Ozone Concentrations

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Executive Summary

This report investigates how the level of the air pollutant ozone is related to different meteorological conditions. It was found that wind, solar radiation and temperature are all important factors in explaining the ozone concentration. On days with high temperatures and low wind speeds the ozone concentration is strongly dependent on the amount of solar radiation: the ozone level tends to be high on days with high radiation levels and low on days with low radiation levels. On cool windy days, the ozone levels are low for all levels of radiation. This indicates that high ozone levels occur when hot, stagnant days are combined with high levels of solar radiation.

1 The Data

The data consists of values for wind, radiation, temperature, and ozone. Wind speed is measured in miles per hour, solar radiation in Langleys, temperature in degrees Fahrenheit and ozone in parts per billion (ppb). These variables were measured on 111 days, from May to September, at sites in the New York metropolitan region. Table 1 summarises the distribution of values for each of the four variables. Temperatures ranged form quite cool (57°F $\approx$ 14°C) to very warm (97°F $\approx$ 36°C) and the wind speed ranged from 2.3 mph (3.7 km ph) to 20.7 mph (33.1 km ph). Both the levels of radiation and the levels of ozone varied over a wide range. The ozone readings are noticeably skewed. Most are quite low (approximately 75% are below 62 ppb) but there are a small number of very high readings (up to 168 ppb).

Table 1: Summary of Data

	Wind	Temperature	Radiation	Ozone
minimum	2.3	57	7	1
lower quartile	7.4	71	113.5	18
median	9.7	79	207	31
upper quartile	11.5	84.5	255.5	62
maximum	20.7	97	334	168

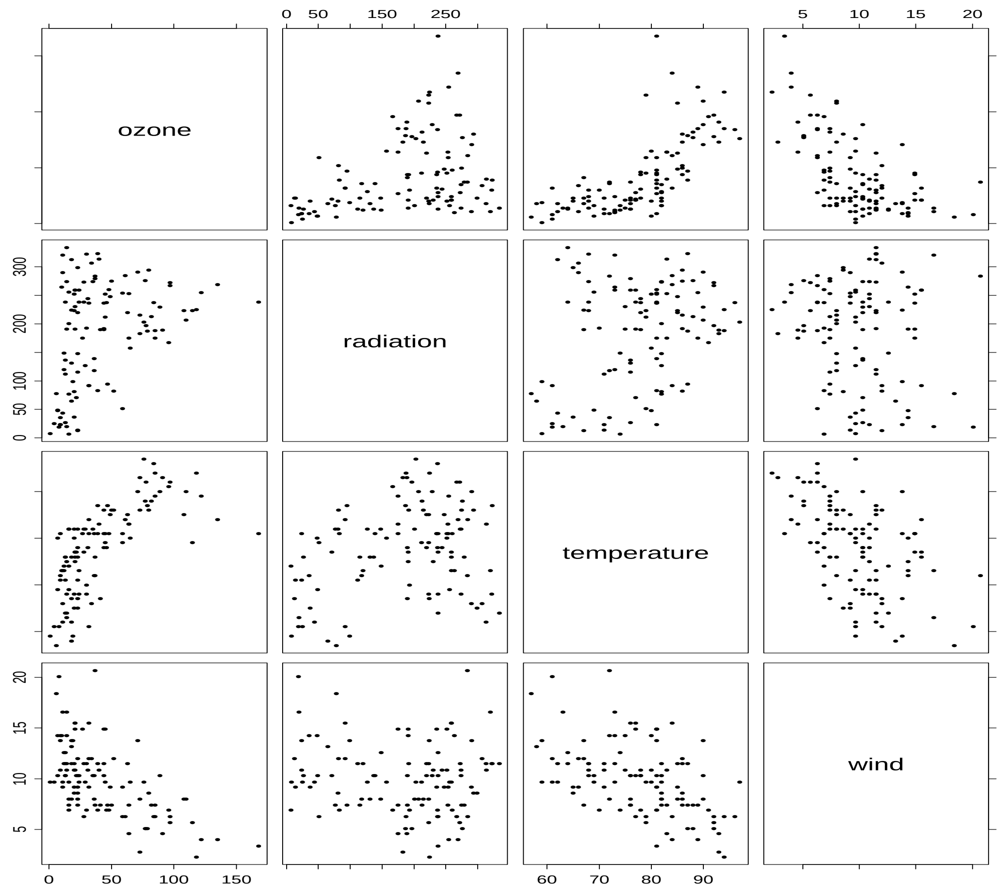

Figure 1: Pairwise scatter-plots of the data.

2 The relationships between the measured quantities

First consider the relationship between pairs of the variables. Figure 1 shows pairwise scatter-plots of the data. Each of these plots summarises the relationship between the plotted variables ignoring the other variables. The effect of temperature, wind, and radiation on ozone can be seen and are discussed first. It is clear that as temperature increases the level of ozone tends to increase, whereas as the wind speed increases the level of ozone tends to decrease. The plot of ozone versus radiation reveals an interesting triangular shape. It indicates that when radiation levels are low the level of ozone is also low, but when radiation levels are high the level of ozone can vary from low to very high. The plot of temperature versus wind indicates a negative relationship between these variables: high temperatures tend to occur with low wind speeds and low temperatures tend to occur with high wind speeds. The plot of radiation versus temperature and the plot of radiation versus wind speed indicate that the relationships between radiation level and the other two variables are quite weak.

The pairwise plots in Figure 1 displayed the individual relationships between pairs of variables but cannot display relationships between three or more variables. The trellis plot in Figure 2 reveals how the relationship between ozone level and radiation level is affected by temperature and wind speed. Each panel contains a plot of ozone versus radiation for a different combination of temperature and wind speed. Each column in the display corresponds to a different temperature range (as indicated along the top of the plot) and each row corresponds to a different range of wind speed (as indicated along the right side of the plot). A clear change in the

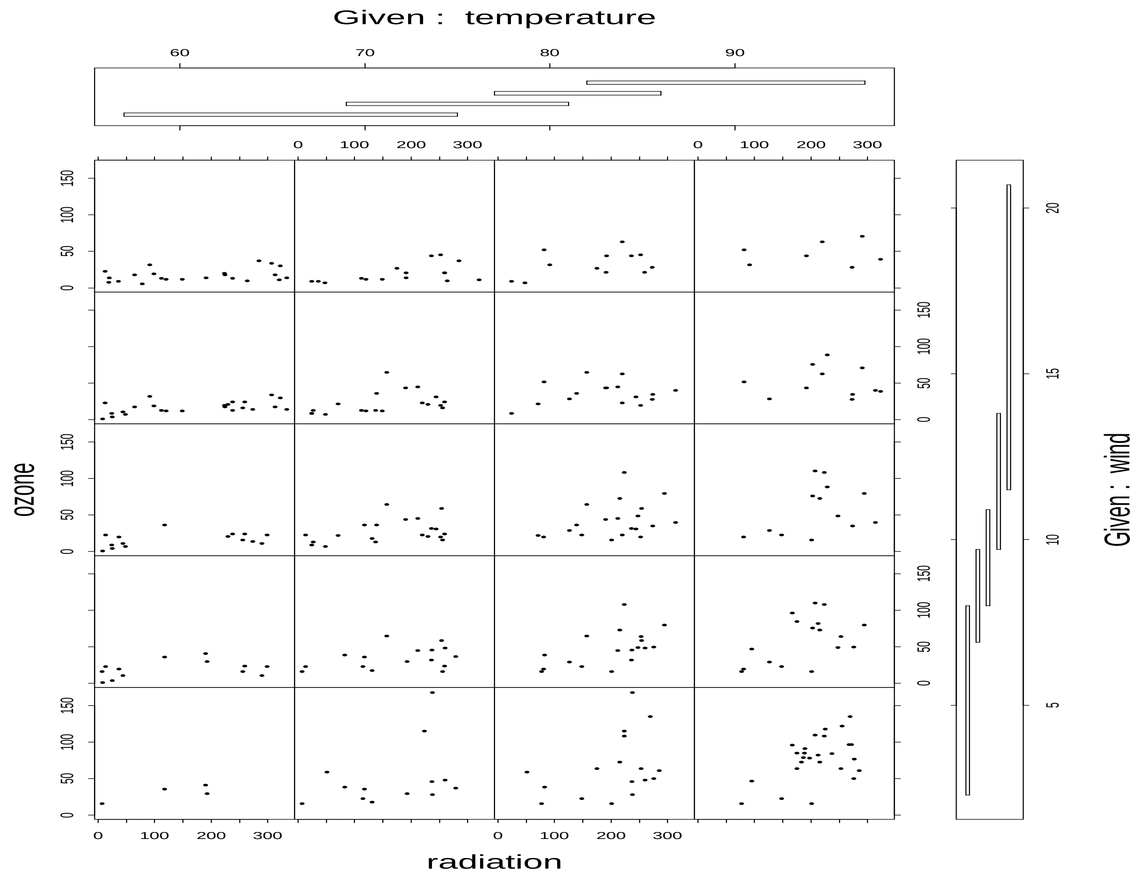

Figure 2: Plots of ozone level versus radiation for different levels of wind and temperature.

relationship between ozone and radiation occurs as we move from the panels in the upper left hand corner to the panels in the lower right hand corner. The panels in the upper left hand corner correspond to cool, windy days. For this type of day, the level of ozone is always quite low irregardless of the level of radiation. The panels in the lower left hand corner correspond to hot, still days. For these days there is a strong positive relationship between radiation level and ozone level. This indicates that for a high ozone level to be observed, the combination of a high radiation level and a hot still day is required.

Statistical Appendix

The analysis for this assignment consisted of examining a series of plots of the data. The "pairs" command in S-plus was used to get the pairwise scatter-plots of the variables. The plot was used to determine how the variables were related on a pairwise basis. The plot is contained in Figure 1 and an explanation of what was learned from it is given in the main body of the report. The "brush" and "spin" plots were used to try to understand how the ozone level was affected by different combinations of the other 3 variables. These plots did not give me a clear indication of what was happening. Trellis plots of ozone versus one of the explanatory variables conditioned on the levels of the remaining two explanatory variables were very informative. I thought the plot of ozone versus radiation conditioned on temperature and wind gave the clearest indication of how the ozone level depended on the levels of the other three variables. This plot is included in my report along with an explanation of the conclusions I reached.