

Why is the number of high pollution days in Christchurch higher in 2011 compared to recent years?

Environment Canterbury
Air Quality Teams
E11/37 October 2011

Why is the number of high pollution days in Christchurch higher in 2011 compared to recent years?

Overview

Analysis following indicates that 16 high pollution days in 2011 can be attributed to dust from earthquake silt, damaged roads or grit. The remaining 12 high pollution days are on a par with the number of high pollution days in the last couple of years. Similar comparisons in other towns indicate that 2011 has not been a winter with increased high pollution days in the Canterbury region. A comparison of non-earthquake related concentrations indicates that emissions in Christchurch are likely to be decreasing still.

Winter weather?

An assessment of the winter weather has not been made, but a comparison of air pollution days around the region, in comparison with previous years, can indicate regional weather trends. Table 1 shows the total number of high pollution days in Canterbury towns each year and table 2 shows the highest concentration measured each year.

More high pollution days were measured in Christchurch in 2011 than in the last 5 years, but less than in 2005 (32 days). The numbers to date in Kaiapoi haven't varied much in the last three years, Ashburton has had a couple more days in 2011, and Rangiora has had less than last year, but more than previous years. Numbers are lower in Geraldine, Timaru and Waimate. As similar weather is experienced across the Canterbury Plains, this indicates that the winter weather doesn't account for the increased numbers of high pollution days in Christchurch. It is more likely that a number of the high pollution days in Christchurch were related to factors other than home heating emissions.

Table 1: Number of high air pollution days each year:

Number of days of PM ₁₀ >50	Christchurch St Albans	Kaiapoi	Rangiora	Ashburton	Geraldine	Timaru	Waimate
2006	27	28	15	26	-	36	10
2007	14	20	4	13	2	36	0
2008	18	19	6	15	6	37	7
2009	13	24	3	9	8	38	10
2010	12	23	13	11	4	49	9
2011	28	24	11	15	3	26	8

Table 2: Maximum daily average concentration each year:

Daily average PM ₁₀ ug/m ³	Christchurch St Albans	Kaiapoi	Rangiora	Ashburton	Geraldine	Timaru	Waimate
2006	184	161	138	136	-	190	95
2007	120	104	107	90	55	128	50
2008	87	86	61	90	72	109	59
2009	85	86	88*(54)	128*(76)	94*(67)	134	112*(89)
2010	91	98	91	79	58	148	97
2011	112	110	70	86	56	113	64

* Dust event of 14 September 2009. Value in brackets is next highest.

Dust?

The high pollution days measured at the Christchurch St Albans monitoring site include two in March related to wind blown silt. Another one in mid March and all the high pollution days from mid June appear to have some component of natural coarse (2.5 to 10um) particles, as well as fine combustion (<2.5um) particles. This can be deduced from comparing concentrations of PM₁₀ with concentrations of PM_{2.5} at the same site. PM_{2.5} monitoring has been carried out in St Albans from 2001 to 2005, but not consistently. It was started again early in 2011.

In 2001 (and other years) the concentrations show a consistent relationship between PM₁₀ and PM_{2.5}, especially when high (figure 2a). This is described by the equation $PM_{2.5} = 0.98 * PM_{10} - 4.91$ with $r^2=0.97$. When concentrations are low (less than ~35 ug/m³) there is an additional relationship indicated. At these times, there are fewer fine particles in the PM₁₀ concentrations. The relationship in 2011 (figure 2b) shows many days when the PM_{2.5} concentrations were much less than the PM₁₀ ones, while some are more closely aligned to the relationship shown in earlier years for high concentrations. The dates some concentrations were measured in 2011 are shown in figure 3.

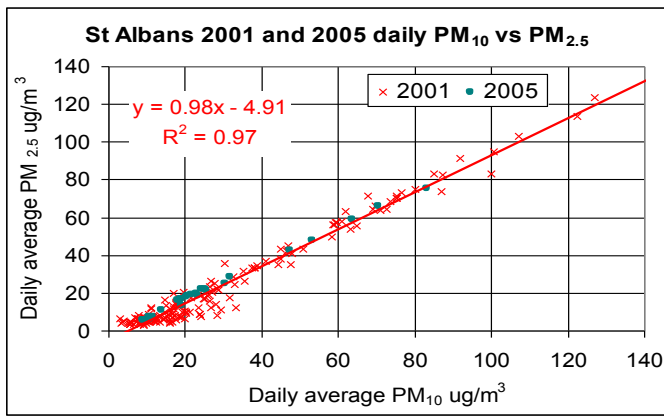


Figure 2a: PM₁₀ vs. PM_{2.5} in 2001 and 2005

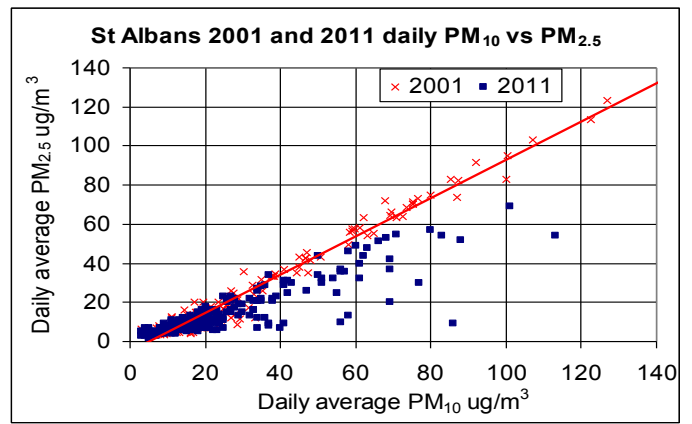


Figure 2b: PM₁₀ vs. PM_{2.5} in 2001 and 2011

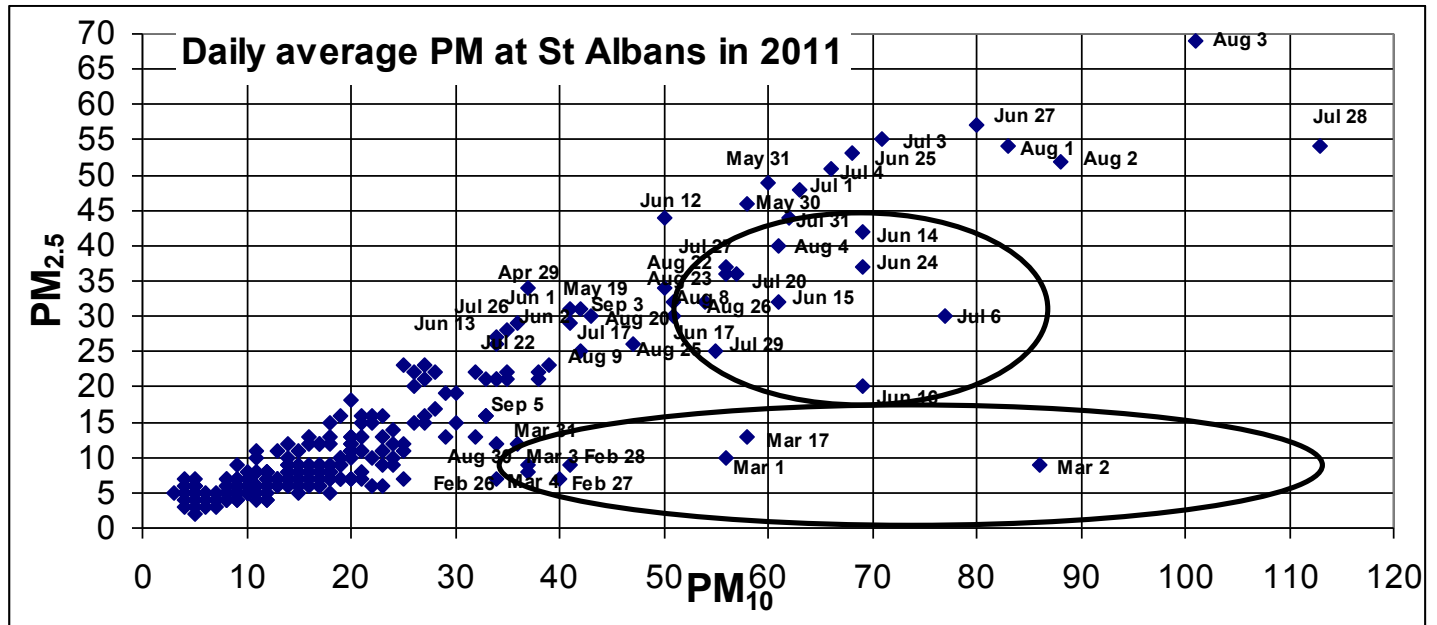


Figure 3: PM₁₀ vs. PM_{2.5} daily concentrations at St Albans from January to September 7, 2011

There were a number of sources of coarse particles during 2011, with liquefaction in the St Albans area from the 22 February and 13 June earthquakes, road works in the area and grit on the roads after the snowfalls on July 25/26 and August 15/16. Significant amounts of dust were evident during strong winds in late February and early March and these can be seen in figures 3 and 4 with high PM₁₀ concentrations and low PM_{2.5} concentrations. The PM_{2.5} concentrations in figure 3 and 4 indicate that there were also significant amounts of dust (2.5 to 10 µm) in mid June, though the weather was also still and cold and fires were in use, so combustion particles are evident as PM_{2.5}. The upper circle in figure 3 highlights concentrations from June 14 to June 24, some dates in July and late August, which show this combination, while other dates are more similar to the relationship shown in figure 2a.

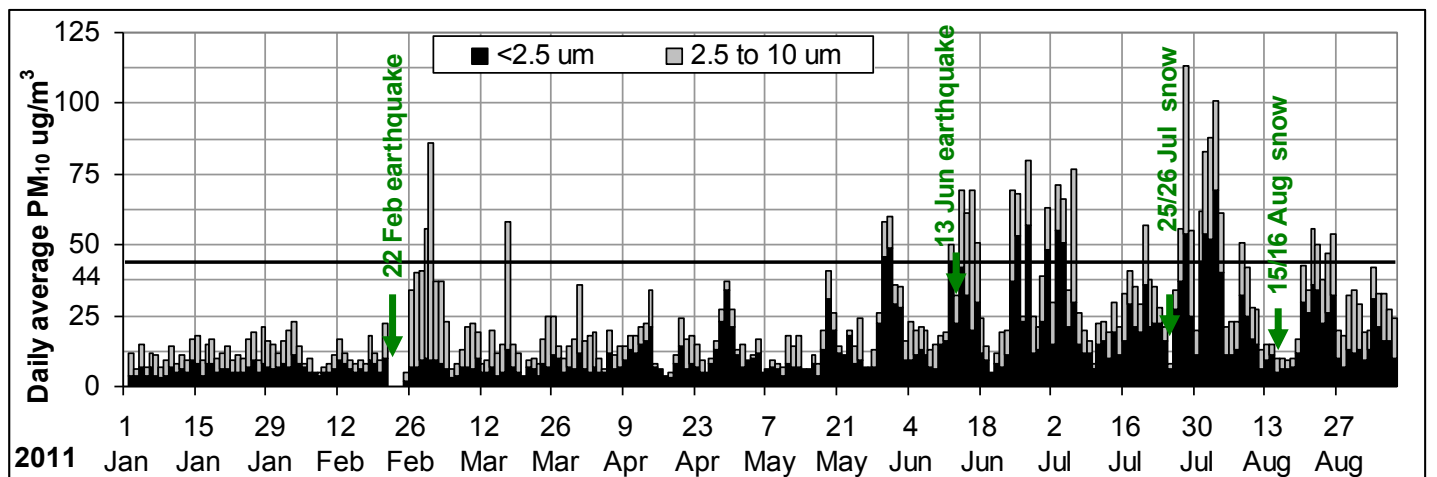


Figure 4: Daily concentrations of PM₁₀ (column height) comprising PM_{2.5} and PM_{2.5-10} concentrations, measured at St Albans

Using the equation above from 2001, a PM_{10} concentration of $50 \mu\text{g}/\text{m}^3$ could be described as equivalent to a $PM_{2.5}$ concentration of $44 \mu\text{g}/\text{m}^3$. All of the circled markers in figure 3 have $PM_{2.5}$ concentrations of less than $44 \mu\text{g}/\text{m}^3$, so if the same relationship to PM_{10} applied in 2011, none of the dates in either circle would be high pollution days. That accounts for 16 of the 28 reported high pollution days in 2011. The remaining 12 days that have both a PM_{10} concentration greater than $50 \mu\text{g}/\text{m}^3$ and a $PM_{2.5}$ concentration greater than $44 \mu\text{g}/\text{m}^3$ (PM_{10} on June 12 was not greater than 50). Looking back to the number of high pollution days shown in table 1, if the total for Christchurch St Albans was 12 rather than 28, it would look more similar to the last few years and the pattern in other towns.

Increased emissions?

It is difficult to measure emissions of PM_{10} directly at any one time. However by examining the maximum **hourly** concentrations of PM_{10} (not the 24-hour averages described above), we can get an indication of the PM_{10} emissions at that time. This assumes that there was at least one hour each winter with 'ideal' weather conditions for high air pollution, which is generally true. These weather conditions are low wind speed, temperature inversion and cold temperatures, from sunset through the night.

In 2011 the highest hourly PM_{10} concentration ($342 \mu\text{g}/\text{m}^3$) was measured at 6pm on 6 July. At this time the $PM_{2.5}$ concentration was 72. This is at a different time of day to every other year's maximum (usually around midnight), and it was warmer than normal, and the two concentrations (PM_{10} and $PM_{2.5}$) were very different, so it is likely that this maximum was caused by dust, not woodburners. If we find the highest $PM_{2.5}$ concentration in 2011, and select the hourly PM_{10} concentration at that same time, that value ($257 \mu\text{g}/\text{m}^3$) compares better with previous years and is more likely to be an indicator of woodburner emissions in 2011. Both concentrations for 2011 are shown in figure 5.

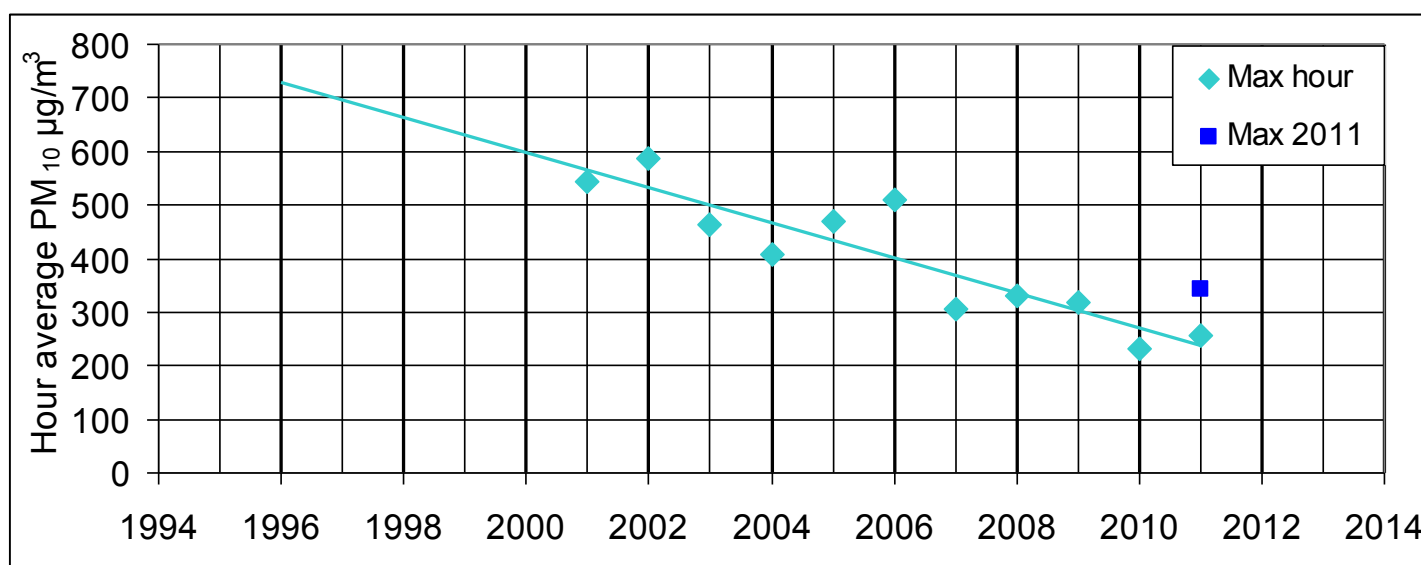


Figure 5: Maximum hour average PM_{10} concentration measured each year at the St Albans monitoring site.

Summary

Indications are that there has been, and continues to be, an unusually large amount of dust in the air in Christchurch during 2011. The dust is likely to be from silt, damaged roads and grit, and an increased amount of dust can be seen after each major earthquake and after each snow event. The increased concentrations are from particles between 2.5 and 10 μm in diameter. These larger dust particles are not as harmful to us as those combustion particles that are less than 2.5 μm in diameter, as the smaller the particle, the further they can be inhaled into our lungs. A dust mask helps protect from the dust particles, but not the combustion ones.

Ignoring the dust particles, the number of typical high pollution days ($PM_{2.5}$ concentrations greater than $44 \mu\text{g}/\text{m}^3$) is similar to the last few years and indications are that emissions of combustion particles are continuing on a downward trend in Christchurch.