1999

RSD Studies in Austin, 1998

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October 1999

INTRODUCTION

Remote sensing devices (RSD) are a relatively new and cost efficient tool for measuring automobile emissions. Using RSD to monitor on-road vehicle emissions is a logical alternative to traditional dynamometer based inspection and maintenance (I/M) programs, such as the IM240, when cost and the vehicle owner's time is taken into account. With RSD, only owners of gross polluting vehicles (determined by high emissions readings on on-road tests) would be burdened to undergo a more thorough inspection and diagnosis of their vehicle. Furthermore, on-road testing is a more representative measure of vehicle emissions since pollution from vehicles is emitted mostly during on-road use.

A preliminary RSD study was conducted in Austin, Texas during July 1998. Austin does not currently have an I/M program. The data show that, when approximately corrected for temperature, the Austin fleet average emissions are not very different from Denver fleet average emissions measured in January of 1999, even though an I/M program using the full IM240 test had been in effect in Denver for four years. In order to compare the two cities, however, temperature and oxygenated fuel corrections had to be made. This adjustment was done using the Denver 1998 IM240 data set to obtain scaling factors.

SCALING FACTOR

Since scaling factors are to be obtained from an IM240 data set, the IM240 data need to be validated in so far as they correlate to RSD data. Such a correlation study was done with Denver 1998 IM240 data and Denver January 1999 RSD data. As is seen in Figure 1, the correlations in measured grams of emission per kilogram of fuel for all three pollutants (CO, HC's, NO) are quite linear with high r^2 values. The slopes are not unity, however. This is more a result of calibration differences and imperfect conversion factors rather than a true discrepancy, and, thus, a scaling factor obtained from IM240 data is valid for use with RSD data.

The same Denver 1998 IM240 data set was used to test the correlation between emission readings when the ambient temperature is low and when it is high. Low ambient temperatures were defined to be between –5 and 5 °C, and high ambient temperatures were defined to be between 30 and 40 °C. Correlation plots (Figure 2) indicate a clear effect of temperature, with increased CO and HC and decreased NOx emissions at higher temperatures. The slopes of these plots incorporate an oxy-fuel effect since from November to February, when most of the cold temperature readings occurred, oxygenated fuel is mandated in the Denver area. During March through October, when most of the warm temperature readings occurred, the fuel is not oxygenated. Thus, the slopes of these plots are appropriate scaling factors since the temperature difference between the Denver readings in January and the Austin readings in July was approximately the difference between the defined "cold" and "warm" readings in the IM240 data. The scaling factors are 1.28, 1.13 and 0.82 for CO, HC and NO, respectively. Furthermore, the incorporation of the oxy-fuel effect is appropriate since Denver vehicles were operating with oxygenated fuels at the time of the on-road testing while the Austin vehicles were not.

AUSTIN AND DENVER COMPARISON

A comparison was done between the Austin July 1998 and Denver January 1999 model year averaged emissions data. The connected points in Figure 3 indicate an apparent difference in average vehicle emissions in Austin and Denver. There is greater CO and HC in Austin, while there is less NO. However, the temperature and oxygenated fuel differences have not been taken into account. The individual points on the plot not connected by a line represent the corrected Austin average emissions values. In order to correct the Austin data to the equivalent at lower temperatures and with oxy-fuels, the average values were divided by the correction factor – the slope of the Denver IM240 temperature correlation plots.

The corrected values for CO fall right on top of the Denver points, indicating that CO emissions from vehicles in Austin by model year are not on average significantly different from that in Denver. The corrected HC values, though not falling on top of the Denver values, are closer and more parallel to the Denver data. This indicates that the HC emissions profiles of the two cities are indeed similar but that an HC offset exists in the instrumentation. This effect in the HC data has been observed before (Popp, 1999). The corrected NO data are closer to the Denver values, but the data sets do not become parallel. This result indicates that there is somewhat of a difference in NO emissions between the two cities. The data have not been corrected for vehicle load. NO emissions increase with load, and this effect may contribute to the difference in NO emissions in the two cities because cars at the Austin site are at slightly higher load than ones at the Denver site.

FURTHER AUSTIN DATA

The Austin data were further analyzed. In one calculation the emissions data were divided into deciles (Figure 4) so that a fleet profile could be discerned. As expected, there are only a few gross polluters, while the majority of vehicles are clean. The CO data were also divided into quintiles and averaged by model year. These plots (Figure 5) show that middle aged broken cars are responsible for most of the CO emissions. The top graph is a plot of average CO emissions from each model year group of cars divided into quintiles. The very high average CO in the 5th quintile compared top the first three indicates again that a few cars are responsible for most of the pollution. The middle graph is simply a plot of the fraction of the fleet from each model year. In the bottom graph, the average CO from each quintile in each model year is weighed by the fraction of the fleet which the group represents. This operation gives the fraction of pollution originating from each group. The result is that most of the CO emission originates from the 5th quintile of vehicles of model year 1984 to 1998.

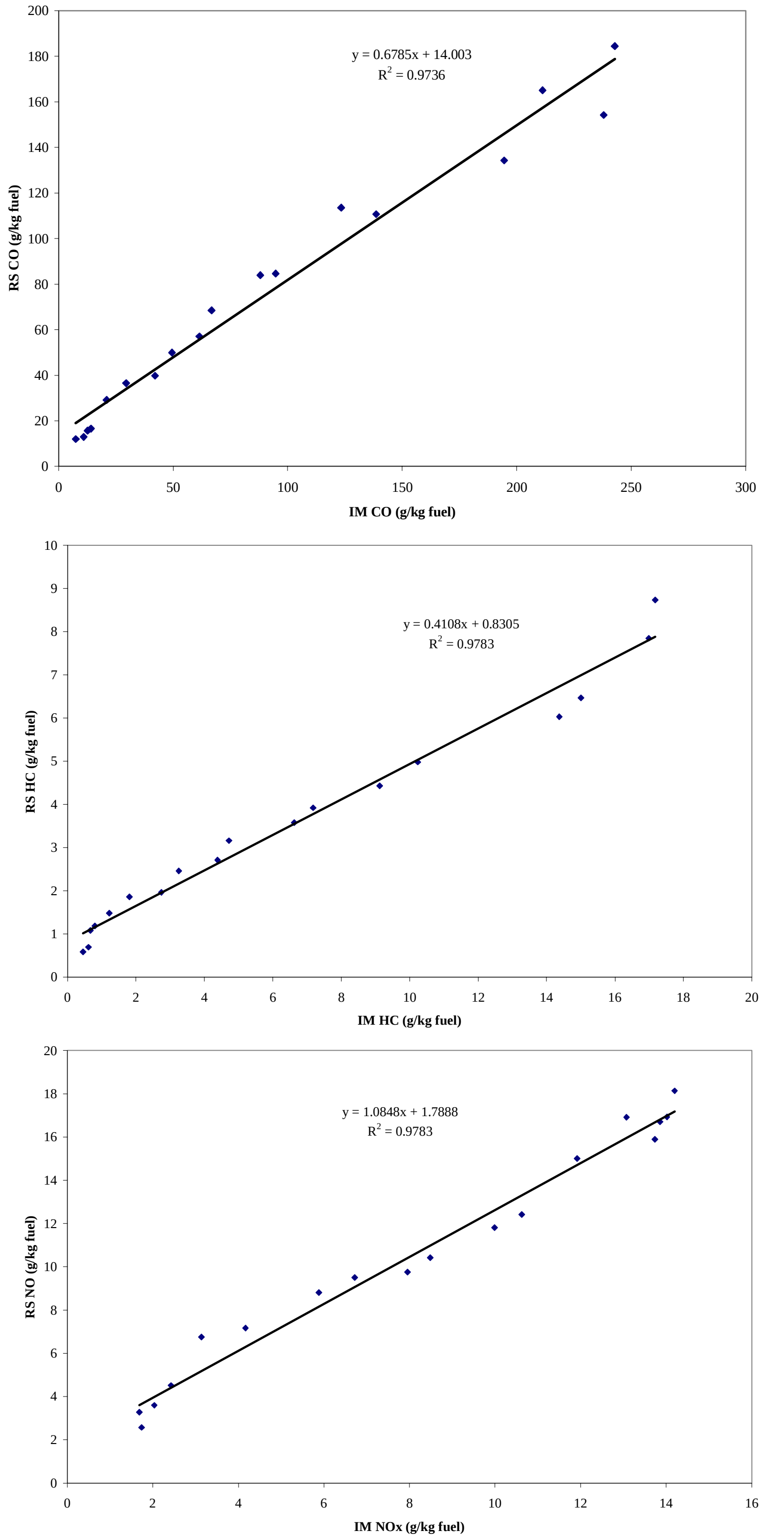

Figure 1: Correlation plots of RSD (Denver – January, 1999) to IM240 (Denver – 1998) for three pollutants. Each point represents a model year average.

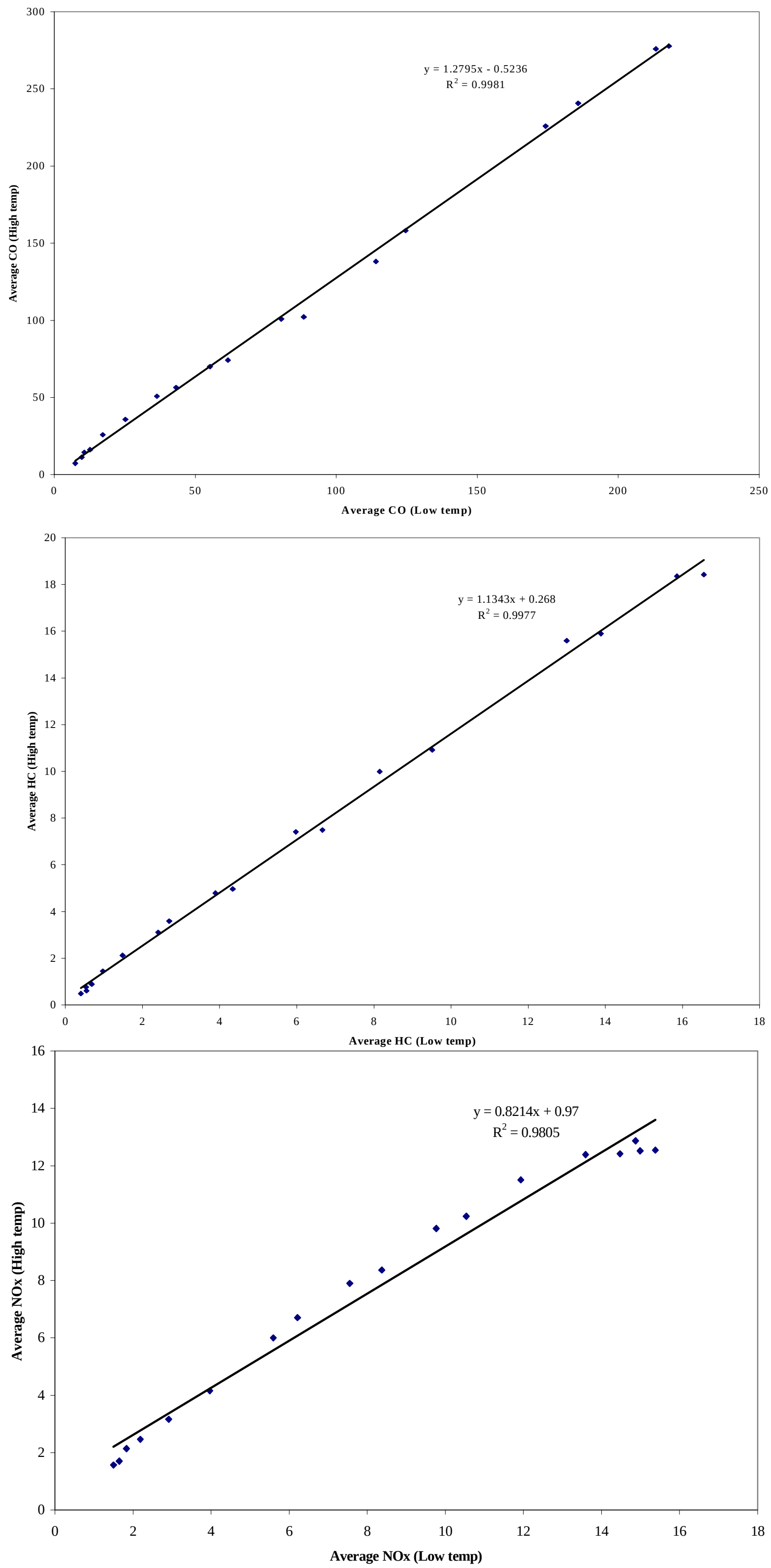

Figure 2: Correlation reported in g/kg fuel of emissions between two temperature ranges from the entire Denver 1998 IM240 data set. Each point represents a model year bin.

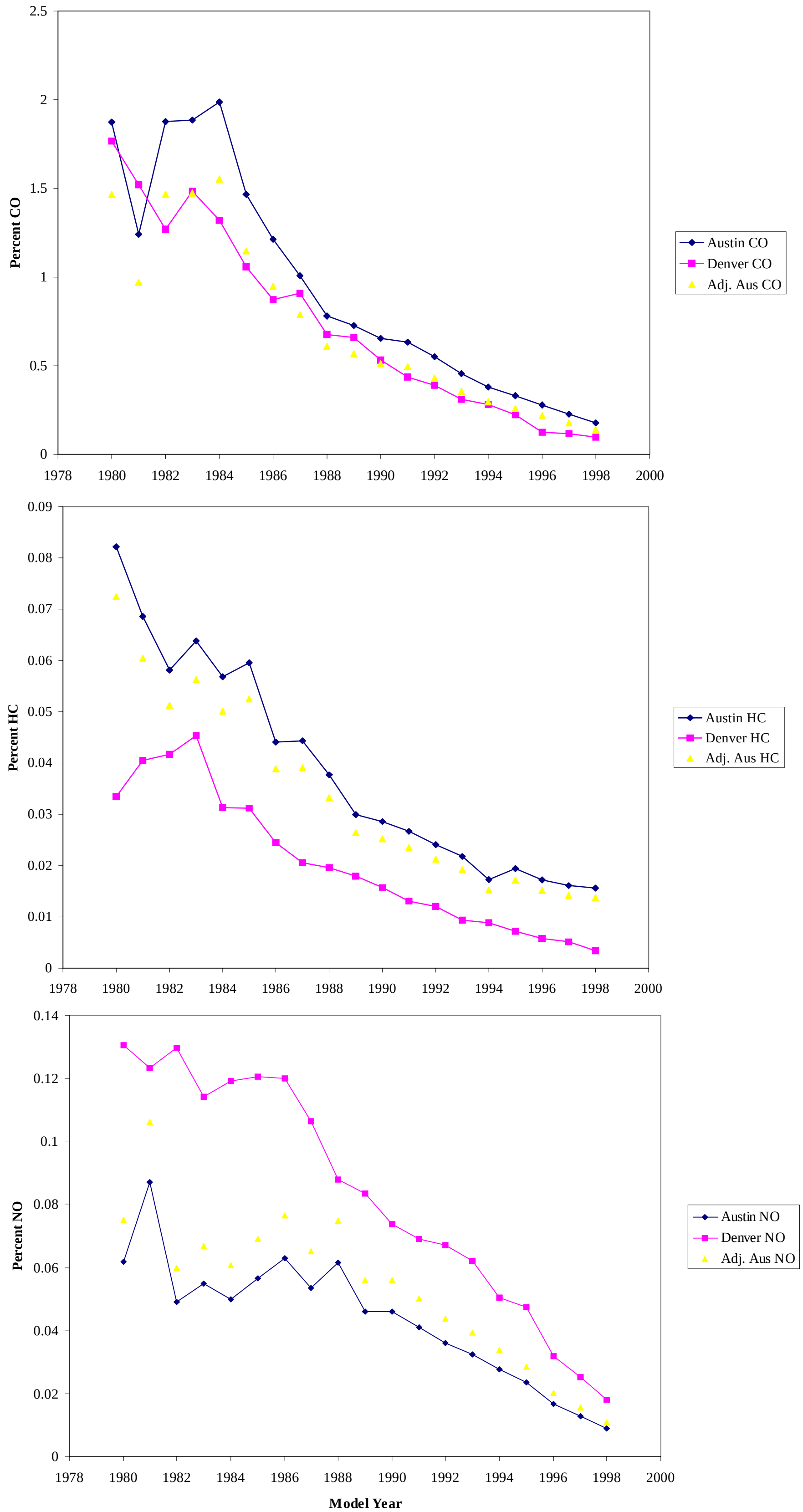

Figure 3: Average emissions by model year for Austin July 1998 and Denver January 1999 RSD data. Points not connected by a line are temperature and oxy-fuel corrected Austin data.

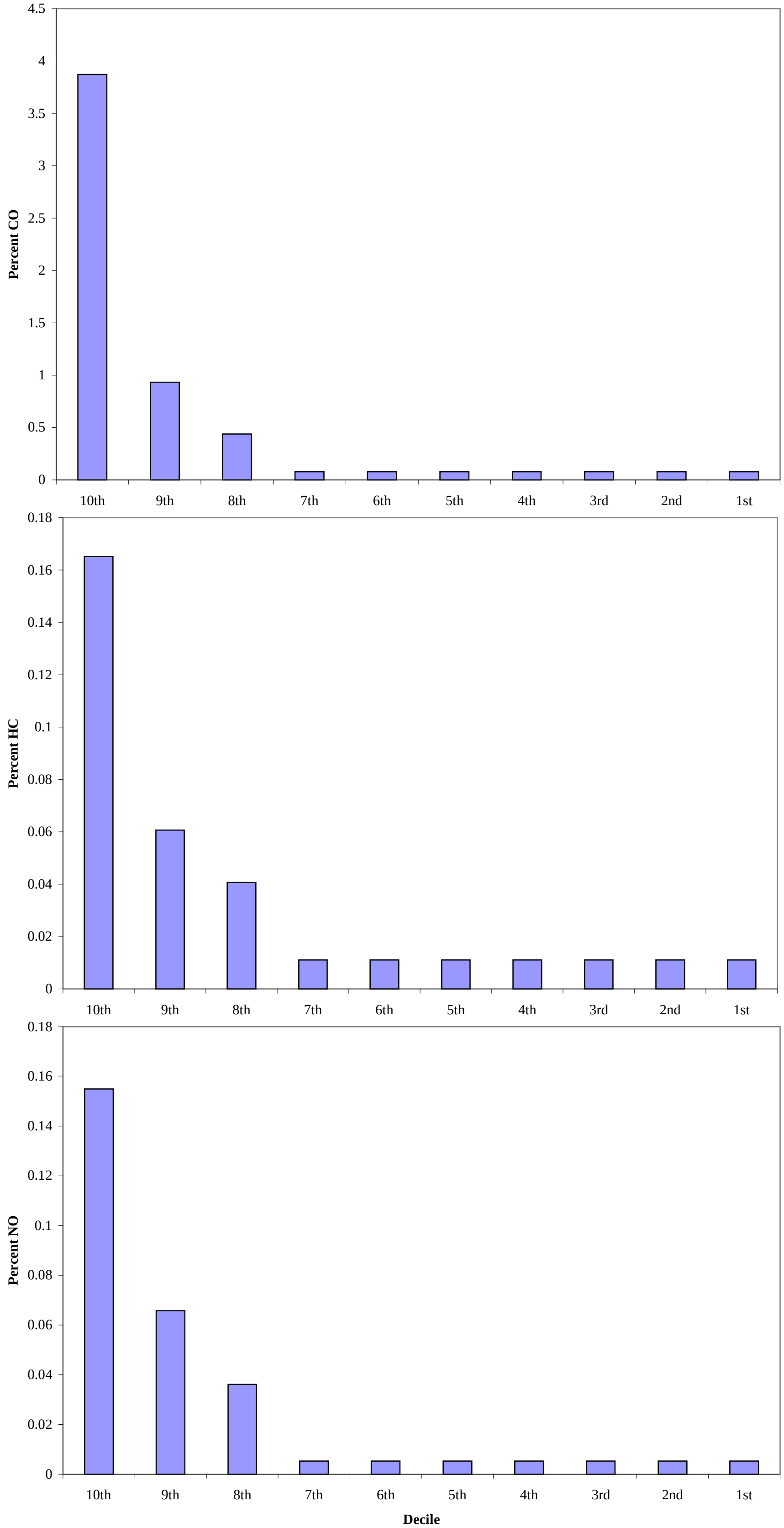

Figure 4: Austin 1998 fleet average emissions in decile bins. The small differences in the lowest 70% have been arranged.

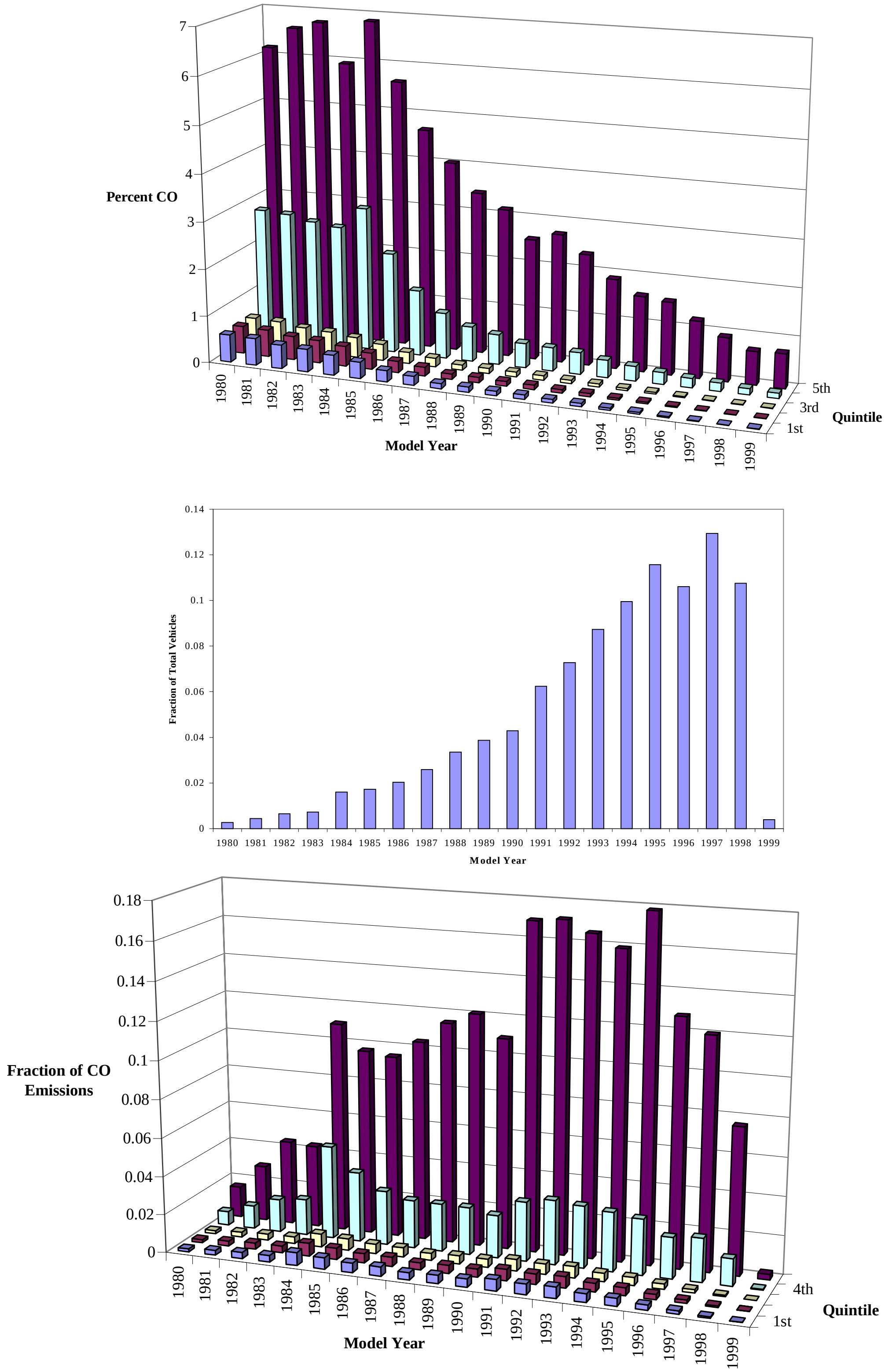

Figure 5: Austin July 1998 CO data presented as; top) average percent CO by model year in quintiles; middle) fraction of vehicles from each model year; bottom) product of the top two data which gives the weighed amount of CO originating from each group.

REFRENCES

Popp, P.J.; Bishop, G.A.; Stedman, D.H. "*On-Road Remote Sensing of Automobile Emissions in the Chicago Area: Year 2.*" Coordinating Research Council, Inc., 1999, Draft Interim Report.