THE LEBEC AIR MONITOR

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ABSTRACT. Data collected between February 2006 and February 2007 with an O3 and PM-2.5 monitor in Lebec, California are analyzed. Extensive analysis is not possible, because of the short timespan, but we give descriptive statistics, mostly as plots. The influence of wildfires on $PM_{2.5}$ and of I-5 truck traffic is discussed briefly. It is noted that there are two schools in close vicinity. In order to get more information about long-term developments, including prediction, more extensive and systematic monitoring is necessary.

Date: June 1, 2008.

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1. Introduction

At the request of the *Mountain Communities Town Council (MCTC)* the *California Air Resources Control Board (CARB)* placed a mobile air pollution monitor at Peace Valley Road in Lebec. The monitor gave hourly measurements of both O3 (ozone) and PM-2.5 (fine particulate matter) between February 2006 and February 2007. For location and pictures of the site, we refer to

http://www.arb.ca.gov/qaweb/site.php?s_arb_code=15990.

The data do not seem to be available any more from the CARB site, but you can get about seven months worth from

http://www.cuddyvalley.org/airmonitor.

Since Lebec is in the San Joaquin Valley Air District, which is a non-attainment area for ozone and particulate matter, we expect to see fairly high levels of pollution. It is interesting to single out Lebec, because it is at an altitude of over 4000 feet, in a rural area without much agricultural or industrial activity. On the other hand, it is adjacent to I-5, which has an average annual daily traffic count of 70,000 cars, of which 20,000 are are trucks, with about 80% of the trucks having 5+ axels. The percentage of cars that are trucks is close to 30%, and it is growing. Lebec is also in the southern part of the San Joaquin Valley, where pollution from the northern part accumulates.

In order to place the Lebec measurements in context, it is important to know the federal and state standards. A comprehensive overview is in Appendix A. For ozone the California one hour standard is 0.09 *ppm* (parts per million) and the eight hour standard is 0.07 *ppm*. Thus, for example, if the average ozone level over any eight consecutive hours in a particular location on a particular day is over 0.0749 *ppm*, then there is a public health problem, and if the problem repeats over consecutive years there is a violation.

Observe that in establishing compliance one first rounds the measurements to two decimals, and then compares the rounded number with the standard. The federal eight hour standard for ozone is 0.08 *ppm*, less strict than the California one. We shall concentrate on the state standards in our data analysis. When we calculate standards, we generally follow the federal guidelines in EPA [1999] and EPA [1998].

For PM-2.5 California only has an annual standard of 12 $\mu g/m^3$ (i.e. microgram per cubic meter). There are no hourly or daily standards.There is a federal 24 hour standard of 35 $\mu g/m^3$ and a federal annual standard of 15 $\mu g/m^3$.

Unfortunately the Lebec monitor did not measure any additional pollutants and was only making observations over a one year period. Since pollution is partly dependent on weather and traffic conditions, observations for a single year are of rather limited value. A permanent monitor at the El Tejon middle school, or alternatively access to the extensive monitoring results of Tejon Ranch Company, would be highly desirable. And the air district might want to reconsider its decision that a monitor next to the I-5 in the Tejon Pass is not really needed.

This decision also should take into account the fact that health effects of air pollution are more serious at higher altitudes. California already has a stricter standard for CO pollution above 4000 feet, in particular in the Lake Tahoe area. And, more generally (Michell et al, Journal of the American Medical Association, 242, 1979, 1163-1168),

> Current National Ambient Air Standards for sulfur oxides, particulates, oxidants, carbon monoxide, nitrogen oxides, hydrocarbons, and lead are probably too lenient for an altitude of 1500 m and above.

The fact that there are 1000 middle and high school kids close to a polluting freeway through a mountain pass would seem to mandate monitoring for ozone, particulate matter, nitrous oxide, and carbon monoxide. There are many publications from the lab of Constantinos Sioutas at USC on pollution near Southern Californian freeways, especially on freeways with a high percentage of heavy truck traffic, which makes it even sensible to monitor for PM 0.18, ultrafine particulate matter.

2. Ozone

For ozone we have measurements in Lebec at 8415 time points (hours) on 363 different days. Thus some days and some hours are missing, because the monitor was not working properly. In Figure 2 we plot ozone for all time points. The red curve draws a smoothed representation, the green horizontal lines are the 0.07 *ppm* and 0.09 *ppm* standards.

Insert Figure 2 about here

Figure 3 gives the average and Figure 4 the maximum ozone levels over the 24 hours of each day. Again, the red curves show trend and the green lines show standards (if applicable).

Insert Figure 3 about here

Insert Figure 4 about here

Since the monitor did not work every day, and not every hour of the day, there are some missing data, but these have been taken into account in computing averages. If we look at the maximum ozone level during the day, we see 13 days where ozone was over the one hour California standard of 0.09 *ppm* at least once (i.e. the maximum was larger than 0.0949).

We have also plotted the distribution of ozone level over the 7100 hours in Figure 5 and the average ozone level by hour of day in Figure 6. Violations of the one hour standard are in the tail of the histogram (last two bins). We also see that ozone attains its highest levels around three pm (in the summer).

Insert Figure 5 about here

Insert Figure 6 about here

We can look at the distribution of ozone over the hours of the day in more detail by using boxplots. This is done in Figure 7. In a boxplot the box covers the interquartile range, i.e. the top of the box is at the 75th percentile, while the bottom is at the 25th percentile. Thus the boundaries of the box cover half of the observations. In the middle of the box we see the median, i.e. the point below (and above) which there is 50% of the observations. The whiskers of the boxplot indicate the range of observations that can still be considered in the normal range, the dots are outliers, and they usually require attention.

The boxplot shows clearly that the median ozone level starts to increase at 6am, then increases to about 2pm, and then decreases to the night level at 9pm. This is, of course, related to temperature. But, no matter what the cause, it implies that ozone levels are highest during the working day (and the school day). The highest variation in ozone levels over the year is between 3pm and 6pm (where the boxes are the largest). Top ozone levels during the evening and night are around midnight.

Insert Figure 7 about here

It is also interesting to look at average ozone levels at the various weekdays. These are plotted in Figure 8, which shows the average maximum ozone level (so the maximum is computed over 24 hours, the average over about 52 weekdays).

Insert Figure 8 about here

Differences are nor large, but they are interesting. We can rule out meteorology as a cause here, because the different days of the week do not have different weather patterns. This suggests that the ozone that causes these differences is generated by human activities, either locally or in the San Joaquin. Again, whatever the cause, the ozone levels are higher on work days (or school days).

To study the state eight hour standard we compute 24 - 7 = 17 running averages of length 8 for each day. If hours are missing, there are fewer running averages, but in any case we compute the maximum for each day. The maximum eight hour average for each day is given in Figure 9, and the distribution of the maximum eight hour averages in Figure 10. The horizontal green line in Figure 9 is the California standard of 0.07 *ppm*. There are 53 violations of this standard and 11 violations of the federal NAAQS.

Insert Figure 9 about here

Insert Figure 10 about here

3. PM-2.5

The situation for PM-2.5 is very different from that of ozone in many respects. We have 7346 measurements over 343 days. They are plotted in Figure 11.

Insert Figure 11 about here

What is mostly obvious from this plot is the huge influence of local wildfires. In September, for example, the Day Fire burned for almost all month (although not always close to where the monitor was).

Let's first look at the standard. The annual California standard is 12 $\mu g/m^3$. If we look at the average of our 7346 observations, we find 13.181 $\mu g/m^3$, which is over the standard. Not by much, only by 0.09 standard deviations, but nevertheless over the annual state standard. One could argue the results are biased because of the wildfires, but wildfires are part of the environment and should be taken into account.

Insert Figure 12 about here

Insert Figure 13 about here

The daily averages are in Figure 12 and daily maxima in Figure 13. They clearly show that PM-2.5 measurements are more variable than ozone measurements. The horizontal green line in Figure 12 show the federal 24 hour standard of 35 $\mu g/m^3$, for which there are 6 violations.

Insert Figure 14 about here

Insert Figure 15 about here

The histogram on the left of Figure 14 shows PM-2.5 levels for 7346 hours. It is pretty useless because of the fire-driven outliers. Figure 15 shows average PM-2.5 level by hour of the day, indicating higher levels in the evening and the night. This is perhaps related to the higher traffic volume on the I-5 during commuting hours, and higher truck volume during the evening and early morning. Again, the red curve smoothes the plot to get a clearer picture of trend.

As with ozone, we have also made a boxplot of the PM-2.5 data per hour of the day. It is given in Figure 16. The plot is pretty useless, because the huge outliers make the boxes really small. So we repeated the plot and only plotted the part for which the vertical axis is below 40. This, in Figure refF:zb, is much clearer. It shows the same trend, of course, as Figure 15.

Insert Figure 16 about here

Insert Figure 17 about here

Finally we show ozone levels as a function of weekday. Because of the many outlierswe have computed the median ozone level for each day, and then the average of all sundays, mondays, and so on. See Figure 18. Again, this rules out meteorology. We see 30% higher PM-2.5 levels during working days. It is difficult to imagine that this could be due to anything but traffic.

4. Regional Comparison

In the tables discussed in this section, we compare Lebec with other communities in Southern California, first on the one hour state ozone standard in Table 1 and then on the annual average PM-2.5 in Table 3. Rows of both tables are ordered from bad to good.

Insert Table 1 about here

Insert Table 2 about here

Insert Table 3 about here

Comparison data come from CARB, but we have to be somewhat careful here, because CARB computed a different estimate of the annual PM-2.5 average (11.85). It is unclear what causes these differences. although treatment of missing data and rounding are obvious candidates. It is clear, however, that as far as ozone is concerned Maricopa, Piru, Ojai and Los Angeles are much better off than Lebec. I assume this is at least partly because of smog accumulating at the south end of the Valley.

For the eight hour standard Kern County is uniformly bad, with Santa Clarita catching up. Lebec closely follows, and is worse than Burbank, Pasadena, Glendora, Simi Valley, and Los Angeles. The eight hour standard seems to give more consistent and stable results than the one hour standard, which is fortunate, because it also supposedly has more relevance for public health.

For PM-2.5 Lebec is worse off than Piru, Simi Valley and about equal to Reseda. A small part of this may be wildfires (although Piru, Simi Valley, and Reseda must also have gotten some of the Day Fire smoke), and a large part is probably traffic, in particular truck traffic.

References

EPA. Guideline on Data Handling Conventions for the 8-Hour Ozone NAAQS. Technical Report EPA-454/R-98-017, United States Environmental Protection Agency, December 1998.

EPA. Guideline on Data Handling Conventions for the PM NAAQS. Technical Report EPA-454/R-99-008, United States Environmental Protection Agency, April 1999.

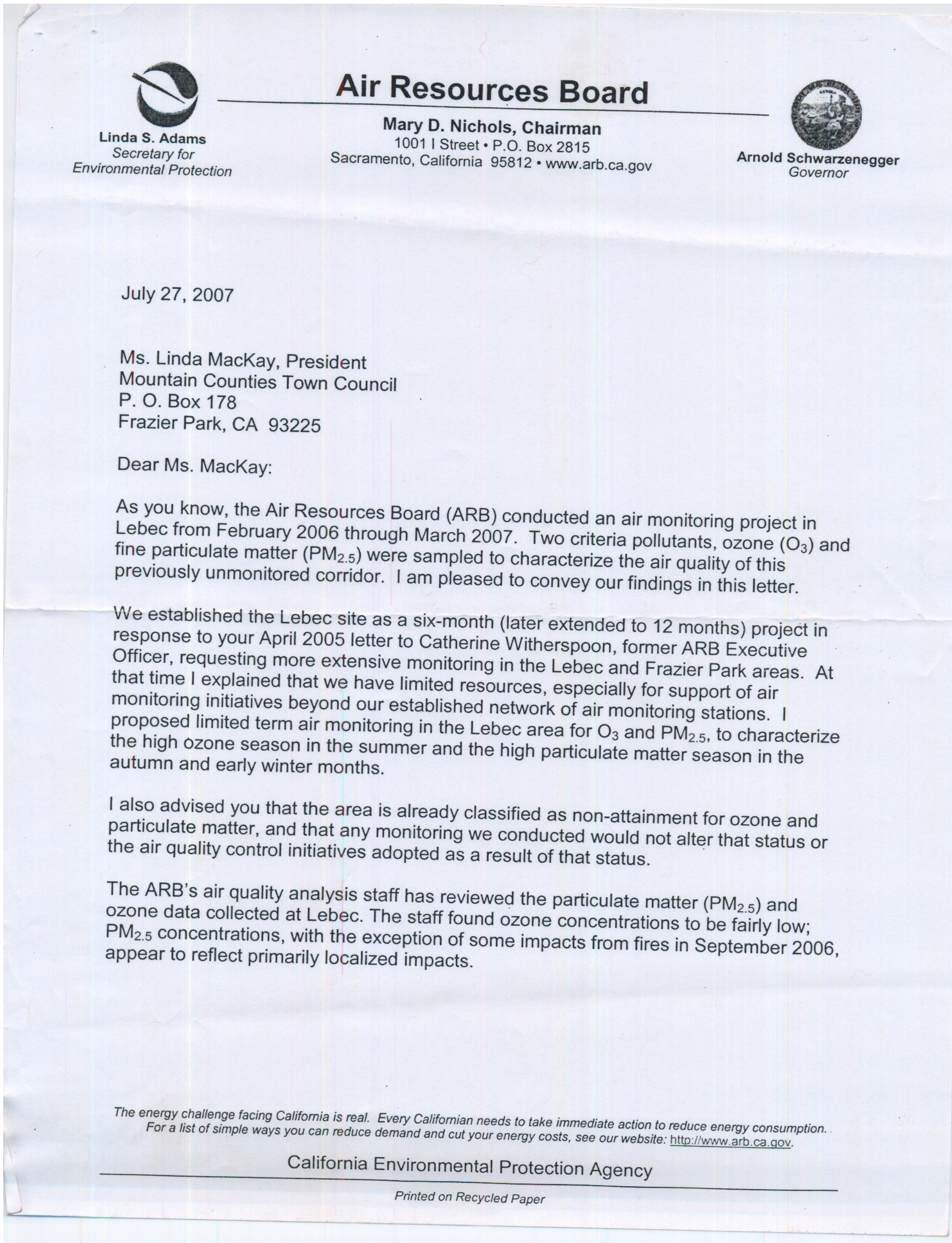
Appendix A. Standards

Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards [1]		Federal Standards [2]		
		Concentration [3]	Method [4]	Primary [3,5]	Secondary [3,6]	Method [7]
Ozone (O_3)	1 Hour	0.09 ppm (180 μg/m^3)	Ultraviolet Photometry	—	Same as Primary Standard	Ultraviolet Photometry
	8 Hour	0.070 ppm (137 μg/m^3)		0.08 ppm (157 μg/m^3)		
Respirable Particulate Matter (PM10)	24 Hour	50 μg/m^3	Gravimetric or Beta Attenuation	150 μg/m^3	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	20 μg/m^3		—		
Fine Particulate Matter (PM2.5)	24 Hour	No Separate State Standard		35 μg/m^3	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	12 μg/m^3	Gravimetric or Beta Attenuation	15 μg/m^3		
Carbon Monoxide (CO)	8 Hour	9.0 ppm (10mg/m^3)	Non-Dispersive Infrared Photometry (NDIR)	9 ppm (10 mg/m^3)	None	Non-Dispersive Infrared Photometry (NDIR)
	1 Hour	20 ppm (23 mg/m^3)		35 ppm (40 mg/m^3)		
	8 Hour (Lake Tahoe)	6 ppm (7 mg/m^3)		—	—	—
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean	—	Gas Phase Chemiluminescence	0.053 ppm (100 μg/m^3)	Same as Primary Standard	Gas Phase Chemiluminescence
	1 Hour	0.25 ppm (470 μg/m^3)		—		
Sulfur Dioxide (SO_2)	Annual Arithmetic Mean	—	Ultraviolet Fluorescence	0.030 ppm (80 μg/m^3)	—	Spectrophotometry (Pararosaniline Method)
	24 Hour	0.04 ppm (105 μg/m^3)		0.14 ppm (365 μg/m^3)	—	
	3 Hour	—		—	0.5 ppm (1300 μg/m^3)	
	1 Hour	0.25 ppm (655 μg/m^3)		—	—	—
Lead[8]	30 Day Average	1.5 μg/m^3	Atomic Absorption	—	—	—
	Calendar Quarter	—		1.5 μg/m^3	Same as Primary Standard	High Volume Sampler and Atomic Absorption
Visibility Reducing Particles	8 Hour	Extinction coefficient of 0.23 per kilometer — visibility of ten miles or more (0.07 — 30 miles or more for Lake Tahoe) due to particles when relative humidity is less than 70 percent. Method: Beta Attenuation and Transmittance through Filter Tape.		No Federal Standards		
Sulfates	24 Hour	25 μg/m^3	Ion Chromatography			
Hydrogen Sulfide	1 Hour	0.03 ppm (42 μg/m^3)	Ultraviolet Fluorescence			
Vinyl Chloride[8]	24 Hour	0.01 ppm (26 μg/m^3)	Gas Chromatography			

Figure 1. State and Federal Standards

Appendix B. CARB Letter



Linda S. Adams
Secretary for
Environmental Protection

Air Resources Board

Mary D. Nichols, Chairman
1001 I Street • P.O. Box 2815
Sacramento, California 95812 • www.arb.ca.gov

Arnold Schwarzenegger
Governor

July 27, 2007

Ms. Linda MacKay, President
Mountain Counties Town Council
P. O. Box 178
Frazier Park, CA 93225

Dear Ms. MacKay:

As you know, the Air Resources Board (ARB) conducted an air monitoring project in Lebec from February 2006 through March 2007. Two criteria pollutants, ozone (O_3) and fine particulate matter ($PM_{2.5}$) were sampled to characterize the air quality of this previously unmonitored corridor. I am pleased to convey our findings in this letter.

We established the Lebec site as a six-month (later extended to 12 months) project in response to your April 2005 letter to Catherine Witherspoon, former ARB Executive Officer, requesting more extensive monitoring in the Lebec and Frazier Park areas. At that time I explained that we have limited resources, especially for support of air monitoring initiatives beyond our established network of air monitoring stations. I proposed limited term air monitoring in the Lebec area for O_3 and $PM_{2.5}$, to characterize the high ozone season in the summer and the high particulate matter season in the autumn and early winter months.

I also advised you that the area is already classified as non-attainment for ozone and particulate matter, and that any monitoring we conducted would not alter that status or the air quality control initiatives adopted as a result of that status.

The ARB's air quality analysis staff has reviewed the particulate matter ($PM_{2.5}$) and ozone data collected at Lebec. The staff found ozone concentrations to be fairly low; $PM_{2.5}$ concentrations, with the exception of some impacts from fires in September 2006, appear to reflect primarily localized impacts.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our website: http://www.arb.ca.gov.

California Environmental Protection Agency

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All of the Lebec air quality data that we collected are now finalized and, as promised, comparative summary data reports are attached for your information and use. Also, all data have been reported to the U. S. Environmental Protection Agency's Air Quality System, the nation's repository for air quality data, and are publicly available.

The attached Tables 1 and 2 show the summarized ozone and $PM_{2.5}$ data, respectively, collected at Lebec compared to the data collected during the same period at the nearest surrounding sites in Kern, Ventura and Los Angeles counties. For example, as shown in Table 1, the "Number of Days >0.070" (the State Standard) indicates that Lebec experiences less days over the ozone standard than Bakersfield, Arvin and several sites in Los Angeles County, but more days over the standard than Azusa, Glendora and downtown Los Angeles. Table 2 shows that Lebec has less days over 35 ug/m^3 $PM_{2.5}$ (the National Standard) than Bakersfield and Los Angeles, but more days over the standard than Pasadena and Simi Valley. The State and Federal ambient air quality standards are health-based standards and can be considered a quantitative description of healthful air quality.

If you have any questions, please contact Gary Zimmerman of my staff at (916) 324-7591 or via email at gzimmerm@arb.ca.gov.

Sincerely,

William V Loscutoff

William V Loscutoff, Chief
Monitoring and Laboratory Division

Attachment

cc: Warren LeLeaux
San Joaquin Valley Unified APCD

Philip Fine
South Coast AQMD

Karen Magliano
Air Resources Board

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Lebec and surrounding sites
Feb 2007 - Mar 2007
Ozone (ppm)

AIRS Site #	Site Name/Address	Feb -Dec 2006							Jan - Mar 2007						
		1st 1-Hr High	2nd 1-Hr High	Number of Days >.09	Max 8-hr High	Max 8-hr 2nd Hi	Number of Days >.070	Number of Days >.085	1st 1-Hr High	2nd 1-Hr High	Number of Days >.09	Max 8-hr High	Max 8-hr 2nd Hi	Number of Days >.070	Number of Days >.085
060379034	LEBEC	0.108	0.107	12	0.099	0.096	52	11	0.098	0.085	1	0.085	0.066	1	0
060290007	EDISON	0.140	0.140	37	0.121	0.118	8	36	0.100	0.090	2	0.086	0.078	3	1
060290008	MARICOPA	0.100	0.100	8	0.094	0.093	62	8	0.090	0.080	0	0.079	0.075	3	0
060290014	BAKERSFIELD	0.123	0.120	52	0.110	0.108	101	53	0.089	0.088	0	0.083	0.076	3	0
060290232	OILDALE	0.120	0.120	22	0.104	0.104	86	37	0.090	0.090	0	0.081	0.076	3	0
060295001	ARVIN	0.135	0.134	66	0.119	0.116	122	61	0.102	0.100	3	0.093	0.088	7	2
060296001	SHAFTER	0.110	0.110	15	0.099	0.094	67	19	0.080	0.080	0	0.073	0.073	2	0
060370002	AZUSA	0.165	0.151	23	0.120	0.112	24	10	0.058	0.049	0	0.046	0.043	0	0
060370016	GLENDORA	0.175	0.155	37	0.127	0.120	41	15	0.058	0.048	0	0.047	0.043	0	0
060370113	WEST LOS ANGELES-VA HOSPITAL	0.099	0.098	3	0.074	0.074	2	0	0.051	0.048	0	0.042	0.041	0	0
060371002	BURBANK	0.166	0.152	25	0.128	0.114	32	12	0.058	0.050	0	0.047	0.041	0	0
060371103	LOS ANGELES - NORTH MAIN	0.108	0.108	8	0.079	0.077	7	0	0.053	0.044	0	0.043	0.036	0	0
060371201	RESEDA	0.158	0.142	34	0.109	0.108	55	17	0.059	0.048	0	0.046	0.042	0	0
060372005	PASADENA - S. WILSON	0.151	0.141	26	0.117	0.116	34	7	0.058	0.050	0	0.046	0.042	0	0
060375005	LOS ANGELES - WESTCHESTER PKWY	0.084	0.076	0	0.066	0.065	0	0	0.058	0.053	0	0.052	0.048	0	0
060376012	SANTA CLARITA	0.156	0.148	62	0.120	0.115	78	40	0.050	0.049	0	0.046	0.044	0	0
061110009	PIRU	0.120	0.100	10	0.093	0.092	41	3	0.080	0.080	0	0.061	0.058	0	0
061111004	OJAI	0.110	0.110	11	0.100	0.096	37	5	0.090	0.080	1	0.080	0.066	1	0
061112002	SIMI VALLEY	0.130	0.120	16	0.104	0.096	44	11	0.110	0.090	1	0.086	0.070	0	1
061113001	EL RIO	0.090	0.070	0	0.070	0.067	0	0	0.060	0.060	0	0.055	0.053	0	0
060710005	CRESTLINE	0.164	0.163	73	0.142	0.126	103	59	0.059	0.055	0	0.055	0.053	0	0

STANDARDS State = 0.09 ppm (1 hr)/0.07 ppm (8 hr)
National = 0.08 ppm (8 hr)

TABLE 1

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24 Hour PM2.5
Feb 2006 - Mar 2007
Data from available sites in area surrounding Lebec

AIRS Site #	Site Name/Address	2006 Days over 35 ug/m3	2007 Days over 35 ug/m3	2006 24-hour Annual Average
060379034	LEBEC*	5	0	11.85
060290014	BAKERSFIELD	29	22	18.65
060370002	AZUSA	8	5	15.50
60371002	BURBANK	6	1	16.50
060371103	LOS ANGELES - NORTH MAIN	8	6	15.56
060371201	RESEDA	1	0	12.94
060372005	PASADENA - S. WILSON	1	0	13.35
061110009	PIRU	0	0	9.17
061112002	SIMI VALLEY	0	0	10.34
061113001	EL RIO	0	0	9.86

Standards National = 35 ug/m3 (24-hour)
State = 12 ug/m3 (annual)

*BAM data for Lebec, rather than the Federal Reference Method, is included in this table. The Lebec 24-hr annual average is based on the sampling period March 2006 - March 2007 rather than the 2006 calender year.

TABLE 2

Appendix C. R Code

C.1. **Recodes.** We start with code that transform the Excel files into a matrix format we can more easily use in R, and that leaves room for missing data.

```
library(gregmisc)

fill<-function(mat) {
mtab<-as.data.frame(tapply(mat[,4],mat[,2:3],sum))
mord<-mtab[order(as.Date(rownames(mtab),"%m-%d-%y")),]
n<-nrow(mord); m<-ncol(mord)
rr<-as.Date(rownames(mord),"%m-%d-%y")
first<-rr[1]-1; last<-rr[n]
nn<-as.integer(last-first); newmat<-as.data.frame(matrix(NA,nn,m))
names(newmat)<-names(mord)
for (k in 1:nn) {
        sel<-which((first+k)==rr)
        if (length(sel) > 0) newmat[k,]<-mord[sel,]
        rownames(newmat)[k]<-format(first+k,"%m-%d-%y")
        }
return(newmat)
}

lebdt<-read.xls("o3.xls")
leboz<-fill(lebdt)
dump("leboz",file="leboz.R")

lebdt<-read.xls("pm25.xls")
lebpm<-fill(lebdt)
dump("lebpm",file="lebpm.R")
```

C.2. **Standards.** This is R code to calculate the number of violations of the state and federal standards.

```
is.valid<-function(x,std) {
ind<-which(!is.na(x)); jnd<-which(!is.na(x[10:21]))
if (length(ind)==0) return(NA)
m<-max(x[ind])
if (m > std) return(m)
if (length(jnd)>=9) return(m) else return(NA)
}
```

```
oz1hr<-function(mat,std=.0949){
length(which(apply(mat,1,function(x) is.valid(x,std))>std))
}

oz8hr<-function(mat,stand=.0849) {
        ab<-t(as.matrix(mat)); bc<-array(NA,dim(ab)); nn<-prod(dim(ab))-7
        for (i in 1:nn)
                {
                aa<-ab[i:(i+7)]
                if (length(which(!is.na(aa)))>5) bc[i]<-mean(aa,na.rm=TRUE)
                }
ab<-t(bc); n<-nrow(ab); c<-rep(NA,n)
for (i in 1:n) {
        ca<-which(!is.na(ab[i,]))
        if (length(ca)>=16) c[i]<-max(ab[i,ca])
    }
return(length(which(c>stand)))
}
```

C.3. **Plots.** These is the code for making various plots (not the box-plots).

```
dateo<-as.Date(rownames(leboz),"%m-%d-%y")
datep<-as.Date(rownames(lebpm),"%m-%d-%y")

my.mean<-function(x) {
        ind<-which(!is.na(x))
        if (length(ind) == 0) return(NA)
        return(mean(x[ind]))
}

my.max<-function(x) {
        ind<-which(!is.na(x))
        if (length(ind) == 0) return(NA)
        return(max(x[ind]))
}

ozvec<-as.vector(t(as.matrix(leboz)))
ozlab<-as.vector(t(matrix(rownames(leboz),length(rownames(leboz)),24)))

pdf("oztot.pdf")
plot(as.Date(ozlab,"%m-%d-%y"),ozvec,type="l",col="blue",ylab="ppm")
```

```
ind<-which(!is.na(ozvec))
kk<-1:length(ozvec)
a<-loess(ozvec[ind]~kk[ind])
lines(as.Date(ozlab[ind],"%m-%d-%y"),predict(a),col="red",lwd=3)
abline(h=.0749,col="green")
abline(h=.0949,col="green")
dev.off()

rm(ozlab)

pdf("ozave.pdf")
ozave<-apply(leboz,1,my.mean)
plot(dateo,ozave,type="l",col="blue",ylab="ppm")
ind<-which(!is.na(ozave))
kk<-1:length(ozave)
a<-loess(ozave[ind]~kk[ind])
lines(dateo[ind],predict(a),col="red",lwd=3)
dev.off()

pdf("ozmax.pdf")
ozmax<-apply(leboz,1,my.max)
plot(dateo,ozmax,type="l",col="blue",ylab="ppm")
ind<-which(!is.na(ozmax))
kk<-1:length(ozmax)
a<-loess(ozmax[ind]~kk[ind])
lines(dateo[ind],predict(a),col="red",lwd=3)
abline(h=.0949,col="green")
dev.off()

pmvec<-as.vector(t(as.matrix(lebpm)))
pmlab<-as.vector(t(matrix(rownames(lebpm),length(rownames(lebpm)),24)))

pdf("pmtot.pdf")
plot(as.Date(pmlab,"%m-%d-%y"),pmvec,type="l",col="blue",ylab="ppm")
ind<-which(!is.na(pmvec))
kk<-1:length(pmvec)
a<-loess(pmvec[ind]~kk[ind])
lines(as.Date(pmlab[ind],"%m-%d-%y"),predict(a),col="red",lwd=3)
dev.off()

rm(pmlab)

pdf("pmave.pdf")
```

```
pmave<-apply(lebpm,1,my.mean)
plot(datep,pmave,type="l",col="blue",ylab="ppm")
ind<-which(!is.na(pmave))
kk<-1:length(pmave)
a<-loess(pmave[ind]~kk[ind])
lines(datep[ind],predict(a),col="red",lwd=3)
abline(h=35,col="green")
dev.off()

pdf("pmmax.pdf")
pmmax<-apply(lebpm,1,my.max)
plot(datep,pmmax,type="l",col="blue",ylab="ppm")
ind<-which(!is.na(pmmax))
kk<-1:length(pmmax)
a<-loess(pmmax[ind]~kk[ind])
lines(datep[ind],predict(a),col="red",lwd=3)
dev.off()

pdf("ozhist.pdf")
hist(ozvec,col="magenta",xlab="ppm",main="")
dev.off()

pdf("ozhr.pdf")
ozhr<-apply(leboz,2,my.mean)
plot(0:23,ozhr,type="l",col="blue",ylab="ppm",xlab="Hour")
kk<-1:length(ozhr)
a<-loess(ozhr~kk)
lines(0:23,predict(a),col="red",lwd=3)
dev.off()

pdf("pmhist.pdf")
hist(pmvec,col="magenta",xlab="mug/m3",main="")
dev.off()

pdf("pmhr.pdf")
pmhr<-apply(lebpm,2,my.mean)
plot(0:23,pmhr,type="l",col="blue",ylab="ppm",xlab="Hour")
kk<-1:length(pmhr)
a<-loess(pmhr~kk)
lines(0:23,predict(a),col="red",lwd=3)
dev.off()

oz8runs<-function(mat) {
```

```
		ab<-t(as.matrix(mat)); bc<-array(NA,dim(ab)); nn<-prod(dim(ab))-7
		for (i in 1:nn)
			{
			aa<-ab[i:(i+7)]
			if (length(which(!is.na(aa)))>5) bc[i]<-mean(aa,na.rm=TRUE)
			}
return(t(bc))
}

ozruns<-oz8runs(leboz)

pdf("oz8hist.pdf")
hist(as.vector(ozruns),col="magenta",xlab="ppm",main="")
dev.off()

pdf("oz8.pdf")
y<-apply(ozruns,1,my.max)
plot(dateo,y,type="l",col="blue",ylab="ppm")
ind<-which(!is.na(y))
kk<-1:length(y)
a<-loess(y[ind]~kk[ind])
lines(dateo[ind],predict(a),col="red",lwd=3)
abline(h=.0749,col="green")
dev.off()


pdf("ozmaxweek.pdf")
w<-weekdays(as.Date(rownames(leboz),"%m-%d-%y"))
a<-apply(leboz,1,max)
i<-which(!is.na(a))
m<-tapply(a[i],w[i],mean)
labs<-c("Sunday","Monday","Tuesday","Wednesday","Thursday","Friday","Saturday")
n<-m[labs]
plot(n,ylab="ppm",axes=FALSE,type="l",xlab="weekdays",col="BLUE",main="Average Maximum Ozone per Weekday")
axis(side=1,at=1:7,labels=labs,col="RED",cex.axis=.6)
axis(side=2,col="RED")
dev.off()

pdf("pmmedianweek.pdf")
w<-weekdays(as.Date(rownames(lebpm),"%m-%d-%y"))
a<-apply(lebpm,1,function(x) median(x,na.rm=TRUE))
i<-which(!is.na(a))
```

```
m<-tapply(a[i],w[i],mean)
labs<-c("Sunday","Monday","Tuesday","Wednesday","Thursday","Friday","Saturday")
n<-m[labs]
plot(n,ylab="ppm",axes=FALSE,type="l",xlab="weekdays",col="BLUE",main="Average␣Median␣PM-2.5␣per␣Weekday")
axis(side=1,at=1:7,labels=labs,col="RED",cex.axis=.6)
axis(side=2,col="RED")
dev.off()
```

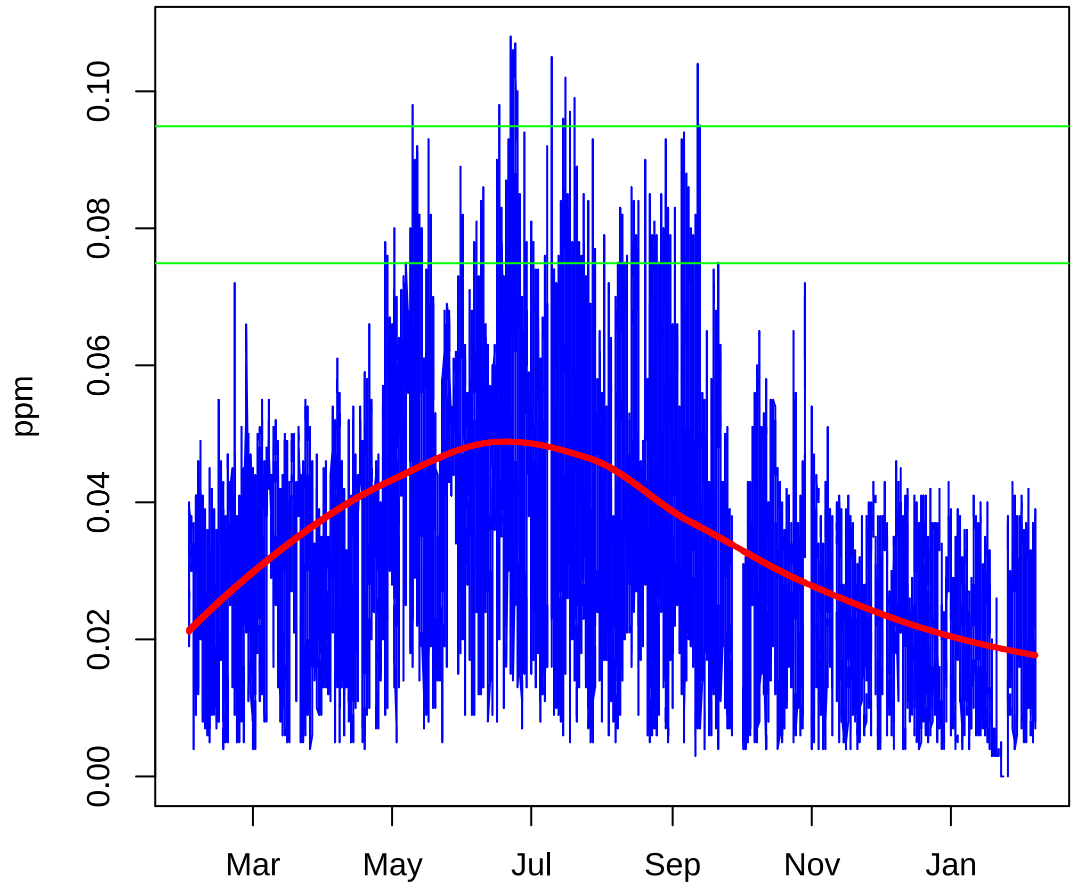

FIGURE 2. Ozone, Hour by Hour

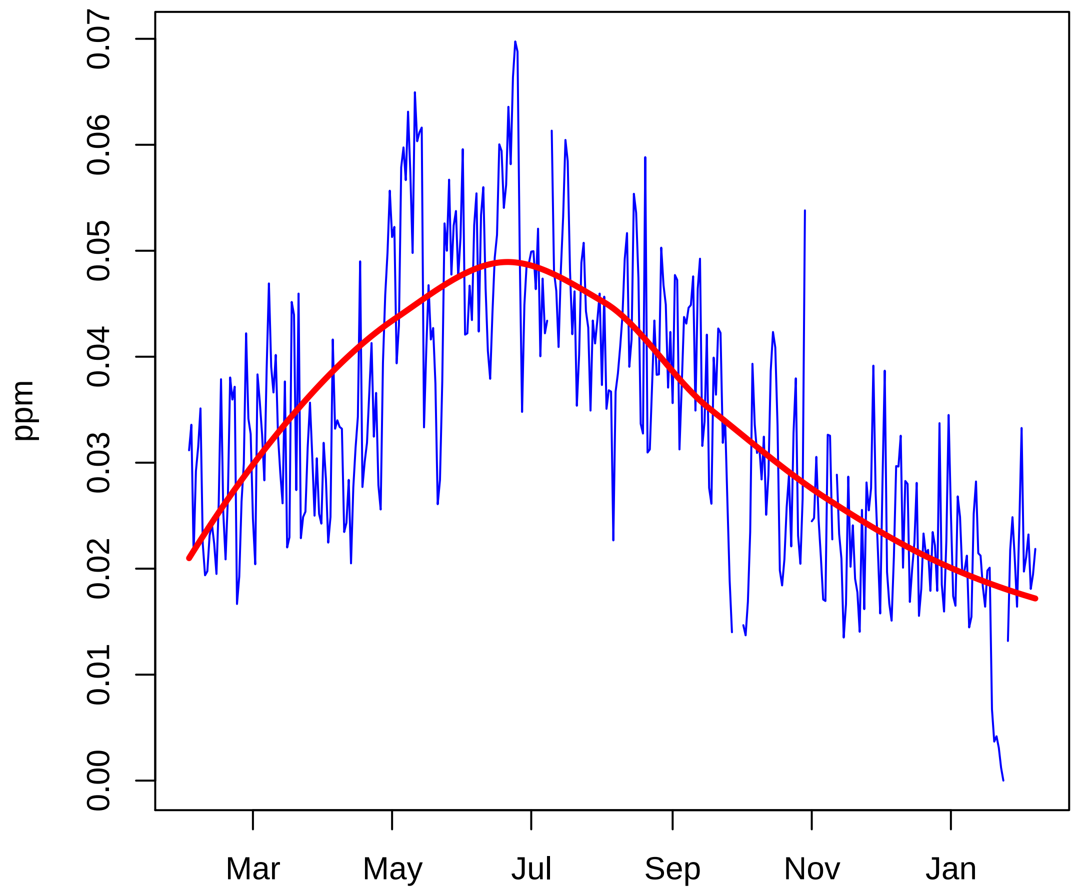

FIGURE 3. Ozone Daily Average

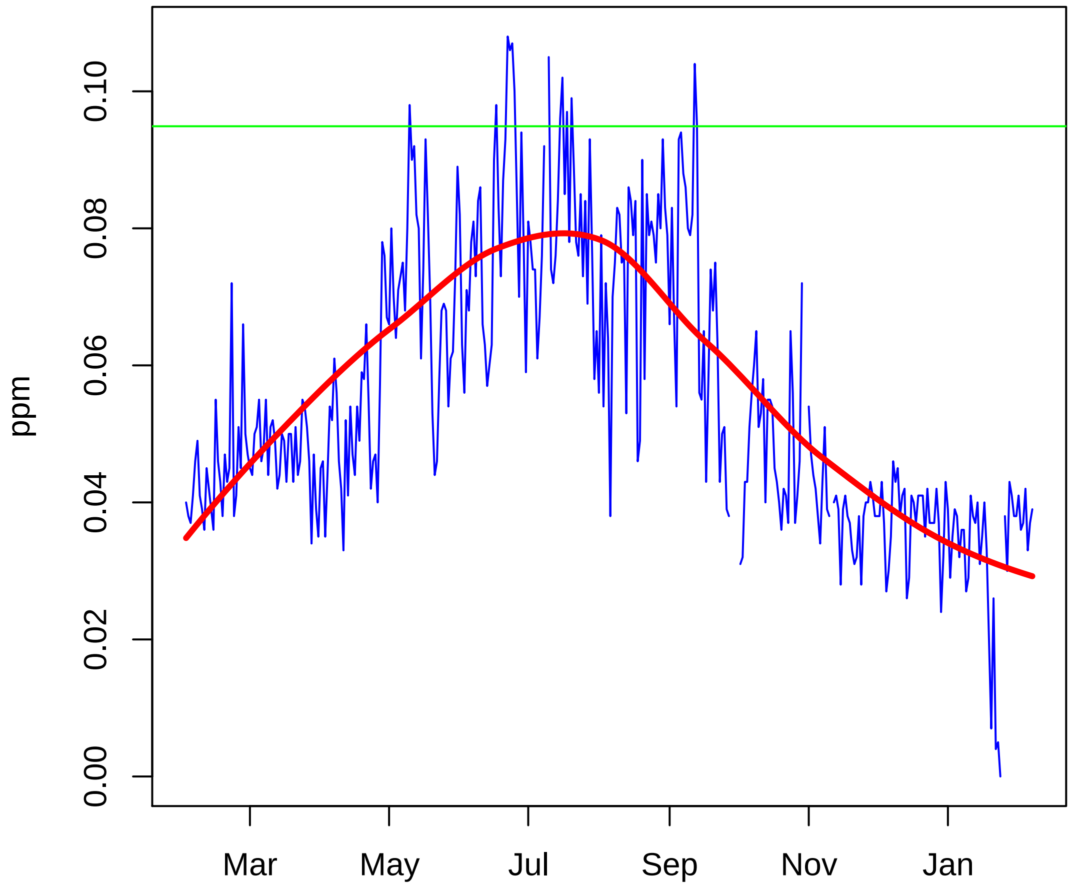

FIGURE 4. Ozone Daily Maximum

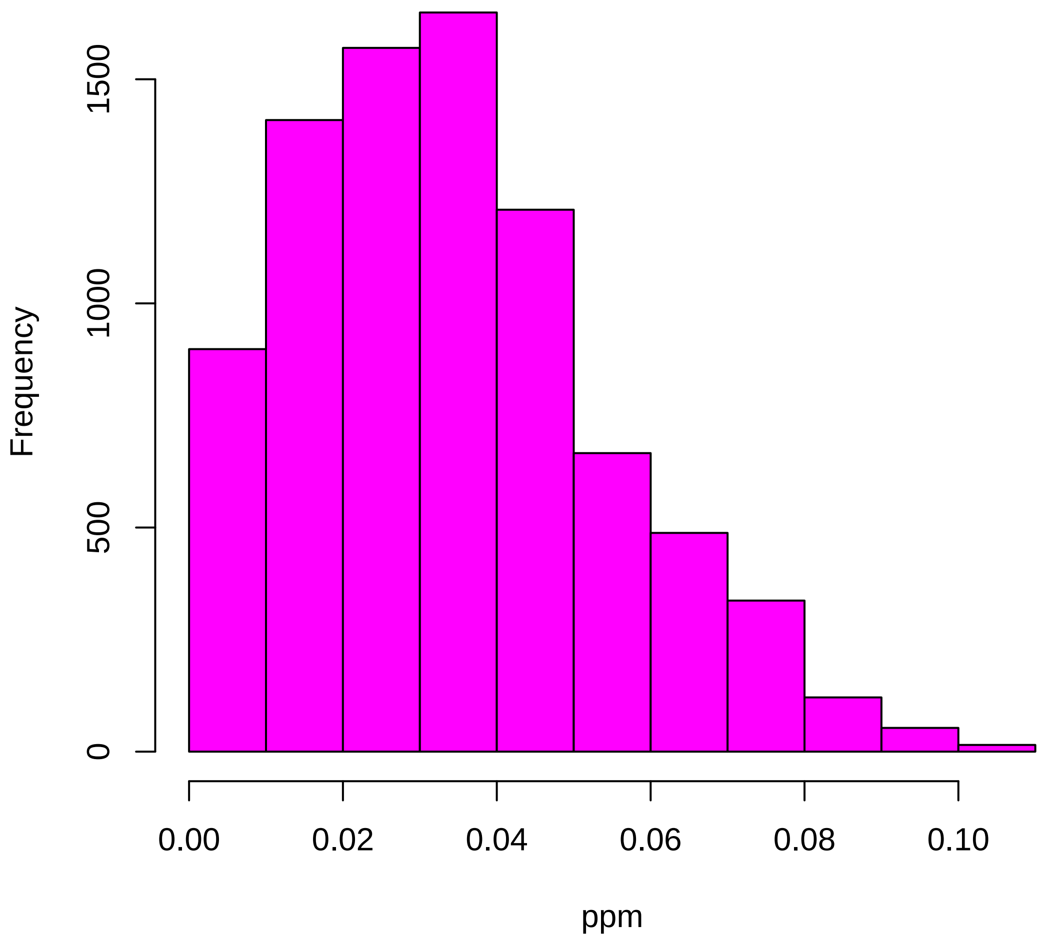

FIGURE 5. Ozone Distribution

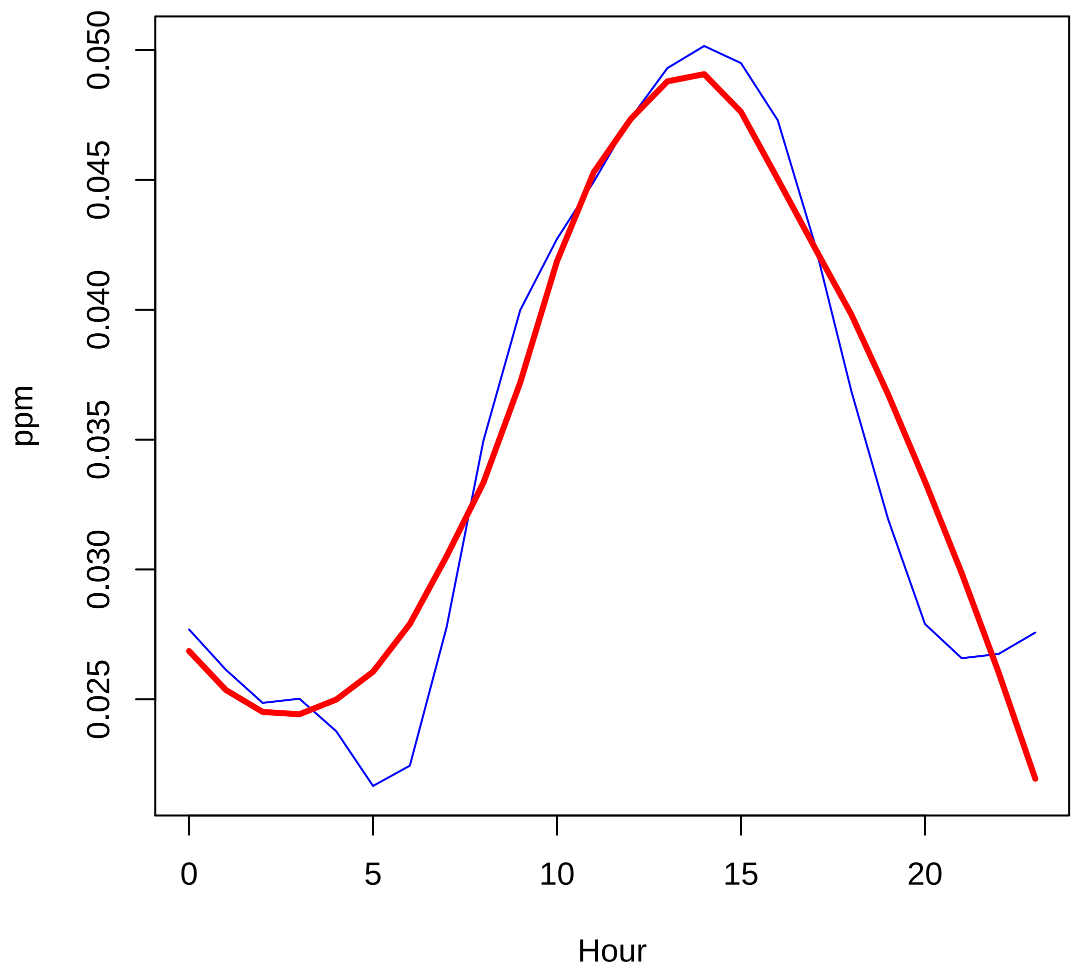

FIGURE 6. Ozone Hourly Average

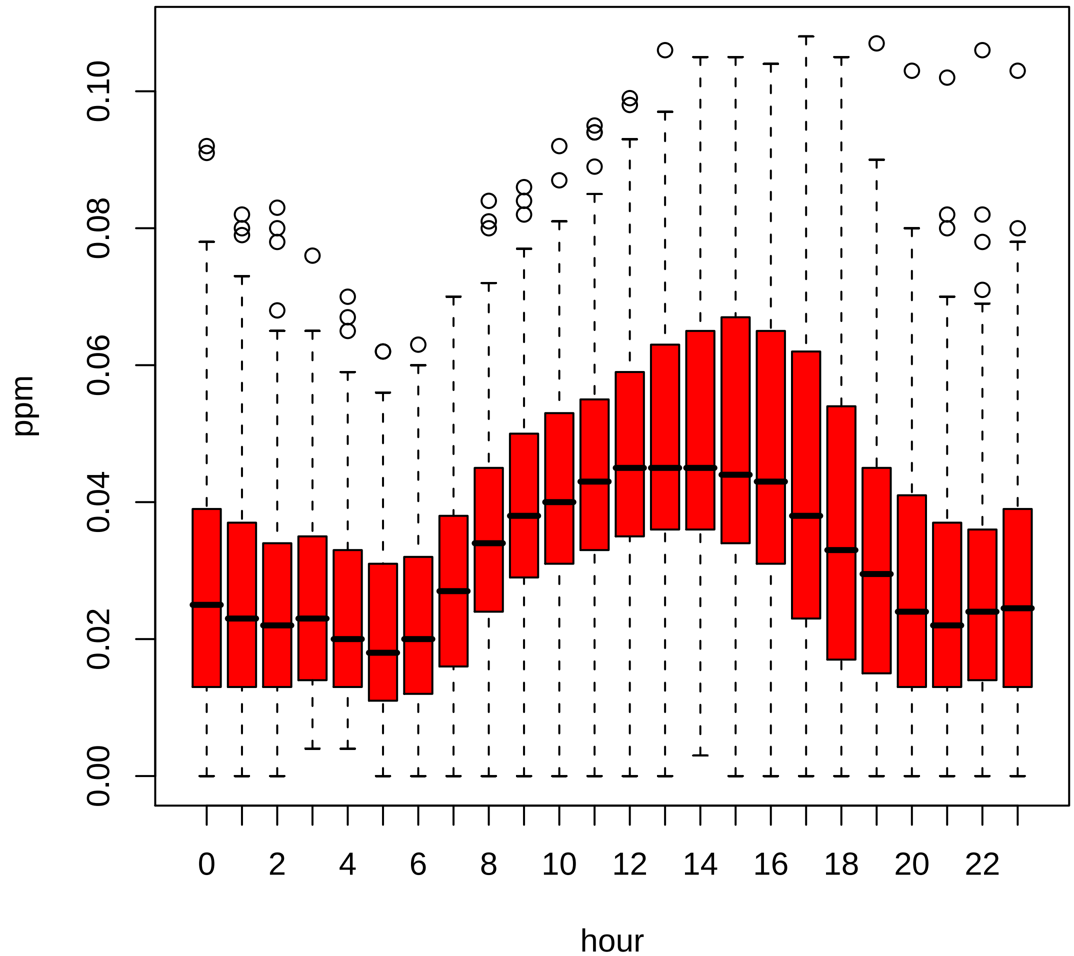

FIGURE 7. Ozone Hourly Distribution

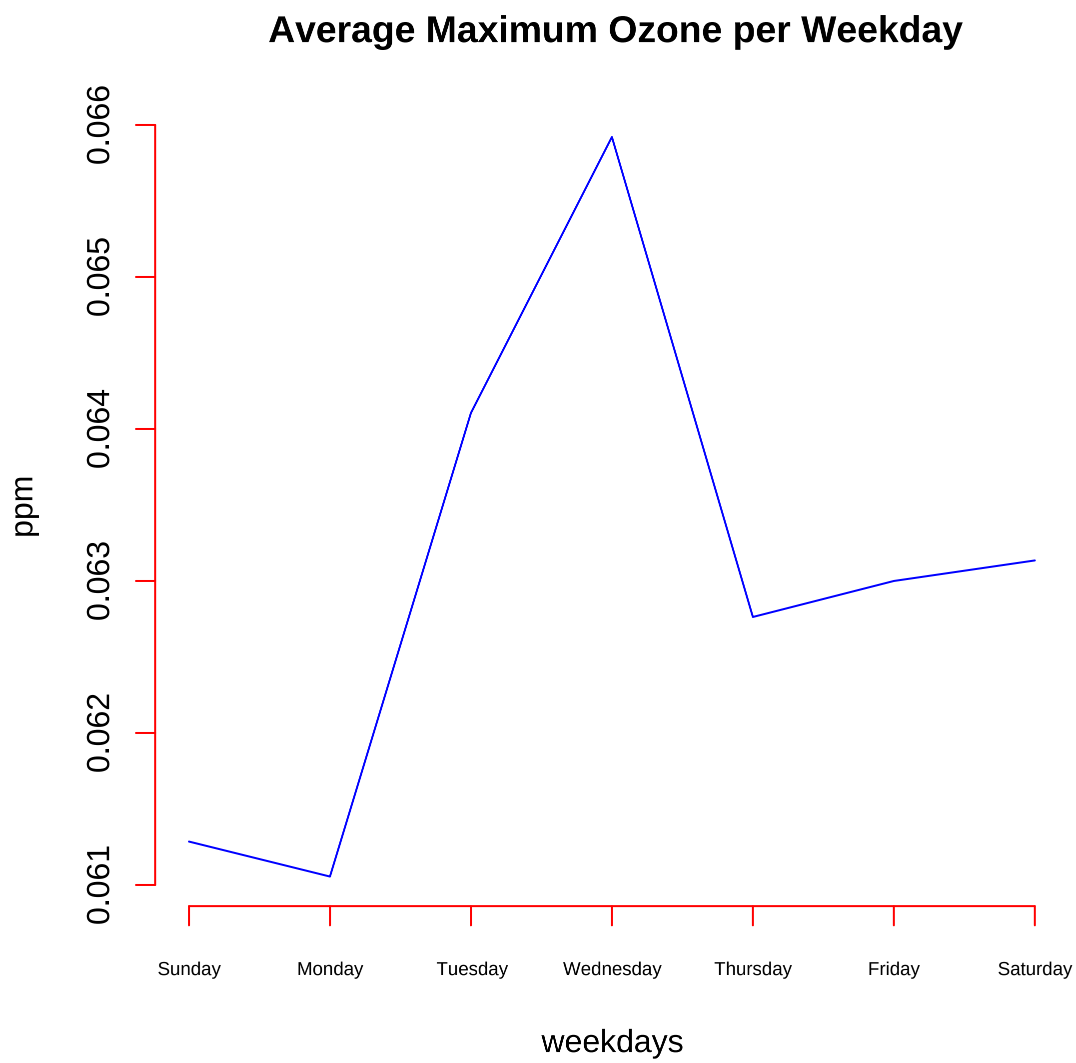

FIGURE 8. Average Maximum Ozone Level by Weekday

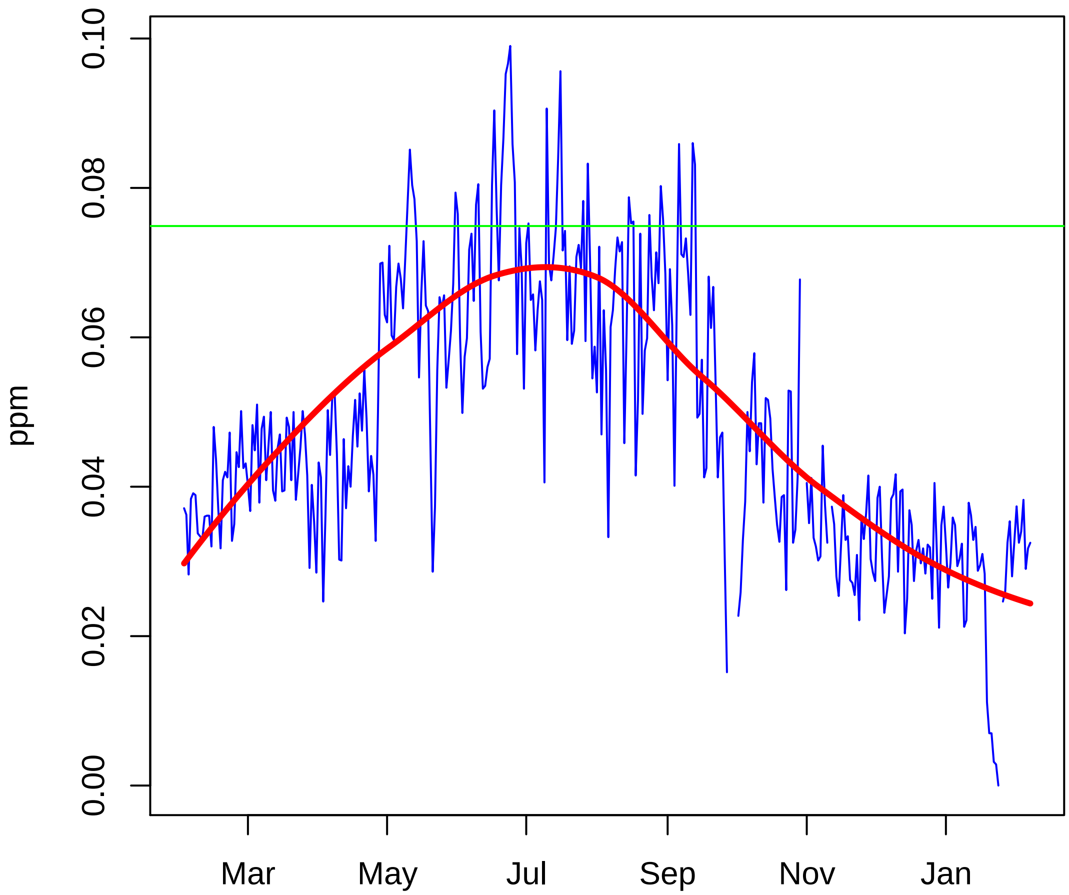

FIGURE 9. Ozone Eight Hour Series

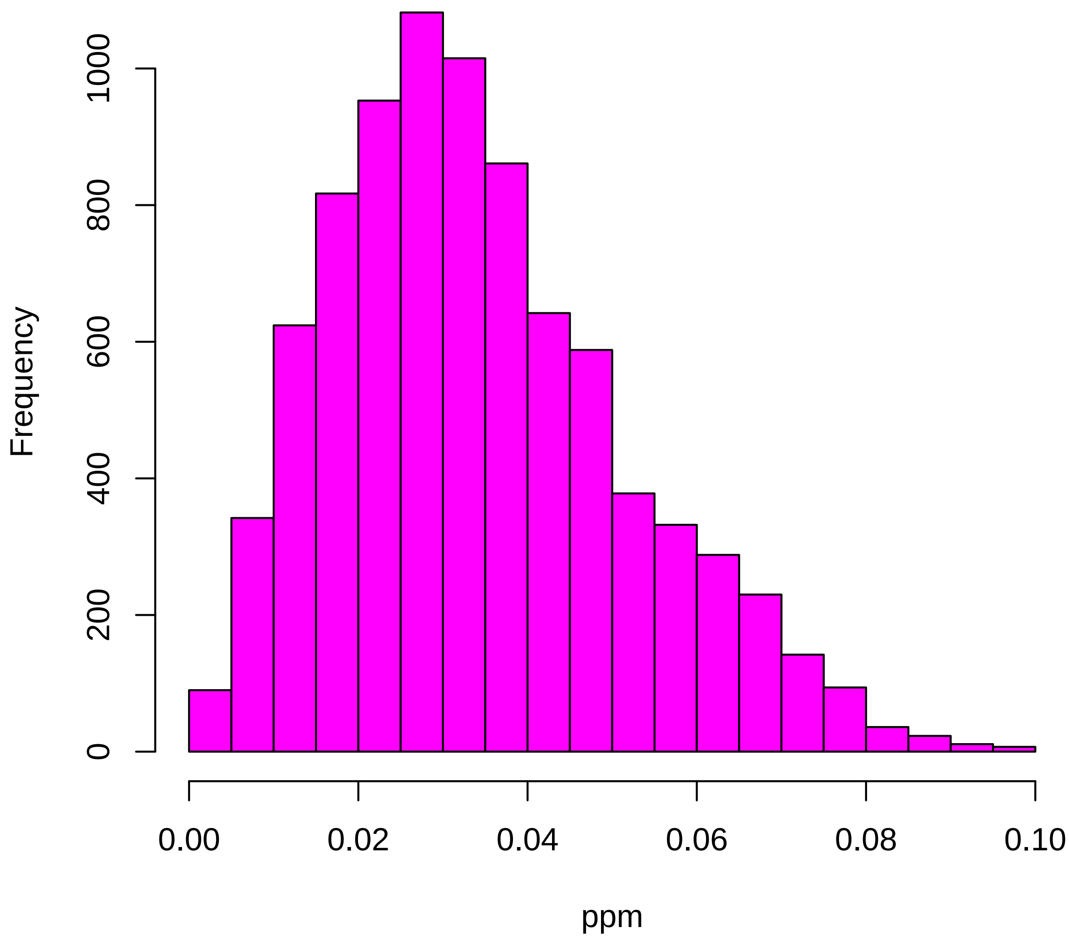

FIGURE 10. Ozone Eight Hour Distribution

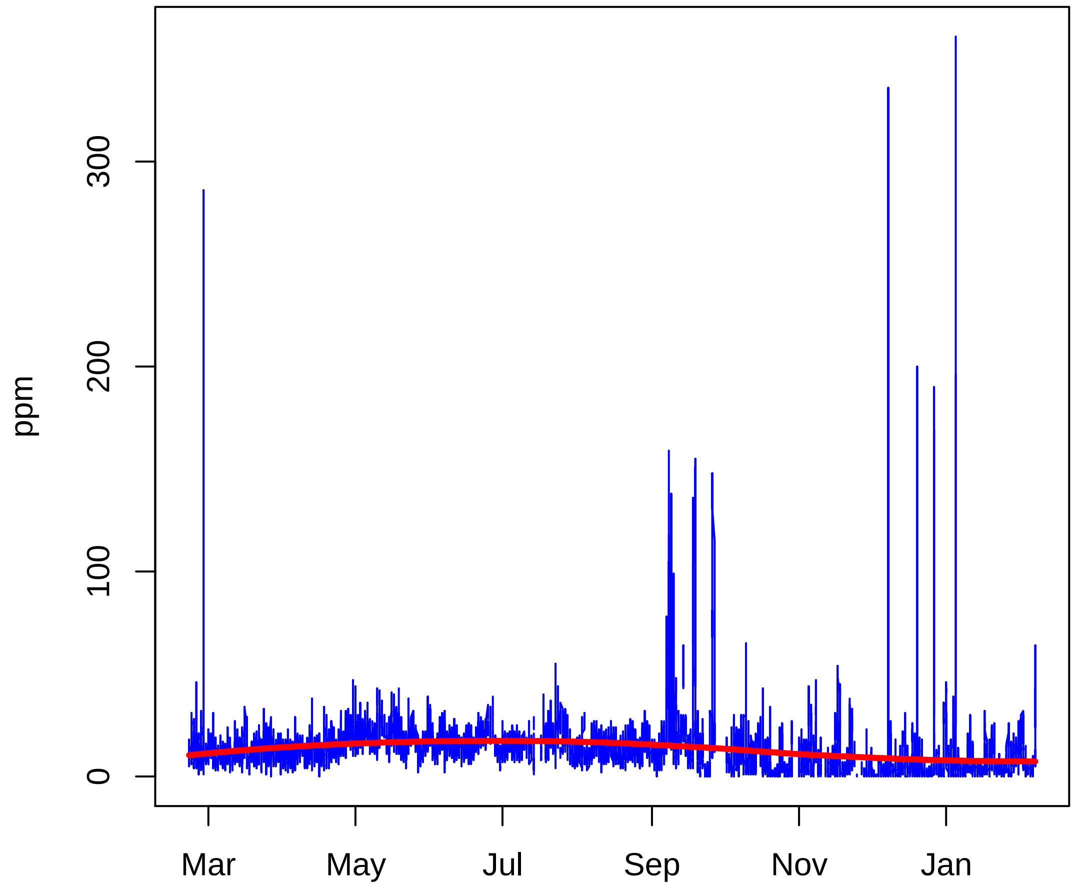

FIGURE 11. PM-2.5, Hour by Hour

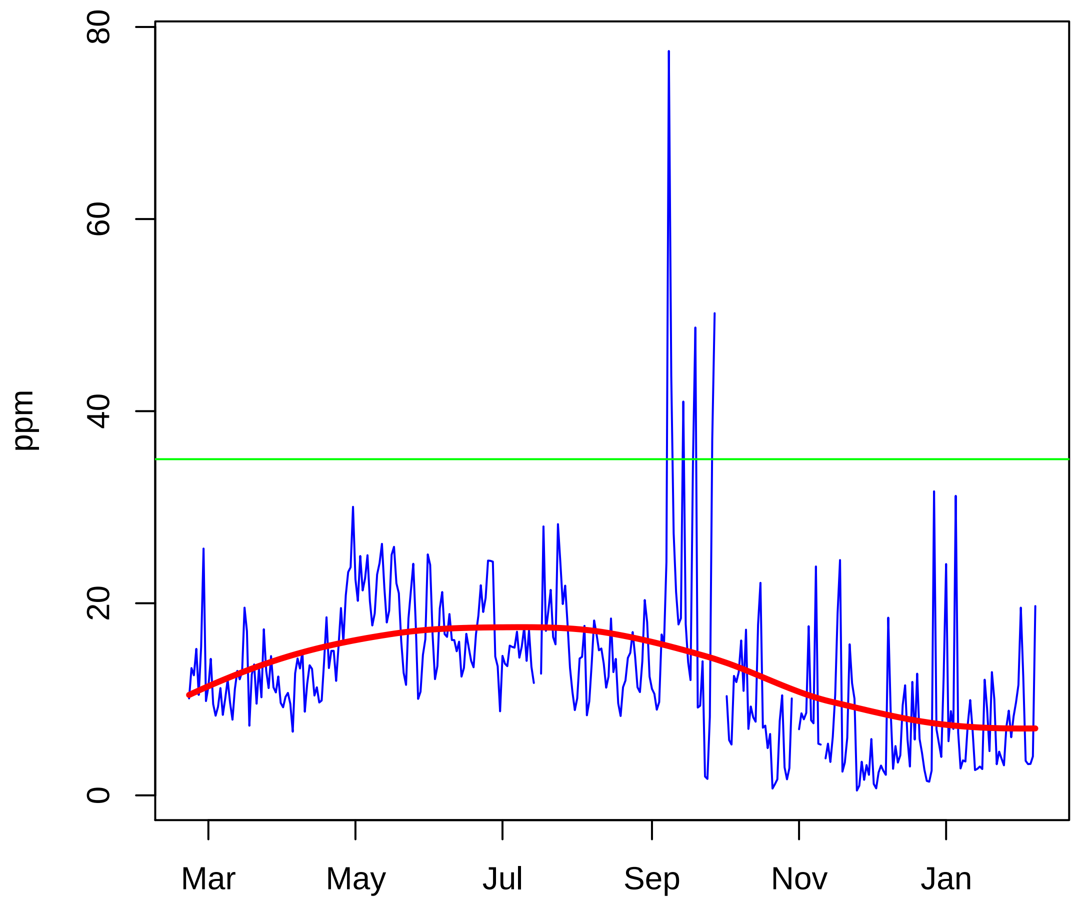

FIGURE 12. PM-2.5 Daily Average

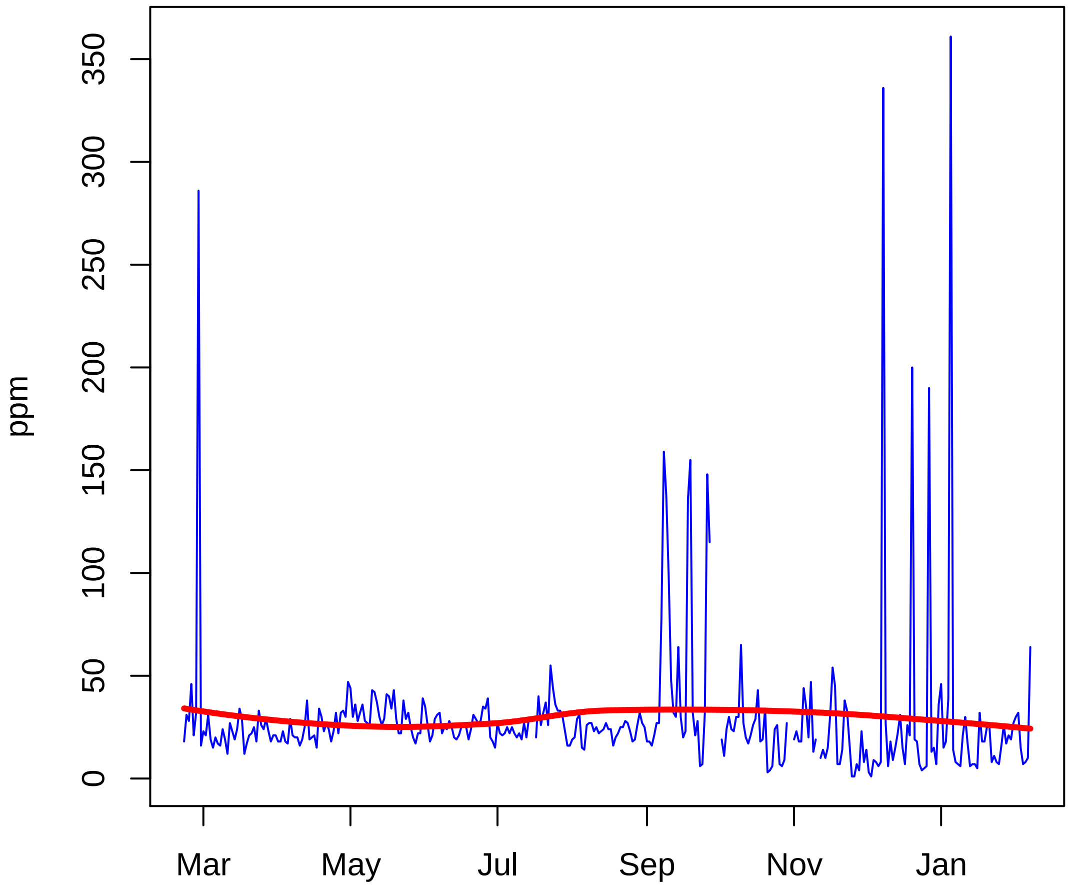

FIGURE 13. PM-2.5 Daily Maximum

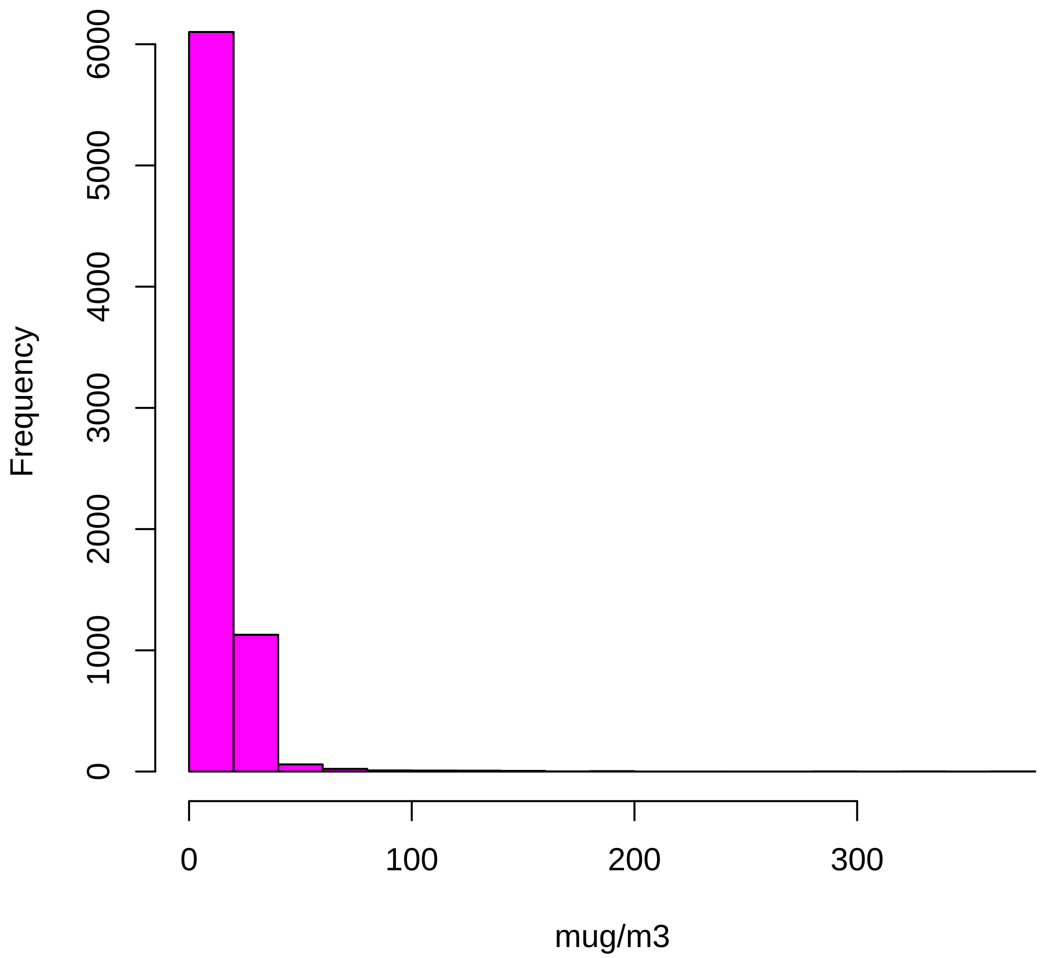

FIGURE 14. PM-2.5 Distribution

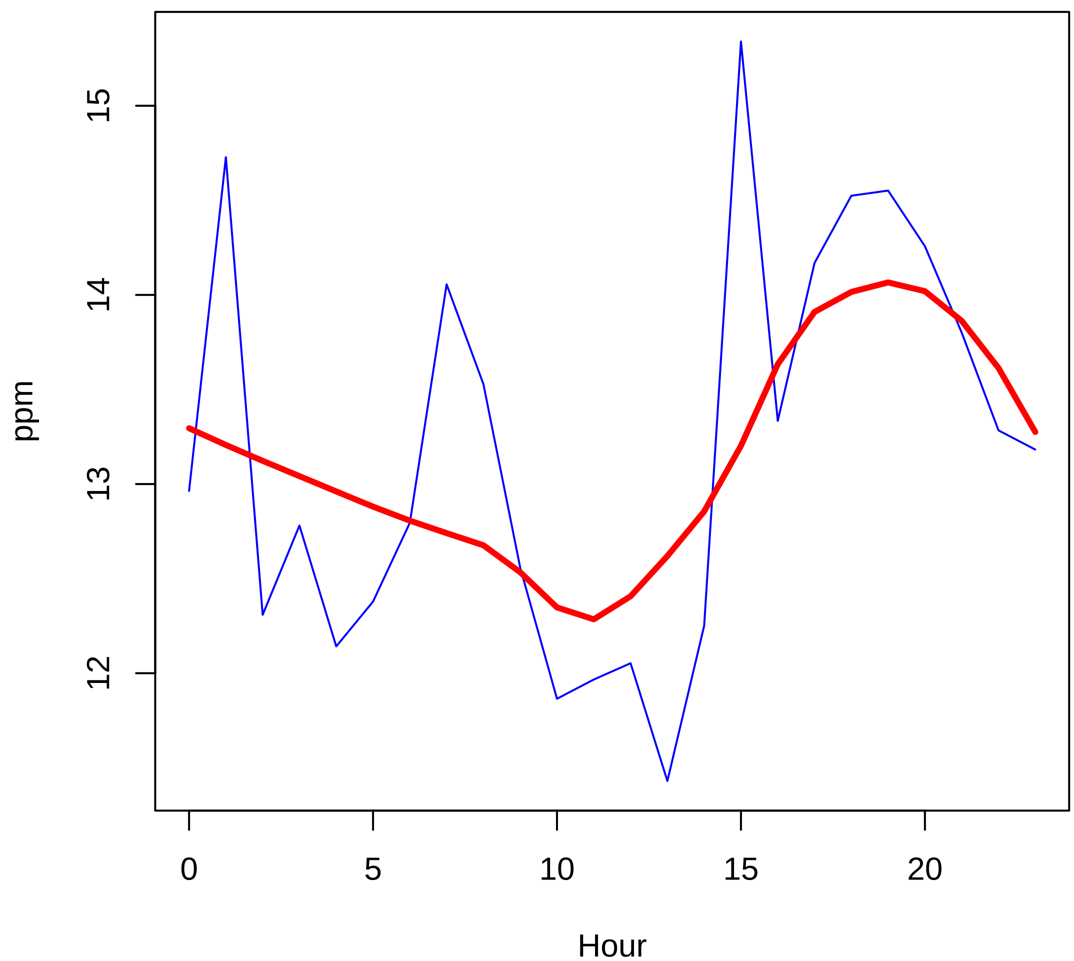

FIGURE 15. PM-2.5 Hourly Average

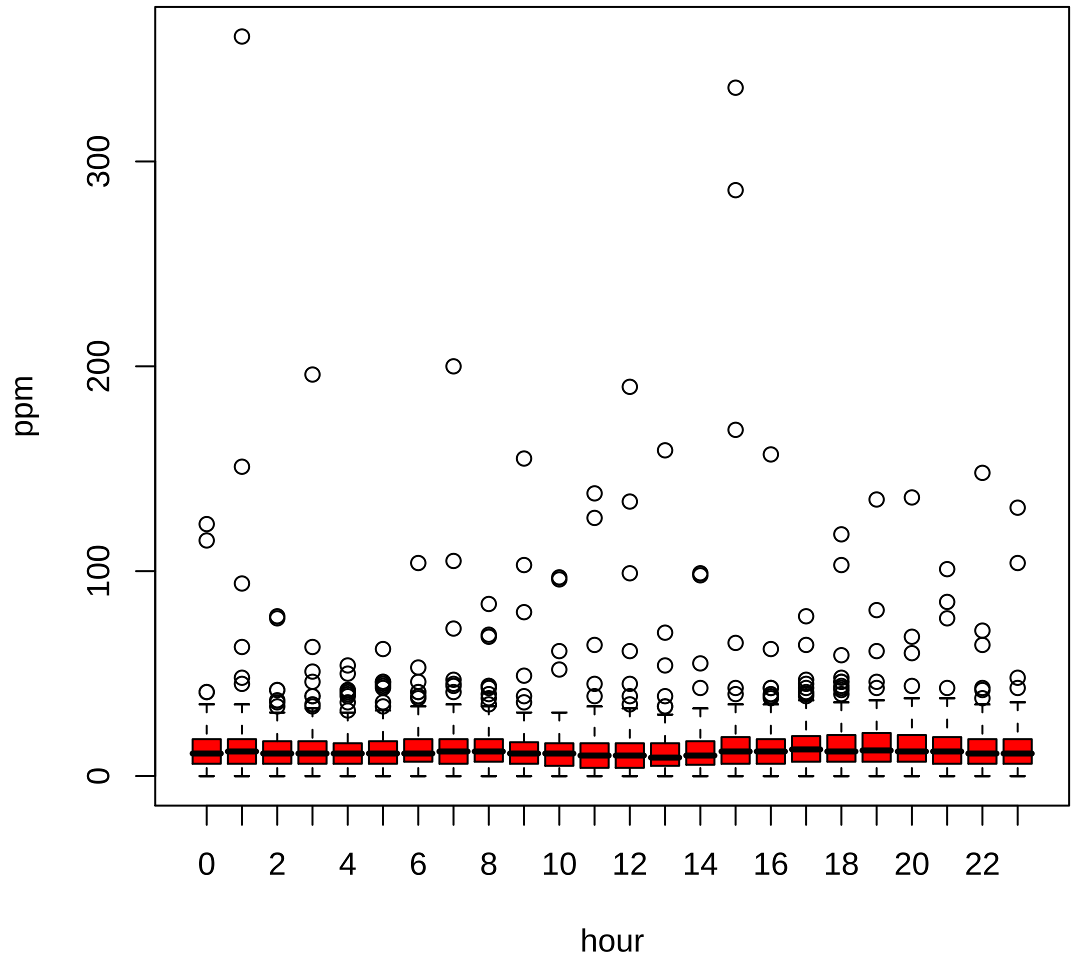

FIGURE 16. PM-2.5 Hourly Distribution

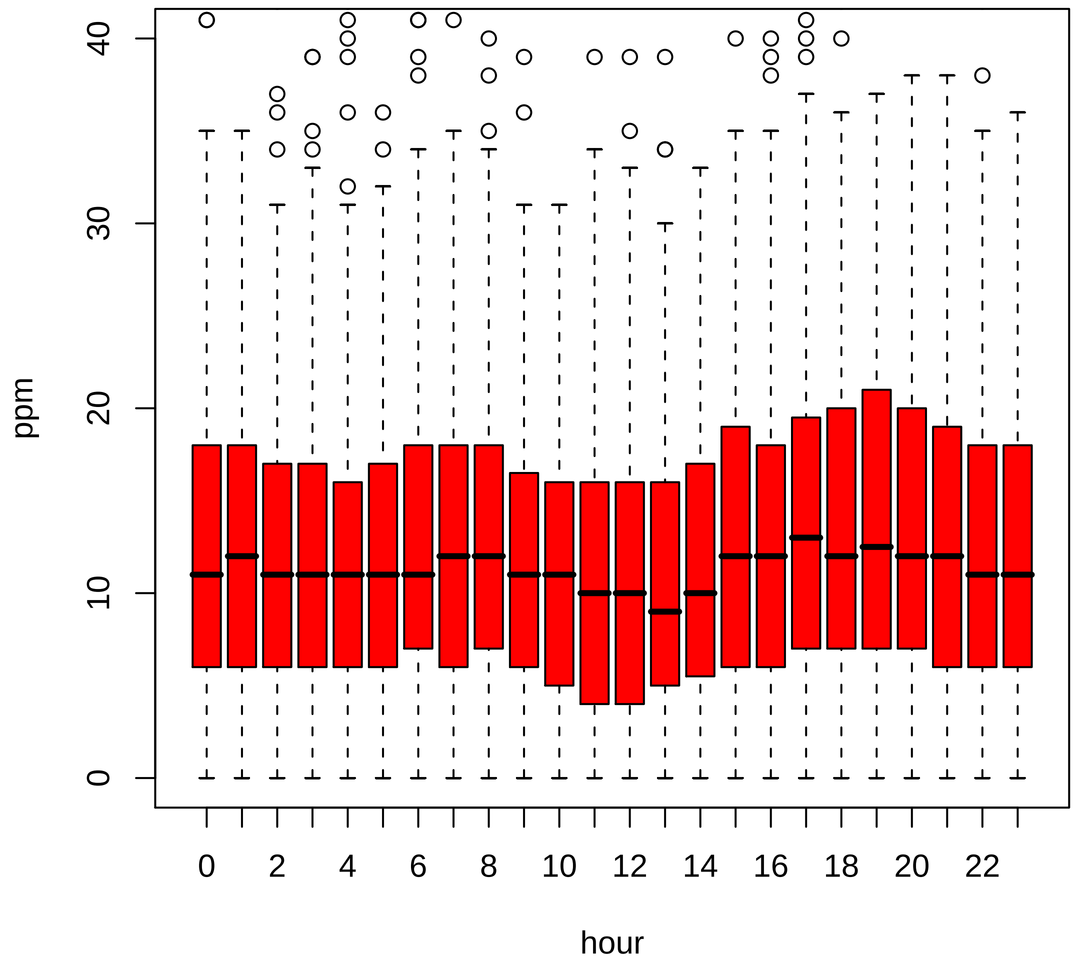

FIGURE 17. PM-2.5 Hourly Distribution (Detail)

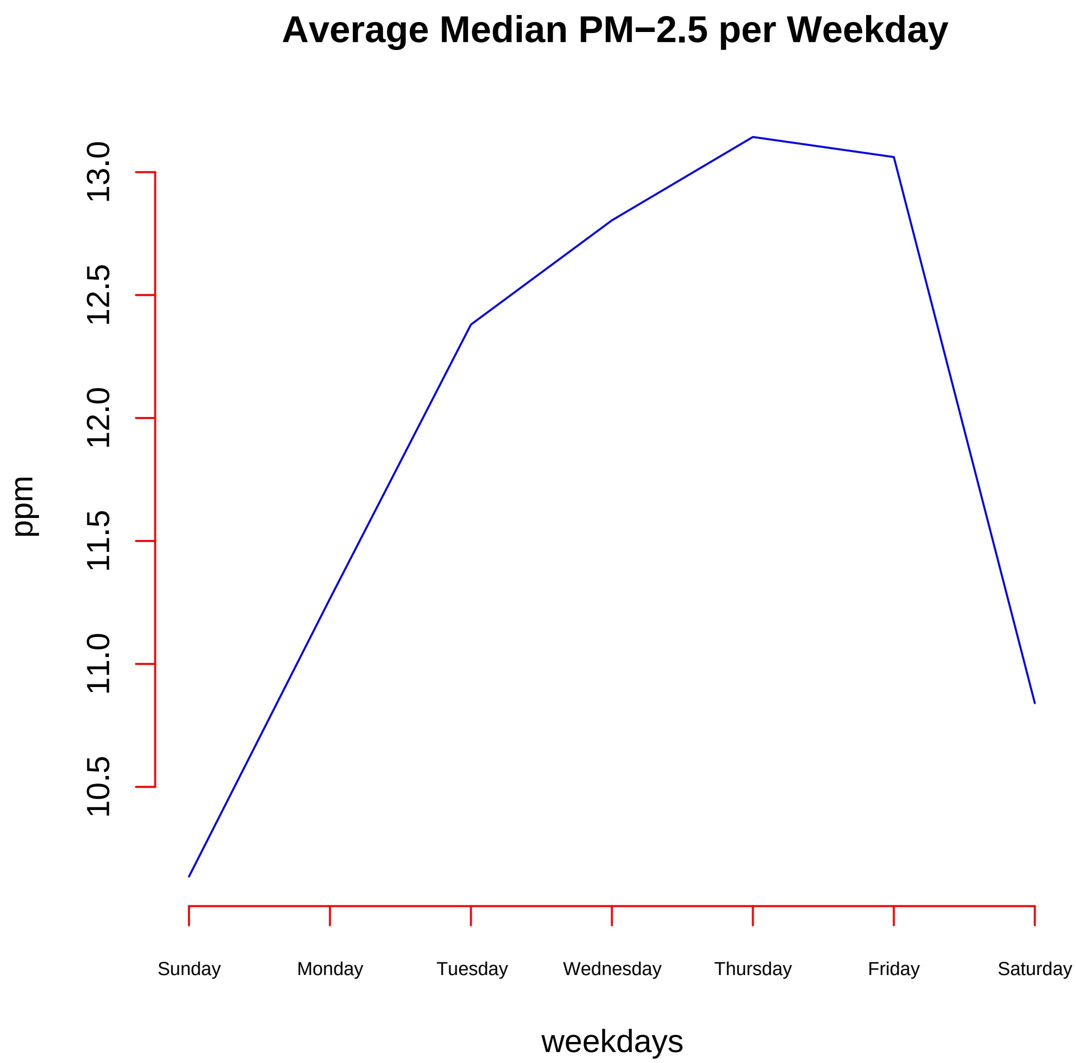

FIGURE 18. Average Median PM-2.5 Level by Weekday

Site	Exceedances
Crestline	73
Arvin	69
Santa Clarita	62
Bakersfield	52
Edison	39
Glendora	37
Reseda	34
Pasadena – S. Wilson	26
Burbank	25
Azusa	23
Oildale	22
Simi Valley	17
Shafter	15
Lebec	13
Ojai	12
Piru	10
Maricopa	8
Los Angeles – North Main	8
W. Los Angeles –VA Hospital	3
Los Angeles – Westchester Pkwy	0
El Rio	0

TABLE 1. One-Hour State Ozone Standard Exceedances

Site	Exceedances
Arvin	125
Crestline	103
Bakersfield	101
Oildale	86
Santa Clarita	78
Shafter	67
Maricopa	62
Reseda	55
Lebec	53
Simi Valley	45
Glendora	41
Piru	41
Ojai	38
Pasadena – S. Wilson	34
Burbank	32
Azusa	24
Edison	10
Los Angeles – North Main	7
W. Los Angeles –VA Hospital	2
Los Angeles – Westchester Pkwy	0
El Rio	0

TABLE 2. Eight-Hour State Ozone Standard Exceedances

Site	Average
Bakersfield	18.65
Burbank	16.50
Los Angeles – North Main	15.56
Azusa	15.50
Lebec	13.18
Pasadena – S. Wilson	12.94
Reseda	12.94
Simi Valley	10.34
El Rio	9.86
Piru	9.17

TABLE 3. PM-2.5 Annual Averages

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