1882.

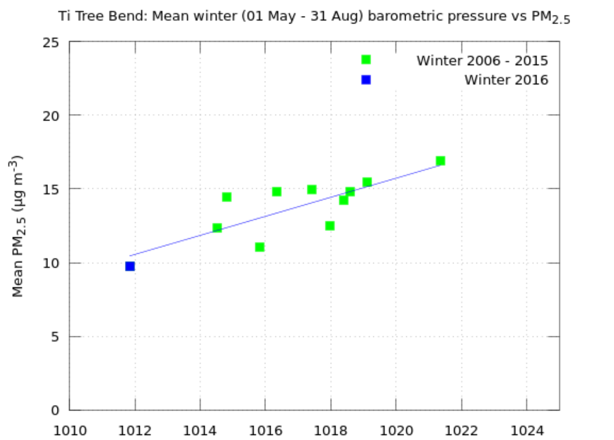

Illustration 3: Scatter plot of mean winter PM2.5 and mean winter barometric pressure at Ti Tree Bend, 2006-2016.

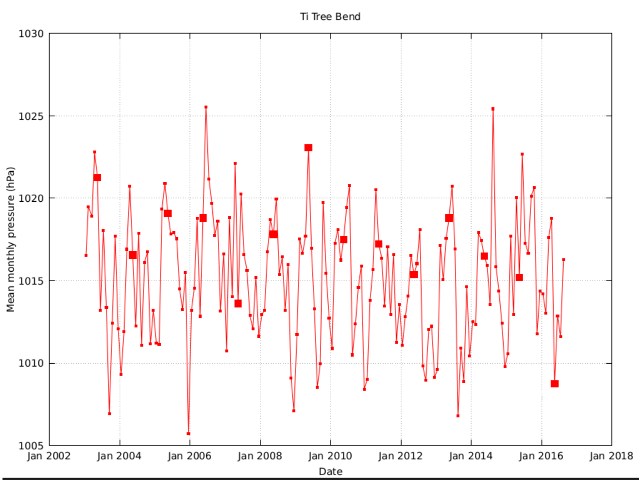

Illustration 4: Time-series of monthly mean barometric pressure, Ti Tree Bend. Thicker symbols denote the month of May each year.

Inspection of the Bureau of Meteorology surface pressure charts, both during and subsequent to the winter of 2016, indicated the usual winter-time more southerly passage of high-pressure systems over Australia did not establish itself. The latitudes of the centre of the high-pressure systems as they tracked to the east followed a more summer-like pattern. At Ti Tree Bend mean winter $PM_{2.5}$ is less well correlated with mean ambient temperature than with mean barometric pressure. An interval of high barometric pressure is often marked by calm and cold weather, as noted, and hecne in a sense incorporates both temperature and wind into the one quantity.

It is explicitly noted that the correlation between $PM_{2.5}$ and barometric pressure is much less well defined for day-averaged data, as shonw in Figure 5. The nominal gradient indicates a 1 C increase in mean winter temperature leads to a 1 $\mu g/m^3$ *decrease* in mean winter $PM_{2.5}$.

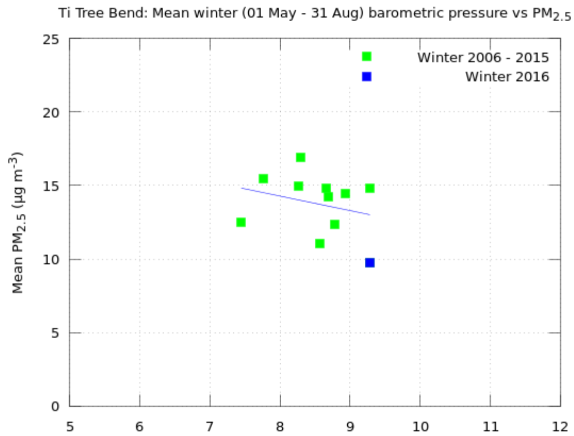

Illustration 5: Scatter plot of mean winter $PM_{2.5}$ and mean winter ambient temperature at Ti Tree Bend, 2006-2016.

3. Implications in a changing climate

The Australian government climate future web site (https://www.climatechangeinaustralia.gov.au/en/climate-projections/climate-futures-tool/projections/) was used to explore some possible future air quality scenarios. The dependence of mean winter PM2.5 with respect to mean barometric pressure and mean temperature, derived above, have been used in this hypothetical study.

The summary output of two emission scenarios were inspected, being RCP 4.5 (somewhat optimistic curbing of carbon emissions by mid centruy, with CO_2 concentrations stabilising near 500 ppmv by 2100) and RCP 8.5 (effectively free growth in emissions, with CO2 concentrations reaching to near 900 ppmv by 2100), for the month of May in the years 2030, 2040, and 2060.

In general there is no clear consensus in the changes to mean surface temperature or mean sea-level pressure from the various models presented on the climate futures web page, but there appears to be an indication that both mean surface temperature and surface level pressure will increase. The size of the increases are of course very difficult to determine, but could be of order 0.5 to 1 C and 0.5 to 1 hPa. If the relationships derived above for Ti Tree Bend between these quantities and mean winter $PM_{2.5}$ have validity, and validity into the future, it suggests that climatic drivers may result in a small decrease in mean winter $PM_{2.5}$ in Launceston in the coming decades.