2.6 REPRESENTATIVENESS OF TWO OZONE EPISODES SELECTED FOR MODELING IN THE SAN FRANCISCO BAY AREA

David Fairley*, Philip T. Martien, Su-Tzai Soong, and Saffet Tanrikulu
Bay Area Air Quality Management District, San Francisco, CA

1. INTRODUCTION

This study analyzes the representativeness of two ozone episodes selected for photochemical modeling in the San Francisco Bay Area (SFBA).

Because of the difficulty in gathering sufficient meteorological, emissions and ambient pollutant data, photochemical modeling is generally restricted to a limited number of days. But the primary goal of the modeling is to estimate the effects of emissions reductions and amount of reductions necessary to meet the ozone standards. Thus, the behavior of ozone on modeled days must represent other high ozone days.

In determining representativeness, several statistical methods were used and the following factors were considered: the location of the ozone peak; wind direction, since this affects the location of ozone precursors; spatial extent of the episode; day of week, especially weekend vs. weekday ozone; episode length, that is, accounting for carryover effects from previous days; and meteorological conduciveness to high ozone.

1.1 Study Domain

The San Francisco Bay Area is home to approximately seven million people, five million automobiles, and several large industrial emissions sources, including electric power generating facilities and refineries. Its topography is complex. The SFBA is bordered by the Pacific Ocean in the west and Central Valley in the east. The Coast Range, extending in the north-south direction, has gaps in the SFBA, allowing air flow between the Pacific Ocean and Central Valley. The remaining portions of the Coast Range have a number of hills and valleys of various sizes. A large temperature gradient develops on most summer afternoons between the ocean and Central Valley.

* *Corresponding author address:* David Fairley, BAAQMD, 939 Ellis St., San Francisco, CA 94109; e-mail: dfairley@baaqmd.gov

Figure 1 shows the SFBA region, including the boundaries of the Bay Area Air Quality Management District (BAAQMD or District). Also shown are the District ozone sites.

Ozone concentrations in the SFBA occasionally exceed the federal 1-hour standard. However, ozone has declined significantly in much of the SFBA since the 1980s. A shift in the location of ozone exceedances is also evident. In the 1980s, peak ozone typically occurred near San Jose, in the southern SFBA. However, in recent years, this area has had few exceedances; high ozone has concentrated almost exclusively in the Livermore Valley, in the eastern SFBA.

1.2 Episode Selection

The Central California Ozone Study (CCOS), conducted in the summer of 2000, made extensive ambient air quality and meteorological measurements to provide data for photochemical modeling.

The field study yielded only one exceedance of the national ozone standard during a period of extensive monitoring – an ozone concentration of 126 ppb at Livermore on 7/31/00. A second exceedance day occurred on 6/15/00, before CCOS monitoring was fully operational. It was determined that, for a variety of reasons, these episodes could not represent all SFBA high ozone days. Among the reasons were that the exceedances occurred at just one site, the episodes lasted only one day, and both days were weekdays. In addition, a cluster analysis of SFBA exceedance days produced two clusters of episode days. Thus, to represent these other conditions, another episode, 7/11/99 – 7/12/99, was selected for modeling. Of the two CCOS episodes, the 7/31/00 episode was selected for modeling primarily because more special-study data were available; however, some of the analyses in this study were also applied to the 6/15/00 episode.

2. DATA AND METHODS

This study utilized air quality data from CCOS and District monitoring sites for 1995 through 2002. Figure 1 shows the District ozone sites.

Several sites were moved during this period – from Mountain View to Sunnyvale, from Richmond to San Pablo, and from one Livermore site to another. Overlapping measurements were made at the Livermore sites for one year. The ozone measurements at these two sites were very highly correlated. The new site's ozone distribution was statistically indistinguishable from that of the older site. For this study, each of these pairs of sites is treated as a single site. The ozone sites are divided into five geographical regions for analysis purposes.

Meteorological data were obtained from the Oakland radiosonde soundings in the central SFBA as well as the District's network of meteorological sites and several airport sites.

Cluster analysis was used to determine if the SFBA ozone episodes could be differentiated. The data used for the cluster analysis were 1-hour ozone maxima for 22 District sites on the 36 episode days. Missing values were filled in using a 2-way ANOVA followed by maximum likelihood estimation assuming that each day's vector of ozone maxima had a multivariate normal distribution. Average linkage clustering was used, where the "distance" between two clusters was the average of the distances between each member of one cluster and each member of the other. The "distance" metric between two days was Euclidean; i.e., simply the distance between the two days' sets of ozone measurements, thought of as two points in 22-dimensional space.

Weibull regression was used to assess the severity of episodes. The dependent variable was District daily 1-hour maximum ozone. Independent variables included meteorological variables from sites with long data records – Livermore, Travis Air Force Base, and Oakland – and an indicator for weekend/holiday. The Weibull methodology follows Cox and Chu (1993) and (1996).

3. SUMMARY OF SAN FRANCISCO BAY AREA EXCEEDANCE DAYS, 1995-2002

Tables 1-3 present features of the 36 days from 1995 through 2002 that exceeded the national 1-hour ozone standard of 124 ppb. Table 2 shows numbers of exceedances by site. One feature that stands out is that Livermore had exceedances on 27 of the 36 days, and had the highest ozone on 20 of those days. Concord was a distant second with exceedances on 10 days and the highest ozone on 6. These sites, along with Bethel Island and Fairfield, all in the eastern side of the SFBA, account for all but seven of the highest ozone values.

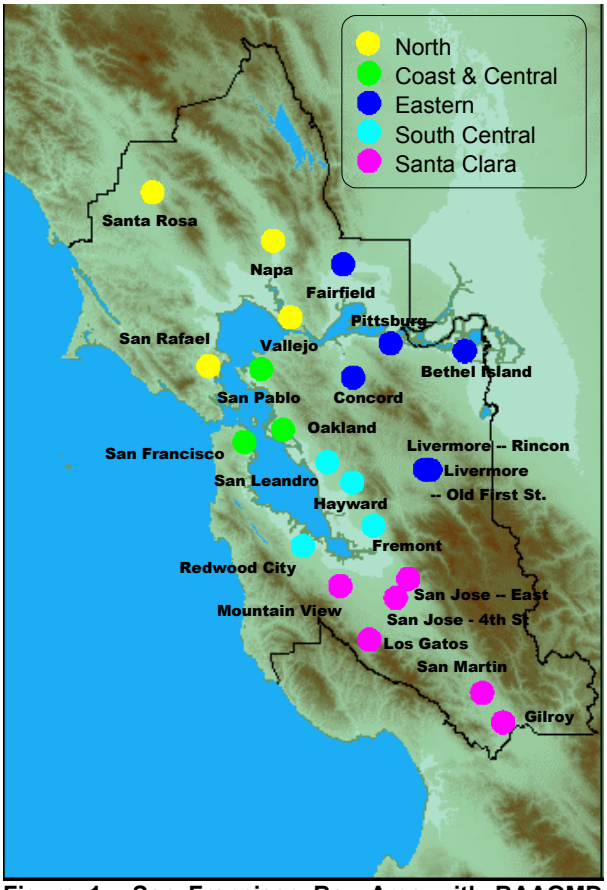

Figure 1. San Francisco Bay Area with BAAQMD boundaries and ozone monitoring sites.

Table 3 presents several aspects of recent SFBA ozone exceedances. There was an exceedance at one or more eastern sites on 33 out of the 36 episode days. Santa Clara County had 11 such days. The other regions – North Counties, Central Bay and South Central Bay had few exceedances by comparison. Of the episode days, there was exactly the same number with an exceedance at a single site as with exceedances at multiple sites. Both 1-day and multi-day episodes were common: 16 of the episodes with 1-hour exceedances were 1-day events, the rest were 2-day or 3-day events.

Table 1. Ozone (ppb) by site* on District days exceeding the national 124 ppb 1-hour ozone standard, 1995-2002

				Eastern (E)						N. Count. (NC)				Central Bay (CB)			South Central Bay (SCB)					Santa Clara Valley (SCC)					Dist
m	d	yr	dow	bi	ff	pt	cc	li	lv	np	va	st	sr	oa	sf	sp	mv	rc	sl	fr	ha	lg	gi	sm	ar	sj	Max
6	23	1995	Fr	86	95	96	90	**130**		81		53	60	36	26	49		68	77	108	88	89	118	113	**127**	100	130
6	24	1995	Sa	76	109	87	98	**142**		74		67	84	84	74	81		116	**150**	**153**	**145**	**130**	107	115	**127**	121	153
6	25	1995	Su	98	**129**	121	**128**	120		**130**		84	88	75	71	78		114	**131**	117	119	97	92	91	113	114	131
7	14	1995	Fr	79	95	91	86	106		80	82	61	57	33	53	52	97	88	67	92	102	101	**130**	**128**	113	108	130
7	15	1995	Sa	84	87	93	99	98		90		88	82	70	88	87	116	**140**	**144**	**149**	**138**	**128**	108	107	**145**	**134**	149
7	27	1995	Th	124	113	119	**152**	**155**		105	91	97	59	26	40	47	79	58	87	107	88	**141**	96	102	106	102	155
7	31	1995	Mo	104	104	104	121	**138**		78	71	73	54	30	40	62	90	69	82	87	94	**135**	86	93	113	98	138
8	14	1995	Mo	107	98	113	**147**	**134**		95	99	73	68	34	42	57	66	60	87	100	88	85	81	88	105	98	147
8	19	1995	Sa	74	88	86	92	**147**		90	100	76	73	75	58	79	84	103	100	99	101	107	90	86	102	97	147
8	20	1995	Su	73	63	71	75	**130**		53	43	52	30	27	37	36	60	56	59	75	64	101	57	69	94	90	130
9	7	1995	Th	**128**	95	124	92	78		92	61	66	47	21	42	53	52	48	69	68	77	63	90	91	80	59	128
6	3	1996	Mo		81	75	87	**128**		73	83	53	51	21	20	27	42	32	38	71		72	91	82	73	59	128
6	30	1996	Su	79	100	92	115	**131**		90	100	66	80	85	51	73	94	69	107	89		113	90	114	88	90	131
7	1	1996	Mo	**137**	113	117	**127**	**133**		83	93	83	56	30	47	44	80	49	79	90		**129**	95	94	102	88	137
7	21	1996	Su	86	74	69	85	**126**		62	54	68	53		27	36	69	34	44	74		91	78	83	86	81	126
7	28	1996	Su	77	89	91	95	**129**		86	69	61	46	27	25	33	68	41	55	75		92	84	103	74	72	129
8	8	1996	Th	90	67	87	99	**133**		76	60	48	37	22	30	33	47		30	53		57	104	99	57	61	133
8	9	1996	Fr	113	101	94	101	**138**		78	81	60	55	36	31	42	71	46	71	76		96	98	109	62	88	138
8	10	1996	Sa		76		97	**137**		69		45		21	23	31	50	32		50		77	92		51		137
7	18	1998	Sa	97	102	95	115	**146**		91	79	63	69	43	26	58	97	54	73	106	99	**133**	**132**	**135**	**129**	**147**	147
8	3	1998	Mo	91	98	75	84	124		72	63	67	73	43	29	56	95	66	90	96	94		**135**	**142**	98	109	142
8	4	1998	Tu	101	121	97	119	**134**		**125**	119	67	74	34	29	47	85	43	101	115	104		118	**144**	120	110	144
8	12	1998	We	123	106	95	**147**	**139**		101	106	68	63	20	19	49	81	42	77	89	92	92	97	112	72	76	147
8	29	1998	Sa	88	70	63	88	**131**		66	59	44	42		30	36	56	36	37	63	63	68	91	98	61	66	131
9	2	1998	We	113	87	70	98	**139**		72	59	56	39		21	29	50	32	45	61	59	76	96	92	47	56	139
9	3	1998	Th	120	110	96	**130**	113		101	104	66	57		23	38	81	36	111	98	116	60	63	72	86	101	130
9	13	1998	Su	94	90	68	87	**136**		88	75	62	52		36	56	83	55	86	102	98	92	88	94	96	88	136
7	11	1999	Su	99	117	88	**126**	**146**		105	113	76	92	76	52	67	109	69	113	**133**	123	116	104	**125**	116	103	146
7	12	1999	Mo	112	120	98	**156**	**144**		115	95	76	61	27	50	47	95	47	89	98	83		101	115	107	109	156
8	25	1999	We	**128**	**129**	95	109	94		103	98	73	81	34	26	63	100		52	70	68	117	105	110	89	109	129
5	22	2000	Mo	115	82	107	**138**	84	82	70	65	43	48	30	21	47		29	43	55	50	46		77	61	58	138
6	15	2000	Th	85	66	78	86	**137**	**152**	57	36	37	32	31	30	36		36	35	44		63		64	**56**	52	152
7	31	2000	Mo	93	79	84	81	**126**	124	63	46	48	25	15	17	23		25	20	56	51	62		48	46	46	126
7	3	2001	Tu	**130**	102	118	**134**		113	99	82	86	68	38	58		55	45	80	91	76	90	90	95	77	84	134
7	9	2002	Tu	97		87	84		**135**	76	82	50	57	34	35	54	70	54	65	84	69	92	121	116	76		135
7	10	2002	We	111	101	111	102		**160**	78	73	67	60	29	29	51	67	48	75	67	70	106	75	90	67		160

District maximum underlined. Exceedances in bold. Successive episodes shown by alternating shading/no shading.

*Sites:	
bi	Bethel Island
ff	Fairfield
pt	Pittsburg
cc	Concord
li	Livermore – old 1st St
lv	Livermore – Rincon
np	Napa
va	Vallejo
st	Santa Rosa
sr	San Rafael
oa	Oakland
sf	San Francisco
sp	San Pablo
mv	Mountain View
rc	Redwood City
sl	San Leandro
fr	Fremont
ha	Hayward
lg	Los Gatos
gi	Gilroy
sm	San Martin
ar	San Jose - East
sj	San Jose

Table 2. Number of 1-hour exceedances (District maximum) by site, 1995-2002

North Counties (NC)		Eastern (E)		South Central Bay (SCB)		Santa Clara County (SCC)		Central Bay (CB)	
Napa	2(0)	Bethel Isl.	4 (2)	Fremont	3(2)	Gilroy	3(1)	Oakland	0
San Rafael	0	Concord	10(6)	Hayward	2(0)	Los Gatos	6(0)	San Francisco	0
Santa Rosa	0	Fairfield	2(1)	Mountain View	0	San Jose	2(1)	San Pablo	0
Vallejo	0	Livermore	27(20)	Redwood City	1(0)	SJ - East	4(0)		
		Pittsburg	0	San Leandro	3(1)	San Martin	5(2)		

Table 3. Number of 1-hour exceedances by year, subregion, number of areas, and episode length, 1995-2002.

		Exceedances by subregion					Single/Multi-site		Episode length		
	District	NC	CB	E	SCB	SCC	1 site	multi-site	1 day	2 days	3 days
1995	11	1	0	9	3	6	3	8	4	2	1
1996	8	0	0	8	0	1	7	1	3	1	1
1997	0	0	0	0	0	0	0	0	0	0	0
1998	8	1	0	7	0	3	4	4	4	2	0
1999	3	0	0	3	1	1	0	3	1	1	0
2000	3	0	0	3	0	0	2	1	3	0	0
2001	1	0	0	1	0	0	0	1	1	0	0
2002	2	0	0	2	0	0	2	0	0	1	0
All	36	2	0	33	4	11	18	18	16	7	2

3.1 Exceedances by Day of Week

Recent history suggests that SFBA ozone exceedances occur more frequently on weekends than weekdays – a so-called "weekend effect," where ozone tends to be higher on weekends than weekdays. Figure 2 shows a histogram of exceedance frequencies by day of week.

The average frequency was 36/7 = 5.1, so that the weekend exceedances were somewhat more frequent than average. The differences are not statistically significant, however, and in fact, Monday has been the most common exceedance day.

The weekend effect appears strongest for inner-bay sites. Blanchard and Fairley (2001) showed that sites ringing San Francisco Bay had statistically significant weekend effects whereas sites further east did not. Note that the three days when Fremont and San Jose recorded the District's maximum were weekend days and eight of the nine exceedances for San Jose, Fremont and San Jose-East occurred on weekends. In contrast, many of Livermore's and Concord's exceedances occurred during weekdays.

Another way to compare the importance of weekends vs. weekdays is to compare design values. For this, seven years were used, 1996-2002 – one year for each day of the week – so that there would be five years of weekdays and two years of weekend days. Thus, design values can be estimated from the 6^{th} and 3^{rd} largest values respectively. (The design value for the 1-hour ozone standard is that ozone concentration expected to be exceeded once per year on the average. Thus, if there are x years of ozone data, the $(x+1)^{st}$ largest value is an estimate of the design value.) For Livermore, the estimated ozone design values were 138 ppb for the weekdays vs. 137 ppb for the weekends. Ninety percent confidence intervals were constructed based on the binomial distribution. They are 134 ppb to 152 ppb for weekdays, compared with 136 ppb to 146 ppb for the weekends. Thus, there is no evidence that Livermore's weekend design value is higher or lower than its weekday design value. By way of contrast, Fremont has a strong weekend effect. Its weekday and weekend design values were 98 ppb and 109 ppb respectively, with confidence intervals of (96, 106) for weekdays, and (106, 133) for weekends. This difference is statistically significant.

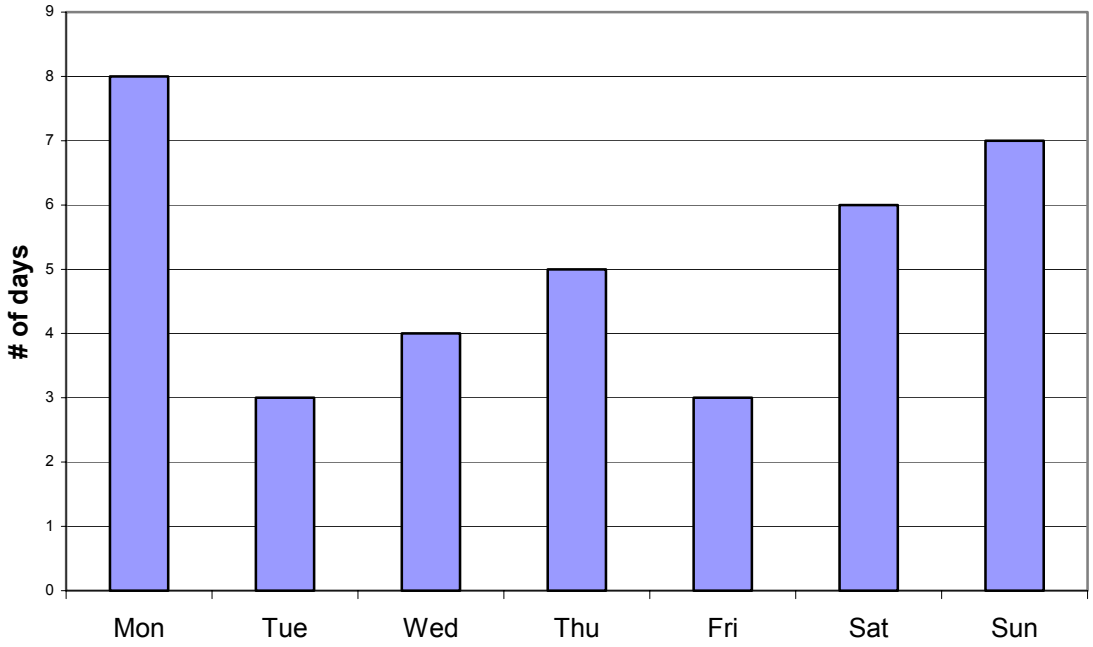

Figure 2. Numbers of exceedances by day of week, 1995-2002.

3.2 Month of Exceedance

In the SFBA, ozone exceedances are most frequent in July and August (Figure 3), and all but two of the 36 exceedances from 1995 through 2002 occurred between June 15 and September 15. This suggests that, to ensure representativeness, modeling days should be selected from this period. However, it is not clear that the dynamics are necessarily different at other times; the main reason for the fewer exceedances may simply be that there tend to be more hot days between mid-June and mid-September.

Since ozone production depends on sunlight, the dynamics of ozone production in September and October may be different from earlier summer months. In recent years, September exceedances have been localized, with only one station exceeding the standard on any day.

3.3 Trends and Representative Days

Figure 4 shows 3-year 4th highest ozone concentrations for 1980 through 2002 for Livermore and the South Bay Area (Santa Clara County and southern Alameda County. The sites included were Fremont, San Jose, Los Gatos, San Jose-East, Gilroy, and San Martin). The District maximum was always either in Livermore or the South Bay Area. In the early 1980s, District maximum ozone occurred in the South Bay Area, but by the late 1980s, South Bay ozone concentrations had diminished to levels similar to Livermore's, and by about 1995, the levels had diminished further, so that Livermore has become the District's design value site.

The South Bay Area now comfortably meets the national 1-hour ozone standard, and Figure 4 shows that the trend toward reduced ozone continues for that area. Thus, the rare days where the ozone peak occurs in this area can be ignored for representativeness and photochemical modeling.

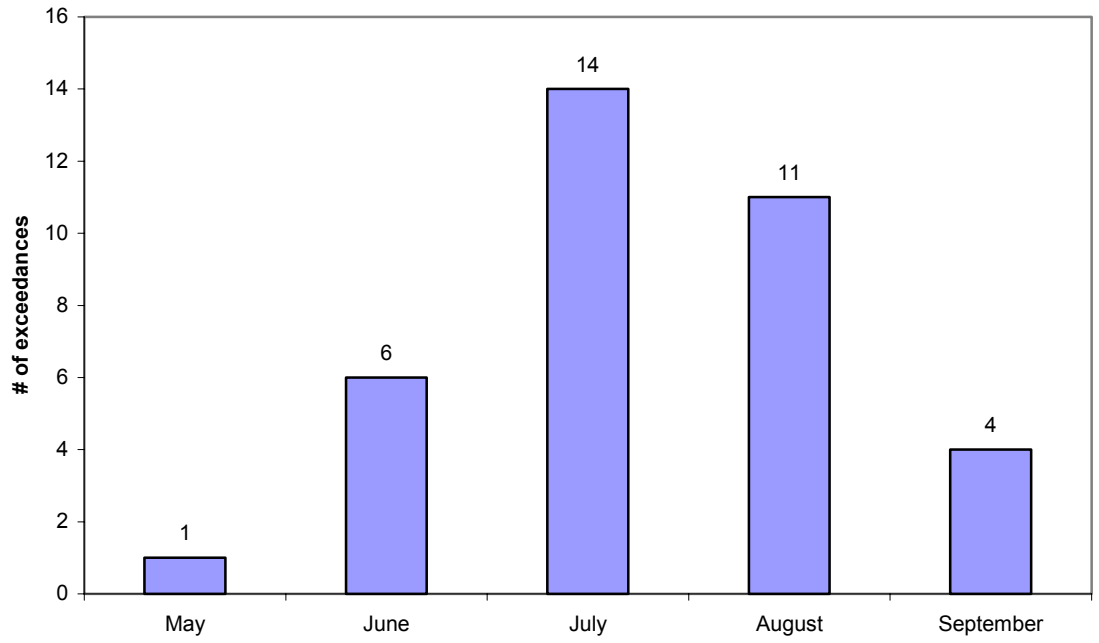

Figure 3. Numbers of exceedances by month, 1995-2002.

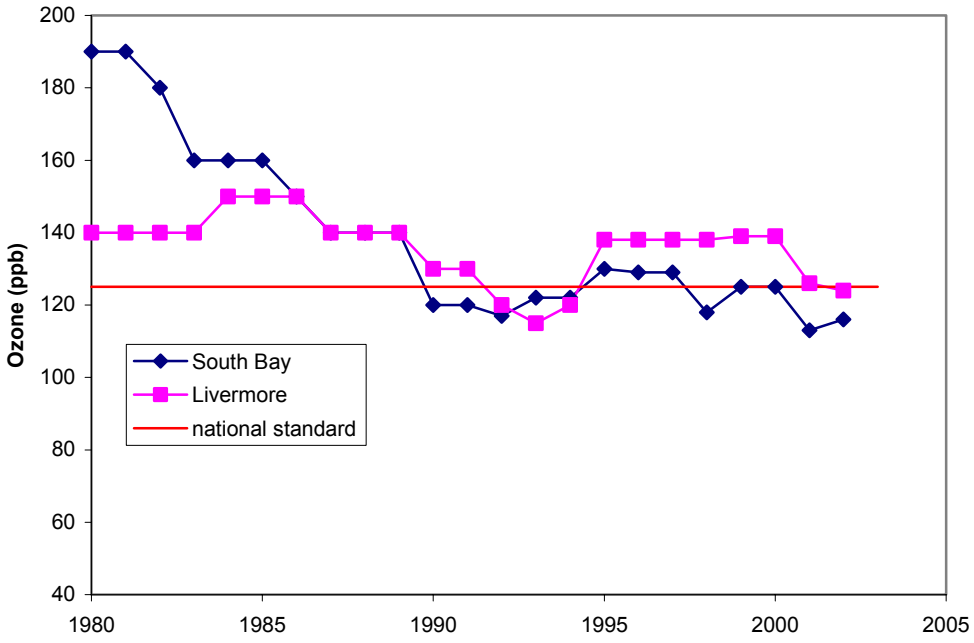

Figure 4. Trends in Livermore and South Bay 3-year 4th highest 1-hour ozone 1980-2002.

4. CLUSTER ANALYSIS

To investigate whether multiple types of episodes existed, a cluster analysis was performed utilizing daily maximum 1-hour ozone from District monitoring sites. Meteorological factors were not included in the cluster analysis itself. Any day with an exceedance of the 1-hour ozone standard (ozone at least 125 ppb) at any site was included, yielding 36 days from 1995 through 2002. Table 1 shows District ozone concentrations for these days.

Figure 5 presents the results of the analysis. Pairs of days connected by short lines are most similar. For example, 8/8/96 and 8/10/96 have lines connecting them with a distance of about 7 ppb (representing the average difference between the 1-hour values on the two days from the 21 sites). The cluster of those two days is similar to 8/29/98. The cluster containing those three days is similar to 9/2/98, and so on.

The analysis shows two days that are very different from the rest – 6/24/95 and 7/15/95, denoted as cluster 3 in the figure. These were days when the maximum ozone occurred at Fremont and there was high ozone at other sites near San Francisco Bay. Such episodes are atypical, with no similar exceedance occurring since 1995. Also, as discussed in section 3.3, South Bay sites now meet the 1-hour ozone standard and the trend shown in Figure 4 suggests that this will continue. Thus, the days in this cluster were excluded from consideration for selection of representative days.

We can break the remaining days into two clusters, denoted in the figure by 1 and 2. Comparing cluster 2 days with the data in Table 1, we note that in every case, the maximum occurred at just one eastern site, with relatively low values everywhere else. Cluster 1 days contain all days where there was ozone at multiple sites and regions, thus representing more widespread high ozone.

Table 4 shows that cluster 1 District peak ozone values were somewhat higher than cluster 2's. Figure 6, however, shows there was considerable overlap. Cluster 3's peaks were among the highest, but the paucity of data makes statistical inference difficult – the differences are not statistically significant.

In contrast, the means of the daily 1-hour maximum ozone values from BAAQMD sites show dramatic differences. There is no overlap between the three clusters (see Figure 7), with cluster 2 having the lowest mean values, cluster 1 in the middle, and cluster 3 the highest.

Cluster 1 had higher average maximum temperatures, especially at San Jose – 37^{o}C vs. 33^{o}C. Cluster 1 winds were somewhat lighter, and the 16:00 PST 850 mb wind directions were southerly, whereas cluster 2 winds were westerly. In terms of timing of the episodes, there was not a significant difference – with most episode days occurring in July and August in both clusters. Both weekends and weekdays were represented in both clusters. An analysis of temperatures and winds at several locations shows that the modeled episode days were not exceptional for their clusters.

4.1 Choice of an Additional Episode

Both days that occurred during CCOS and that exceeded the national 1-hour ozone standard in the SFBA (6/15/00 and 7/31/00) were from cluster 2. Thus, there were no CCOS days where the exceedance of the standard was widespread. Also, both days were weekdays, so no weekend exceedance was represented. Moreover, both were single-day episodes.

Therefore, an episode was selected from cluster 1 that included two successive episode days, 7/11/99 and 7/12/99, a Sunday and Monday. On these days, exceedances occurred at both Livermore and Concord, and an exceedance also occurred at San Martin on 7/11/99.

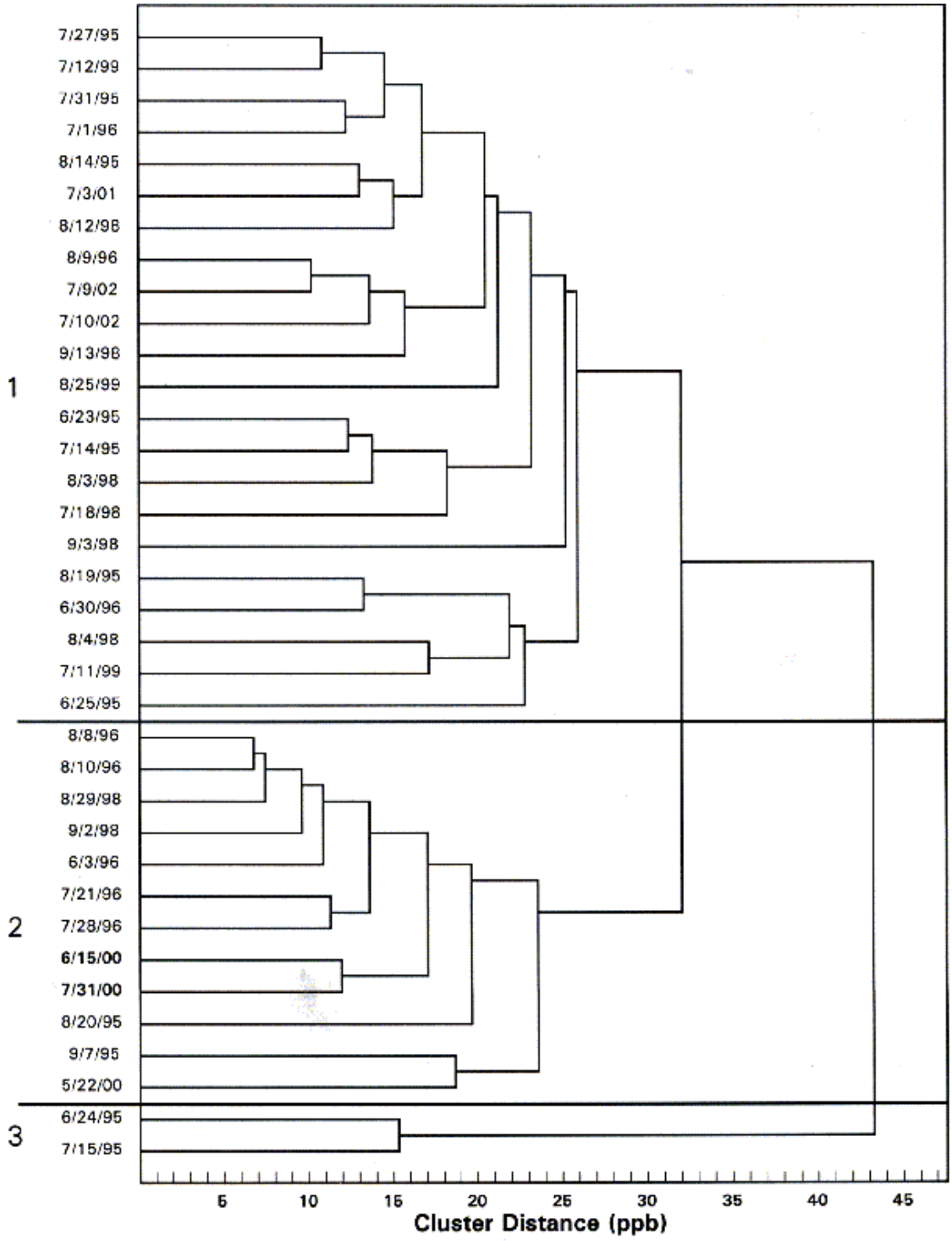

Figure 5. Clustering of Bay Area days exceeding the national 1-hour ozone standard, 1995-2002. Thick, horizontal lines divide the three main clusters.
Note: Data are 1-hour ozone in ppb. Clustering uses average Euclidean distance between days.

Table 4. Ozone and meteorological summary statistics: medians by cluster and values by key exceedance day.

	Cluster			Cluster	7/11/99	7/12/99	6/15/00	7/31/00
	1	2	3	Differ-	Cluster	Cluster	Cluster	Cluster
n	22	12	2	ences*	1	1	2	2
District Max ozone (ppb)	138	131	151	2<1	146	156	152	126
District Ave ozone (ppb)	89	65	107	2<<<1	102.8	92.5	52.7	56.7
Livermore max temp (C)	39	37	39	2<1	40	41	39	39
SJ max temp (C)	37	33	37	2<<<1	35	38	32	34
850 mb 4 am temp (C)	25	24	25	1≈2	25	26	26	25
850 mb 4 pm temp (C)	25	23	25	1≈2	26	27	27	26
Travis 10-4 ws (mps)	3	3	3	1<2	2	4	5	4
San Martin 10-4 ws (mps)	4	4	4	1<2	3	4	5	4
850 mb 4 am ws (mps)	3	3	2	1≈2	6	3	8	2
850 mb 4 pm ws (mps)	3	3	1	1≈2	5	2	5	1
850 mb 4 am wd (deg.)	150	235	78	1≈2	345	160	10	310
850 mb 4 pm wd (deg.)	170	252	260	1<<2	25	245	255	280

* This column shows the extent to which the clusters differed for the selected ozone and met. variables. A '≈' indicates that there was no statistically significant difference. One < sign indicates statistical significance ($p < .05$). Two < signs indicate significance at the .01 level. Three < signs indicates significance at the .001 level. Because cluster 3 had only 2 values, it was not tested for statistical significance.

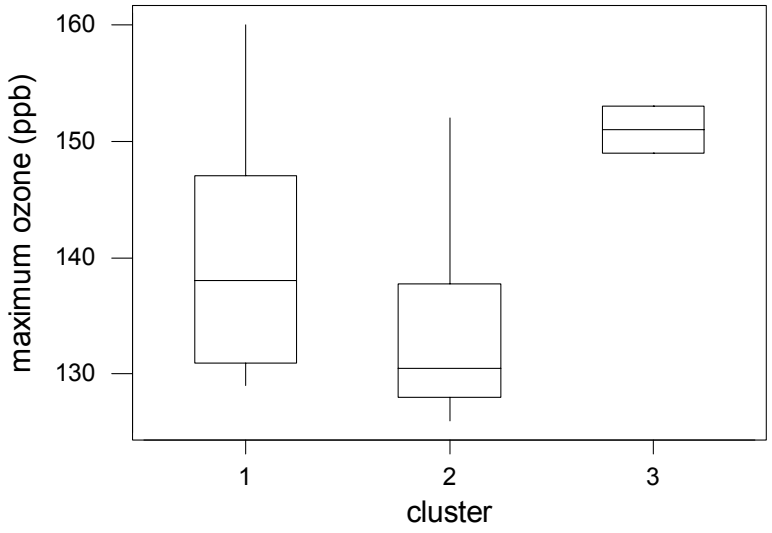

Figure 6. Boxplots of daily maximum ozone by cluster. Boxes show 25th and 75th percentiles. Horizontal lines in the boxes are medians. Vertical lines above and below the boxes indicate the range of the data unless there are outliers. Outliers are shown with asterisks (see Figure 7).

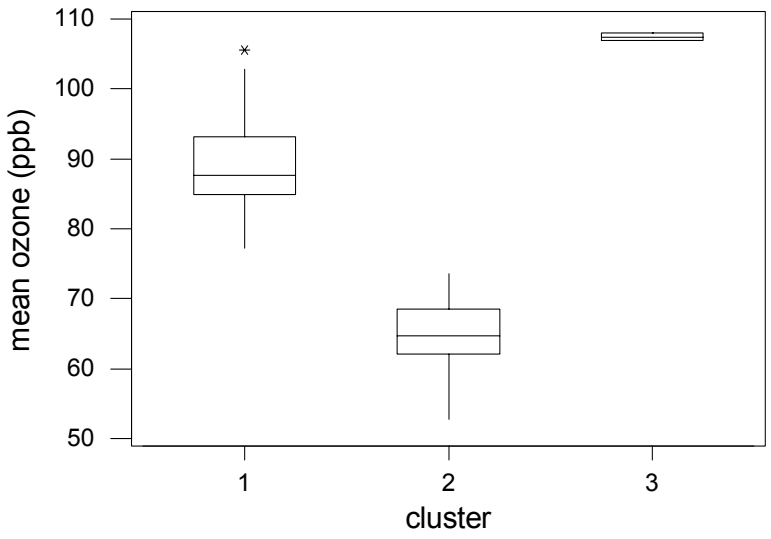

Figure 7. Boxplots of the means of 1-hour ozone maxima for the 21 sites, by cluster, 1995-2002.

5. REPRESENTATIVENESS OF THE MODELED EPISODES

With the inclusion of the 7/11/99-7/12/99 episode, the modeled episodes include both weekday and weekend exceedances, both single and multiple site exceedances, and both single and multi-day exceedances. Table 4 shows that the meteorology for these episodes was not dramatically different from the cluster averages, at least for the meteorological variables considered. To compare the episodes in terms of their potential to form high ozone, we applied a statistical regression analysis, as described in the following subsection.

5.1 Ozone Conduciveness

The Weibull regression was used to assess the meteorological conduciveness of episodes, following the U.S. EPA guidance document (EPA 1996). This method uses regression to predict District maximum 1-hour ozone from various meteorological and temporal variables. These variables were limited to those with long time series because of the need to establish an index of meteorological ozone potential. Here, daily basin-wide maximum ozone for June-September, 1990-2002 was regressed against Livermore and nearby Travis Air Force Base (AFB) surface meteorology, Oakland radiosonde temperature and wind variables, one-day lags of these variables, day-of-year, and an indicator for weekend/weekday.

The Weibull regression analysis found the following variables to be useful predictors: Livermore maximum temperature, Travis AFB mid-day average windspeed, previous-day afternoon 850 mb winds with an easterly component, and whether it was a weekend or weekday. The Weibull probability of exceeding an ozone concentration of x for a given day, t, was:

$$\exp\{-[x/p(t)]^{5.7}\}, \text{ where}$$

$$p(t) = 3.8*T + 0.20*(T-\overline{T})^2 - 1.3*WS + 0.11*(WS - \overline{WS})^2 + 5*I_{180} + 7*Iwe - 114,$$

T = Livermore maximum temperature on day t, WS = 10 am to 4 pm average windspeed at Travis AFB on day t, I_{180} = 1 if previous-day 4 pm 850 mb winds had an easterly component, 0 otherwise (on day t-1), and I_{we} = 1 if t was a weekend or holiday and 0 otherwise. p(t) can be thought of as the predicted ozone.

The resulting formula was then applied to a longer time period – the 24 years from 1979 through 2002. The rankings of the modeling episode days were as follows: 7/11/99: 7, 7/12/99: 25, and 7/31/00: 67. In other words, of the 7,195 days from 1979 through 2002 with Livermore and Travis meteorological data, the 7th largest value of p(t) occurred for t=7/11/99, the 25th largest for 7/12/99 and the 67th largest for 7/31/00. Modeling analyses typically focus on the design value, which for the 1-hour ozone standard is the 1-hour maximum concentration that occurs once per year on average. With 24 years of data, one would want to select the day with the 24th largest prediction. Thus, 7/12/99 appears close to ideal.

6. DISCUSSION

The 2000 CCOS field study yielded only two days where SFBA ozone exceeded the national 1-hour standard, and only one where there was extensive data. A cluster analysis of the 36 exceedance days between 1995 and 2002 produced two main clusters. Both the CCOS exceedance days fell in one of the clusters. Furthermore, both of them were 1-day episodes at the same location, and both fell on weekdays. Therefore, another episode was selected for modeling, a 2-day episode that included a weekend day, with exceedances at multiple sites.

A Weibull regression was performed to assess where the modeled episode days fell in terms of conduciveness to high ozone. A formula predicting District-wide 1-hour maximum ozone was developed from 1990-2002 data, where Livermore maximum temperature, Travis mid-day windspeed, previous-day 850mb easterly winds, and whether it was a weekend/holiday were found to be significant predictors. Applying this formula to the 24 years from 1979 through 2003, we found that one of the modeled days had a frequency of about once per year, close to ideal for modeling, one had a frequency of less than once per year, and one had a frequency of more than once per year.

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