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Assignment 1: Local Air Quality

Introduction

For this assignment I choose to look at particulate matter that is 2.5 microns or smaller (PM2.5) in the city of Abbotsford, British Colombia in 2004. To understand the concentrations of PM2.5 for the Abbotsford area, pollution sources and sinks as well as meteorological, and geographical effects must be analyzed.

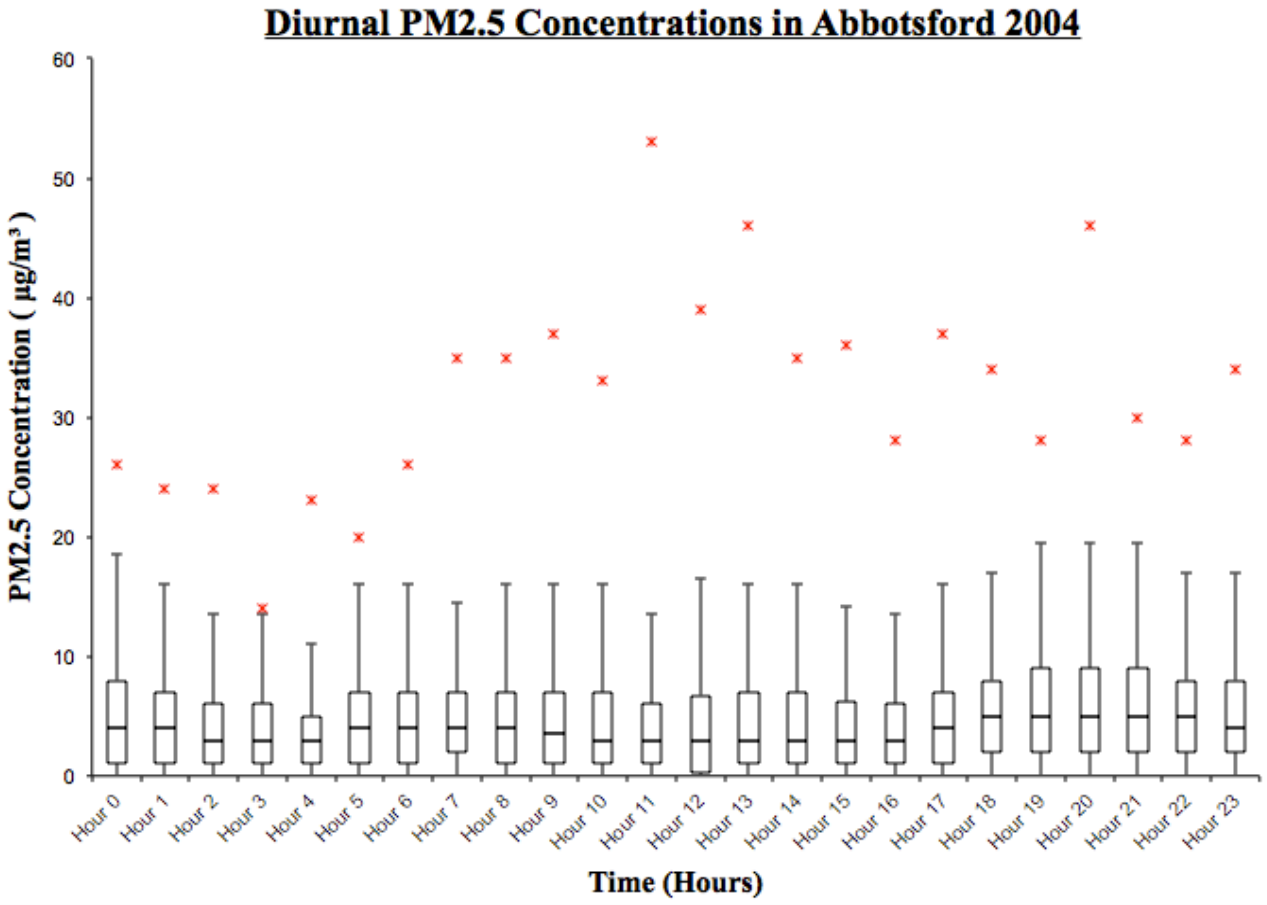
Sources and Sinks

Particulate matter is airborne particles that range in size, which can be emitted on a small scale or large scale. In this case we are interested in particulate matter that is 2.5 microns or smaller. Some of the major emitters of PM2.5 that would affect Abbotsford include highways/roadways (vehicles), air traffic (airplanes), forest fires, industrial/commercial areas, residential areas, and marine shipping traffic. There are other sources but those listed above are the primary sources that contribute to Abbotsford's PM2.5 concentrations.

PM2.5 is not necessarily life threatening; in fact, few people die each year due to air pollution. Although, since the particles are extremely small, humans breathe them deep into their lungs, which then poses heath hazards. This is more of an inconvenience then a major health risk. On a poor air quality day, people are more likely to find it hard it breathe or to feel sick causing them to stay indoors. There are two factors that affect your heath when it comes to pollutants like PM2.5, exposure and dose. Exposure refers to how many pollutants you are exposed to over a certain time and dose refers to how many pollutants you breathe in (heavy or light breathing). Therefore, large concentrations of PM2.5 would greatly affect athletic activities

outside due to the higher dose athletes would be receiving through heavy breathing. The exposure would depend on how long they are outside for. What is clear is that PM2.5 has a direct impact on humans and mainly affects respiratory function.

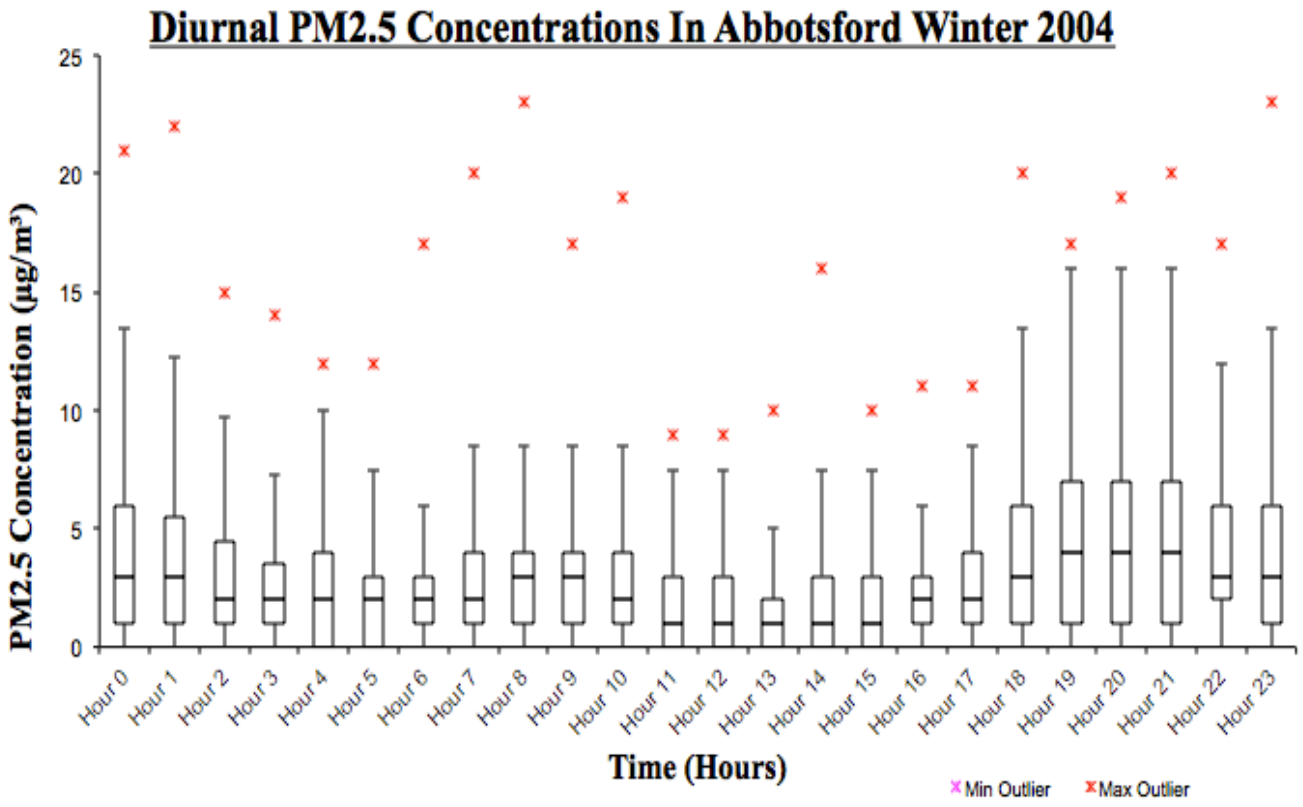
Analysis and Summary Graphs



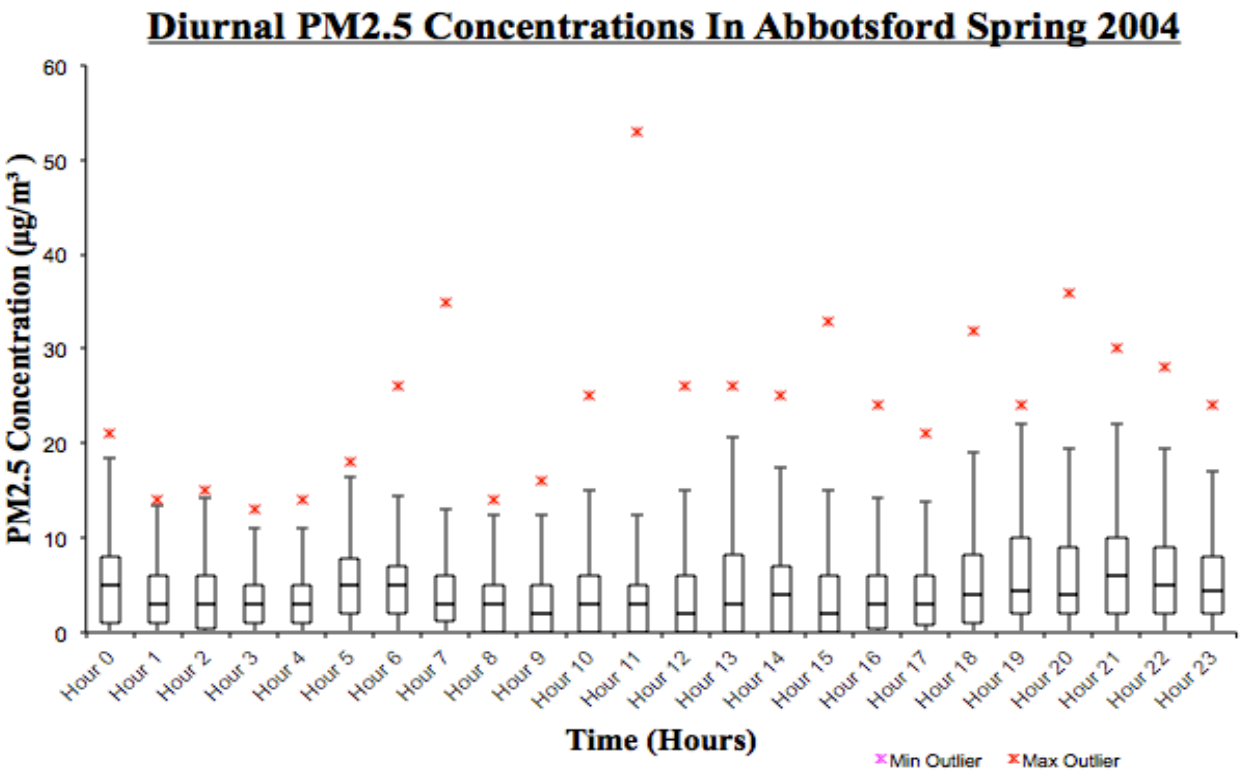
(Figure 1)

Figure 1 shows PM2.5 concentrations for each day of the year over a 24-hour period in Abbotsford. The over all concentration of PM2.5 is low, and the shape of the graph is expected. There is a clear increase in PM2.5 concentration from hour 5 to hour 9 and then a decrease over the afternoon with another increase again from hour 17 to hour 21. The reason for the increases

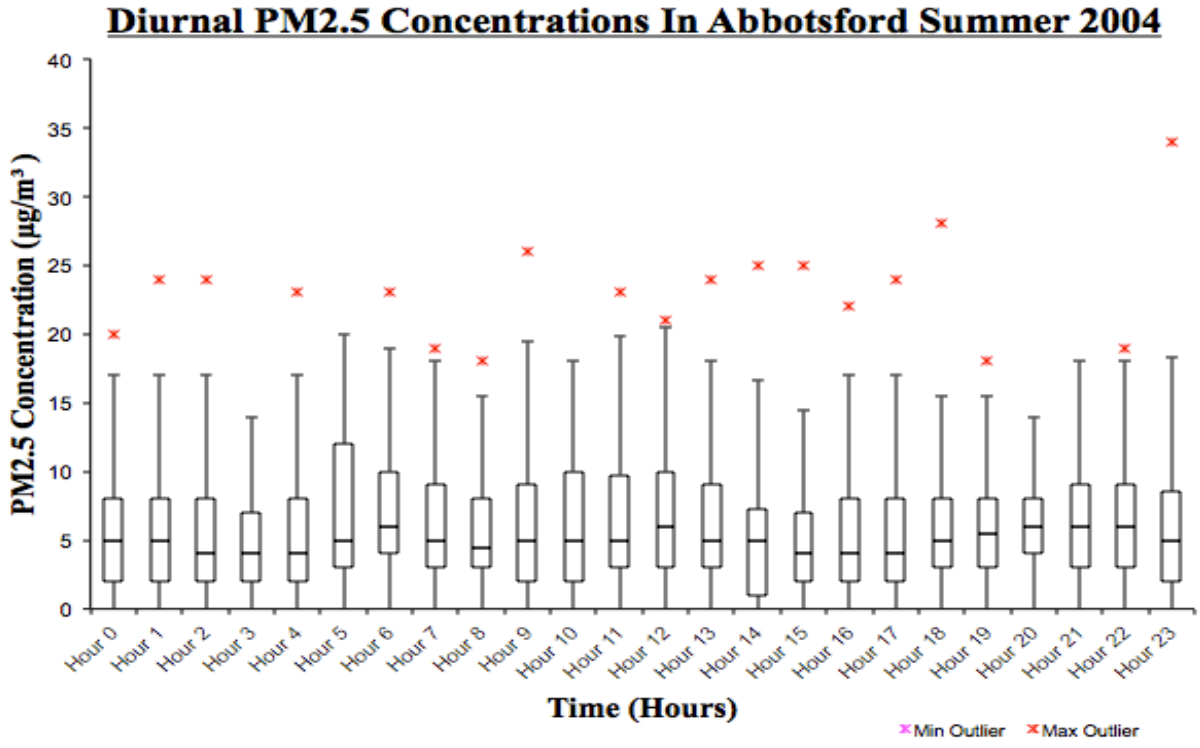
is due to rush hour traffic at the morning and in the evening. A large amount of people all commute to work and back home again in their vehicles causing spikes in PM2.5 concentrations during those time periods. There are a number of max outliers, which would most likely be caused by microclimates, or meteorological events that affect the Abbotsford area. These will be discussed later. The next four figures break down PM2.5 concentrations for each season: winter, spring, summer and fall.



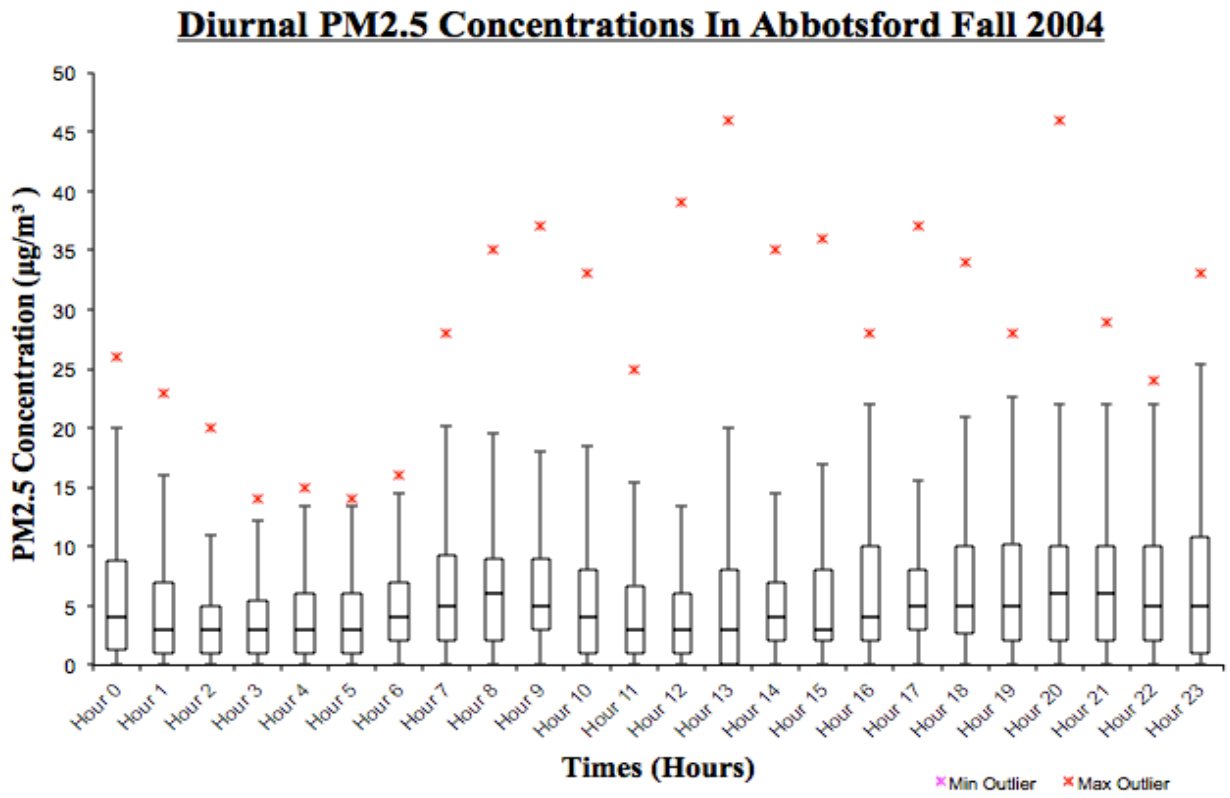
(Figure 2)



(Figure 3)



(Figure 4)



(Figure 5)

As you can see the same pattern of higher concentrations of PM2.5 occurs in the morning and at night due to rush hour traffic during each season. It looks like the concentrations of PM2.5 are fairly constant with slightly lower concentrations in winter ***(figure 2)*** and higher variation between high and low concentrations at specific times of the days. There is also a high variation between high and low concentrations at specific times of the day in the fall ***(figure 5)***. The reason for this variation in winter and fall could be due an increase in people driving to work during rush hour in the morning and in the evening. This could be because it usually rains a lot during these seasons, which would cause more people to drive rather than use other forms of transportation. This is why the variations are more constant in summer ***(figure 4)*** and spring ***(figure 3)*** because the weather conditions are better, and that gives people more transportation alternatives, like biking or walking. I also noticed the highest concentrations of PM2.5 are in the summer and this could because of forest fires, increases in construction which causes dust, and

the fact that more people want to get out and enjoy the nice weather. When it is raining in the winter and fall people are more likely to stay indoors and only go out when they have to.

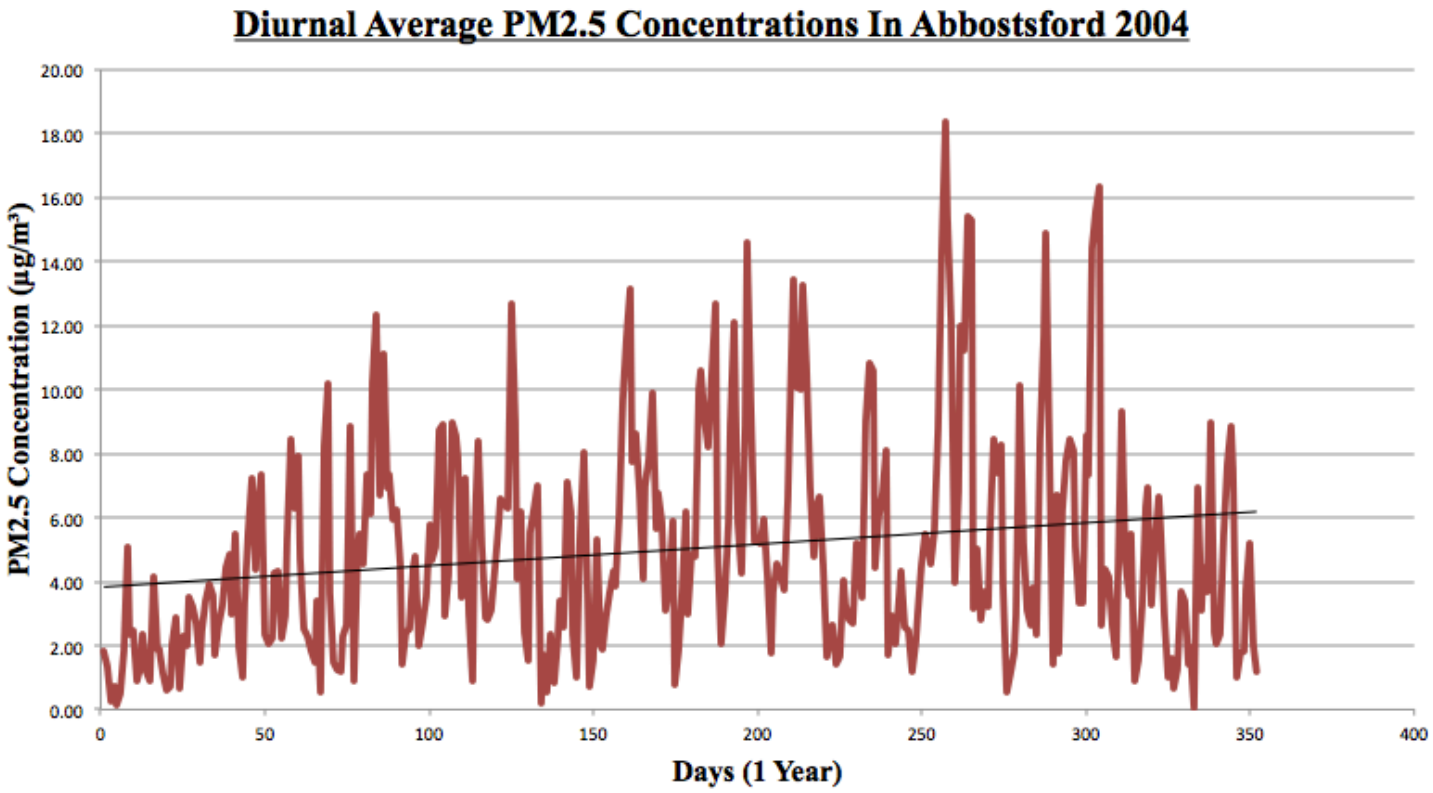
Air Quality Standards

Since air pollution is a problem and can affect your health, the Government of Canada has set specific standards that have to be met. For PM2.5 over a 24-hour period the average concentration cannot exceed 28μg/m^3. ***Figure 6*** shows the standards that have to be met in Canada for specific pollutants.

Pollutants	Old Standards	New Standards	
		2015	2020
$PM_{2.5}$ Annual	-	10 μg/m^3	8.8 μg/m^3
$PM_{2.5}$ for 24-hour	30 μg/m^3	28 μg/m^3	27 μg/m^3
Ozone for 8-hour	65 parts per billion	63 parts per billion	62 parts per billion

(Figure 6) ***Source:*** Environment Canada. Web. http://www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=A4B2C28A-2DFB-4BF4-8777-ADF29B4360BD.

After calculating the 24-hour average concentrations for Abbotsford, I can conclude that the concentrations in 2004 did not exceed the standard of 28μg/m^3. ***Figure 7*** below shows this diurnal average of PM2.5 and how it fluctuates each day. The highest the average diurnal concentration got in the Abbotsford area looks to be just over 18μg/m^3. This is good news, but just because this area of Vancouver is below the standard it does not mean that other areas are. This is where meteorology and geographic location are important in explaining how pollutants can be dispersed and clustered in specific areas.



(Figure 7)

Meteorological and Geographical Effects On PM2.5 Concentrations

Abbotsford's location geographically plays a large role in synoptic scale climate effects as well as mesoscale climate effects. Starting from synoptic scale effects, Abbotsford is located in the mid- latitudes and is near the Pacific Ocean. It experiences large low-pressure systems off the Pacific Ocean. These low-pressure systems do a good job of dispersing air pollutants because of their strong winds and heavy rains. That is why in the winter ***(figure 2)*** and fall ***(figure 5)*** there are slightly lower PM2.5 concentrations due to a greater number of low-pressure systems. It is the opposite for the summer time, where high pressure dominates and Subsidence occurs. Other synoptic scale effects are boundary layer venting and trans-pacific pollution transport. These events carry pollutants and dust from Asia and Africa across the Pacific Ocean, which then affects Vancouver. These events would cause drastic spikes in PM2.5 concentrations and cause outlier values which would explain some of the extreme outlier values in the winter ***(figure***

2), spring ***(figure 3)***, and fall ***(figure 5)***. It is hard to pinpoint these events exactly because of the lack of information about when these events occur.

On a smaller scale, there are a number of mesoscale processes that affect Abbotsford and cause increases in PM2.5 concentrations. First, because of its location, pollutants produced in Vancouver often get blown down valley due to the prevailing westerly winds. This leads to higher concentrations of pollutants like PM2.5 outside of Vancouver in areas like Abbotsford. The boundary layer plays a very important role in pollution dispersion. Often during the summer months, warmer conditions during the day cause convection and dispersion of pollutants while at night an inversion forms where the air is cooler at the surface then it is in the atmosphere. These types of conditions are said to be very stable and can cause capping inversions where pollutants get trapped in a shallow boundary layer near the surface. Thus, we see higher concentrations of PM2.5 at night in spring ***(figure 3)*** and summer ***(figure 4).*** Another reason we see higher concentrations during the late evening in spring and summer is due to anabatic and katabatic winds. During the day anabatic winds cause warm air to rise along mountain slopes, and at night katabatic winds cause cool air to sink into the valley causing stable conditions and an inversion, which traps pollutants. In the summer months we also have the formation of land and sea breezes. A sea breeze is very important because during a sea breeze event, pollutants emitted from the greater Vancouver area are transported down valley into places like Abbotsford. This could explain the higher concentrations of PM2.5 during the day in summer ***(figure 4).***

Conclusions

Air pollution is very complicated and dependent on emission sources as well as geographical and meteorological influences. While it is not life threatening, in most cases it still poses health risks. Abbotsford is located in a complex area, which makes it hard to predict and

understand pollution dispersion. The above analysis of PM2.5 concentrations explains why certain patterns exist seasonality and the meteorological/geographical influences that cause these patterns. We can conclude that Abbotsford's PM2.5 concentrations in 2004 were lower and within the 2015 standard set by the Canadian Government.

References

- Ian McKendry: Course notes and website: http://ibis.geog.ubc.ca/courses/geob402/
- Environment Canada Website: http://www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=A4B2C28A-2DFB-4BF4-8777-ADF29B4360BD.