Appendix Y

Evaluation of Exceptional Events Based on Rules of Thumb

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1. Overview

In relation to regional air quality, evaluation of the historic influence of various meteorological and chemical processes upon air quality concentrations allows meteorologists to identify the weather conditions normally associated with high ozone concentrations. As part of the SMAQMD's air quality forecasting program, STI evaluated high ozone concentrations in the Sacramento region and developed several rules of thumb for meteorological conditions to predict when 8-hr ozone concentrations will be greater than 0.095 ppm in Sacramento County. This appendix describes (1) the conditions associated with high ozone concentrations in Sacramento County and (2) an evaluation of whether 1-hr ozone concentrations exceeding the federal 1-hr ozone standard of 0.120 ppm would have been expected in the absence of wildfires on June 23, June 27, July 7, and July 10, 2008. The rules of thumb described in this appendix were developed independently to the regression equation described in Appendix X.

On these four dates, fires were burning in northern California and ozone levels in Sacramento were high. The 8-hr rules of thumb were used to analyze the smoke impact days and evaluate whether 1-hr ozone concentrations on those dates would most likely not have exceeded the 1-hr standard in the absence of ozone precursor pollutants (hereafter referred to as smoke) from the wildfires. If high ozone levels occurred even though meteorological conditions did not meet the rules of thumb for high ozone concentrations, an exceedance without smoke from wildfires would have been unlikely. Since the rules of thumb were designed to predict when 8-hr concentrations exceed 0.095 ppm, we determined what the 1-hr concentrations were when 8-hr concentrations exceeded 0.095. During the 2007 through 2010 period, on days when any monitor in Sacramento County recorded an 8-hr ozone concentration greater than 0.095 ppm, the average 1-hr maximum concentration was 0.118 ppm, with a minimum of 0.107 ppm and a maximum of 0.137 ppm. Again, the rules of thumb for high ozone concentrations in Sacramento were developed specifically for 8-hr ozone and have not been fully vetted for 1-hr ozone. Thus, they can offer, at best, only a rough correlation.

The rules of thumb for high ozone levels in the Sacramento region were also used to identify smoke-free days similar in meteorology to the four smoke-impact days. The peak 1-hr ozone concentrations in Sacramento County on these similar days were reviewed. If the 1-hr ozone concentration did not exceed the federal 1-hr ozone standard for a given smoke-free day, it is unlikely that an exceedance would have occurred on the smoke-impact day in the absence of smoke. There can be considerable difficulty in finding good matches between smoke and non-smoke days; thus, these comparisons do not provide conclusive evidence that an exceedance would or would not have occurred, but merely suggest what may have been likely.

In summary, the rules of thumb for high ozone levels in Sacramento suggest that, in the absence of smoke from the wildfires, 1-hr ozone concentrations exceeding the federal standard

- *Would likely not* have occurred June 23, 2008.
- *Would likely not* have occurred June 27, 2008.
- *Would likely* have occurred July 7, 2008.
- *Would likely not* have occurred July 10, 2008.

2. Meteorological Indicators Overview

The rules of thumb to predict 8-hr peak ozone concentrations in Sacramento County use a combination of local- to synoptic-scale surface data and upper-level meteorological data. The meteorological processes represented include transport, recirculation, and horizontal dispersion of pollution by wind; variations in sunlight due to clouds; the vertical mixing and dilution of pollution within the atmospheric boundary layer; and air temperature. The variability of these processes, which affects the variability in pollution, is strongly governed by the diurnal heating and cooling cycle, the movement of large-scale high- and low-pressure systems, and local and regional topography.

Development

To develop the rules of thumb, STI conducted detailed analyses of the meteorological conditions and ozone concentrations in Sacramento County for May through October in 2006 through 2009. In particular, STI obtained and reviewed surface and upper-air weather maps, daily ozone data for the Sacramento region, and surface and upper-air data from the National Oceanic and Atmospheric Administration for the Sacramento region. From past STI analyses concerning ozone concentrations in the Sacramento region, explicit meteorological parameters were identified and calculated (e.g., average morning wind speeds at Sacramento Executive Airport). STI meteorologists analyzed the relationships between the meteorological parameters and daily maximum 8-hr average ozone levels in the Sacramento region. From these examinations, threshold values for the meteorological parameters were identified as favorable for daily maximum 8-hr average ozone concentrations above 0.095 ppm. Surface and upper-level weather maps were also examined to identify weather patterns conducive to high ozone levels in the Sacramento region.

Rules of Thumb

In general, 8-hr ozone concentrations in excess of 0.095 ppm occur in the Sacramento region when an aloft ridge of high pressure is located over California (see **Figure 1**). Aloft ridges produce subsidence in the mid-to-low levels of the atmosphere. As the air sinks, it warms due to compression, which forms a temperature inversion that stabilizes and dries the atmosphere. This process limits the vertical mixing of boundary layer air (which traps pollutants near the ground) and limits cloud production (which increases ozone photochemistry).

On the other hand, aloft low-pressure systems are associated with rising air, weaker or no temperature inversion, strong vertical mixing, and possibly clouds or precipitation. Subtle variations in the location and strength of the high- and low-pressure systems have a strong influence on the local stability of the atmosphere; local instability can have a dramatic influence on cloud cover and the vertical dispersion of pollution and, thus, a dramatic influence on ozone concentrations.

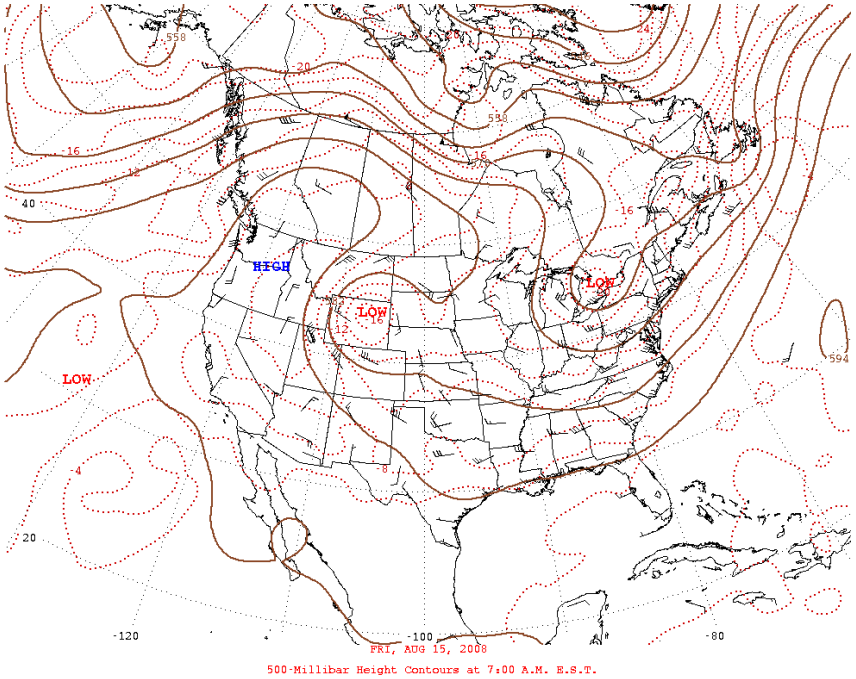

Figure 1. Plot of 500-mb heights for 4:00 a.m. PST on August 15, 2008, indicating a ridge of high pressure over California, a favorable pattern for high ozone levels in the Sacramento region. Source: National Weather Service.

Besides influencing tropospheric stability and cloud cover, aloft pressure systems also influence the strength and location of surface high- and low-pressure systems. In turn, the large-scale pressure patterns interact with local mechanisms to produce the observed local flows in the Sacramento area. The local mechanisms are strongly driven by the diurnally changing temperature contrast between the land surface of the Sacramento Valley and the water surface of the Pacific Ocean. In the Sacramento area, the large-scale summertime boundary layer flow is typically a sea breeze from the southwest, commonly referred to as the Delta breeze. On clear summer days, the Central Valley typically warms much faster than areas nearer the coast; the end result of this differential heating is lower surface pressure inland (thermal trough) with higher surface pressure nearer the Pacific Ocean and, subsequently, a flow of maritime air through the Sacramento River Delta. High ozone concentrations normally occur in the Sacramento region when the thermal trough is over or just west of Sacramento (see **Figure 2**).

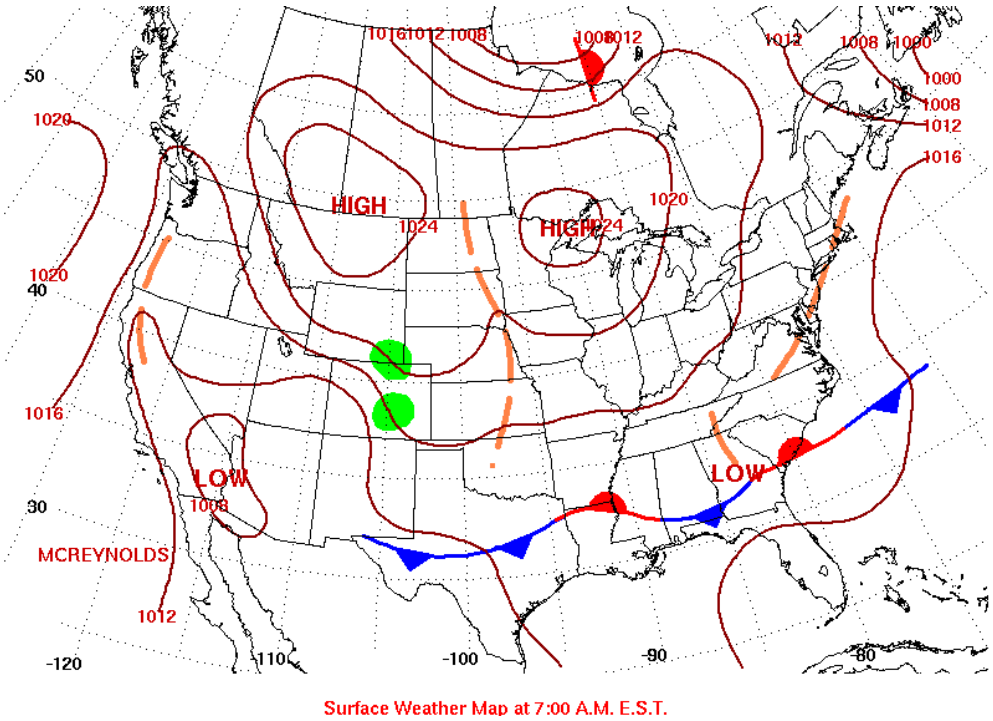

Figure 2. Surface weather map for 4:00 a.m. PST on August 15, 2008, indicating a thermal trough of low pressure extending from the Sacramento region northward into western Oregon (brown dashed line). Source: National Weather Service.

The timing and strength of the Delta breeze can strongly influence ozone concentrations in the Sacramento region. A strong Delta breeze will effectively disperse pollutants in the Sacramento area, resulting in low ozone concentrations. A weak Delta breeze that does not occur until late in the day, however, can limit pollutant dispersion, leading to high ozone concentrations (see **Figure 3**). Owing to its position near the Sacramento River Delta, onshore breezes are enhanced through Fairfield as maritime air surges inland through the Sacramento Valley; thus, Fairfield morning wind speed is a good indicator of Delta breeze strength. At night, in the foothill region just east of Sacramento, winds can reverse direction and come from the east, fostering stagnation, reduced transport distances, and, under some circumstances, recirculation—all of which lead to pollutant buildup.

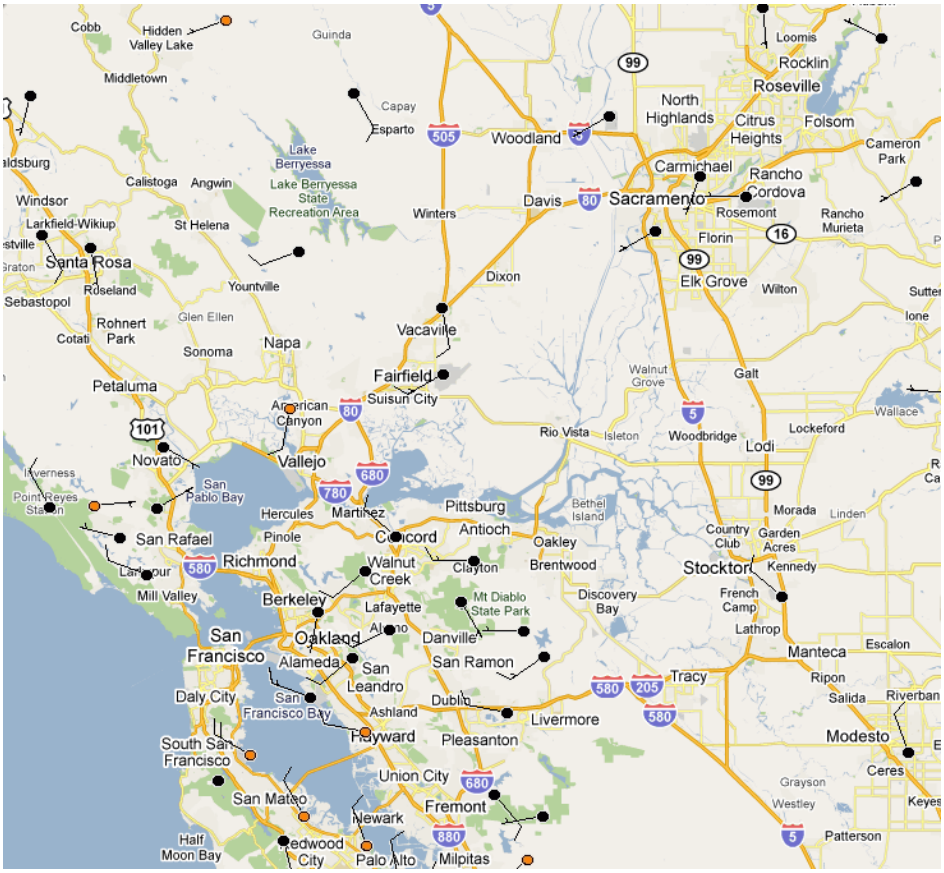

Figure 3. Map of the surface wind barbs for 21Z on August 15, 2008, indicating weak southwest onshore flow in the Delta and Sacramento area.
Source: http://mesowest.utah.edu

The specific rules of thumb for the meteorological parameters associated with 8-hr ozone concentrations in excess of 0.095 ppm in Sacramento County are shown in **Table 1**. In addition to these criteria, aloft ridges of high pressure over California and thermal surface lows over or just west of Sacramento are necessary for high ozone levels. In general, all or nearly all criteria must be met for high ozone concentrations to occur; however, experienced meteorologists use the rules of thumb subjectively because there are not a specific number of rules that absolutely must be met for high ozone levels to occur in the Sacramento region.

Note: KOAK=Oakland International Airport, KSAC = Sacramento International Airport, KSUU = Fairfield, KSFO= San Francisco International Airport, KRENO= Reno International Airport, and 12Z = 4:00 a.m. PST.

Table 1. Rules of thumb for the daily maximum 8-hr average ozone concentrations above 0.095 ppm in the Sacramento region.

Meteorological Parameter	Rule of Thumb
12Z KOAK 925-mb Temperature	≥25°C
12Z KSAC 500-mb Height	≥5850 m
KSAC High Temperature	≥93°F
9 to 11 a.m. PDT KSAC Wind Speed	<4 knots
9 to 11 a.m. PDT KSAC Wind Dir.	>150° and <270°
9 to 11 a.m. PDT KSUU Wind Speed	<15 knots
9 to 11 a.m. PDT KSFO Wind Speed	<10 knots
12 to 6 p.m. PDT KSAC Wind Speed	<6 knots
12Z KSFO – KSAC Pressure Gradient	<3.0 mb
00Z KSFO – KSAC Pressure Gradient	<4.0 mb
12Z KSAC – KRNO Pressure Gradient	<-2.0 mb
00Z KSAC – KRNO Pressure Gradient	<0.0 mb

3. Meteorological Conditions on Smoke Days

This section describes the meteorological conditions observed on June 23, June 27, July 7, and July 10, 2008; provides an evaluation of whether the meteorological conditions were conducive to 8-hr ozone concentrations above 0.095 ppm (historically, 8-hr concentrations above 0.095 ppm have yielded 1-hr ozone concentrations ranging from 0.107 to 0.137 ppm, with an average of 0.118 ppm); and presents the meteorological details and ozone concentrations on the meteorologically similar days, or surrogate matching days, without smoke from wildfires. The ozone concentrations discussed and shown in tables below were observed at the Folsom-Natoma monitor.

Smoke Day: June 23, 2008

Summary: The maximum 1-hr ozone concentration was 0.161 ppm at Folsom-Natoma. However, as shown in **Table 2**, the meteorological conditions did not support these high ozone concentrations. In addition, the large-scale weather pattern was not conducive to high ozone concentrations. Finally, a peak 1-hr ozone concentration of only 0.079 ppm occurred on the matching non-smoke impact day (June 16, 2008).

Table 2. Meteorological conditions for the smoke impact day, June 23, 2008, and the matching day, June 16, 2008. Green indicates that a criterion for high ozone was not met. Note that, in general, all or nearly all criteria must be met for high ozone concentrations to occur.

Meteorological Parameter	Criteria for 8-hour Ozone Above 0.095 ppm	Event Date (June 23, 2008)	Matching Surrogate Date (June 16, 2008)
12Z KOAK 925 mb Temp	≥25°C	21°C	19°C
12Z KSAC 500-mb Height	≥5850 m	5840 m	5830 m
KSAC High Temperature	≥93°F	86°F	84°F
9 to 11 a.m. PDT KSAC Wind Speed	<4 knots	2 knots	6 knots
9 to 11 a.m. PDT KSAC Wind Dir.	>150° and <270°	190°	211°
9 to 11 a.m. PDT KSUU Wind Speed	<15 knots	17 knots	19 knots
9 to 11 a.m. PDT KSFO Wind Speed	<10 knots	12 knots	10 knots
12 to 6 p.m. PDT KSAC Wind Speed	<6 knots	7 knots	7 knots
12Z KSFO – KSAC Gradient	<3.0 mb	3.3 mb	3.2 mb
00Z KSFO – KSAC Gradient	<4.0 mb	4.1 mb	4.0 mb
12Z KSAC – KRNO Gradient	<-2.0 mb	-2.3 mb	-1.9 mb
00Z KSAC – KRNO Gradient	<0.0 mb	0.5 mb	0.9 mb
Max. 8-hr Avg. Ozone Conc.		0.123 ppm	0.068 ppm
Max. 1-hr Ozone Conc.		0.161 ppm	0.079 ppm

Meteorology Details

Large-Scale Pattern: An upper-level high-pressure system was centered offshore of Baja California and extended northeastward into the central United States (see **Figure 4**). An upper-level trough of low pressure was located off the Pacific Northwest coast. These two features were positioned on either side of Sacramento. At the surface, a thermal trough was positioned over Sacramento (see **Figure 5**). The upper-level and surface pressure patterns for the matching day of June 16, 2008, are shown in **Figures 6 and 7**, respectively. The combination of these patterns is not conducive for high ozone concentrations.

Temperatures: Aloft and surface temperatures were mild. Warm temperatures are required for high ozone concentrations.

Local Winds: Winds were calm or light southwesterly at Sacramento during the morning hours and increased to over 7 knots from the southwest during the afternoon hours. The morning winds were conducive to high ozone concentrations, while the afternoon winds were not.

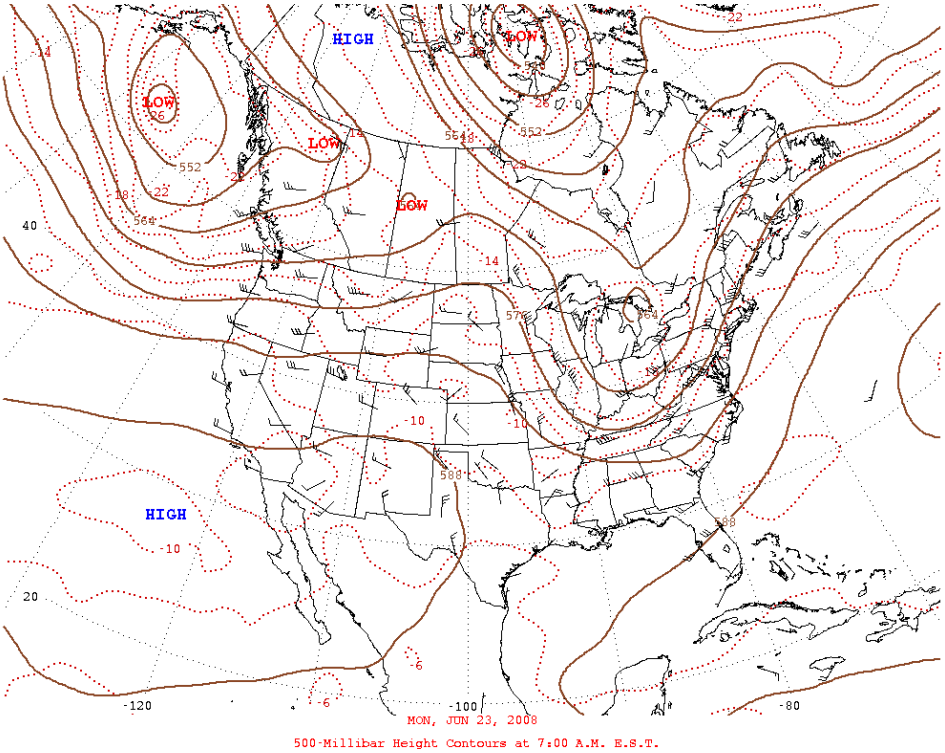

Figure 4. Map of 500-mb heights on a smoke day at 4:00 a.m. PST on June 23, 2008. Source: National Weather Service.

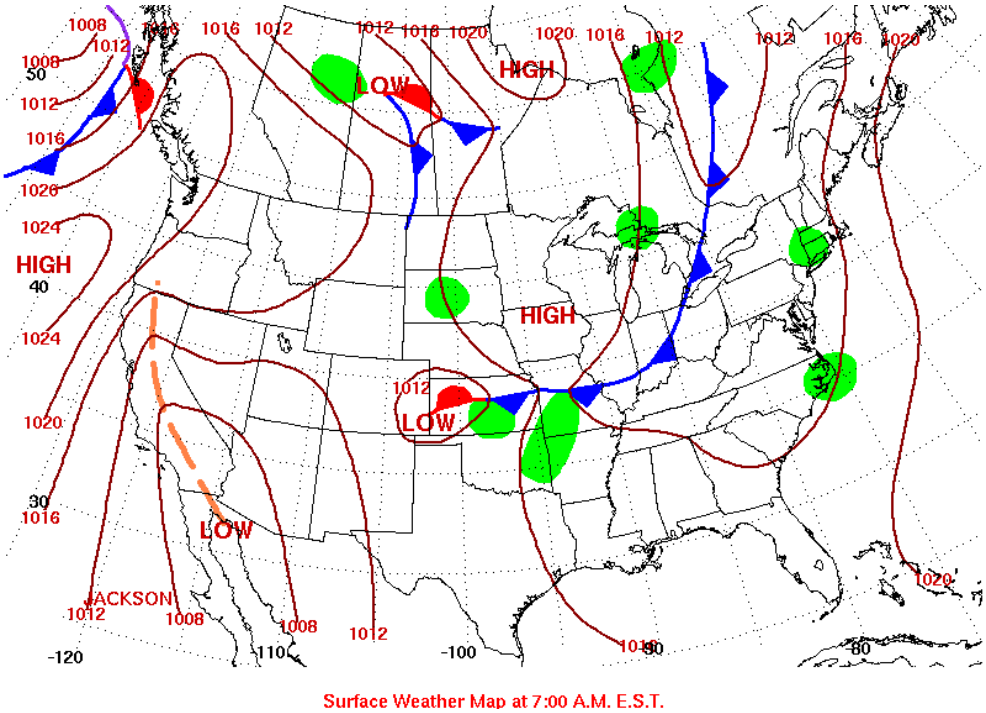

Figure 5. Surface weather map for 4:00 a.m. PST on June 23, 2008, a smoke day. Source: National Weather Service.

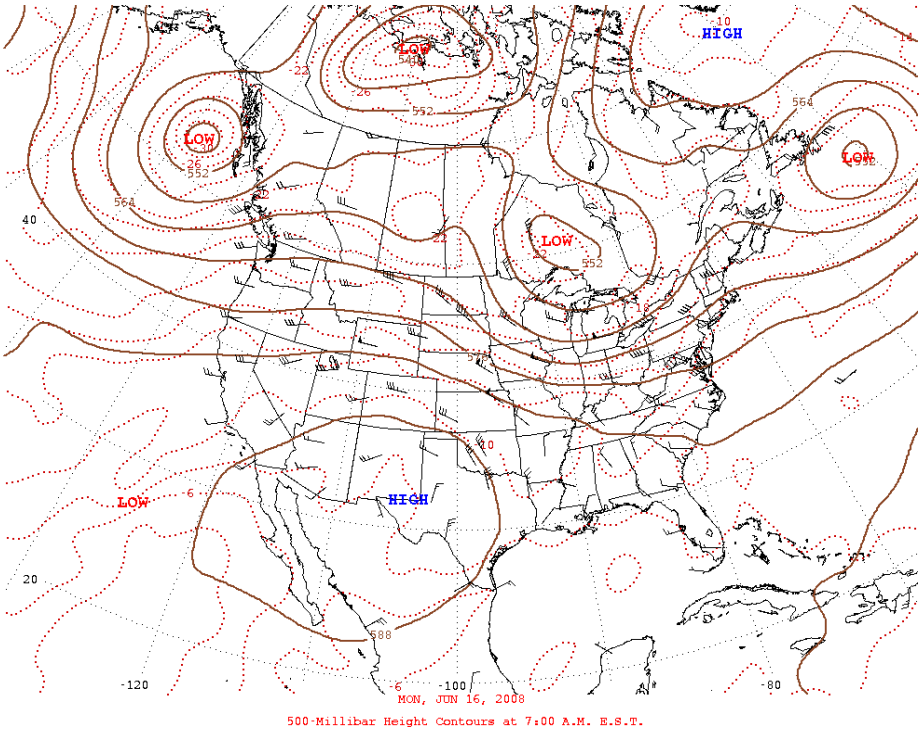

Figure 6. Map of 500-mb heights at 4:00 a.m. PST on June 16, 2008, a surrogate matching day to the smoke day of June 23, 2008. Source: National Weather Service.

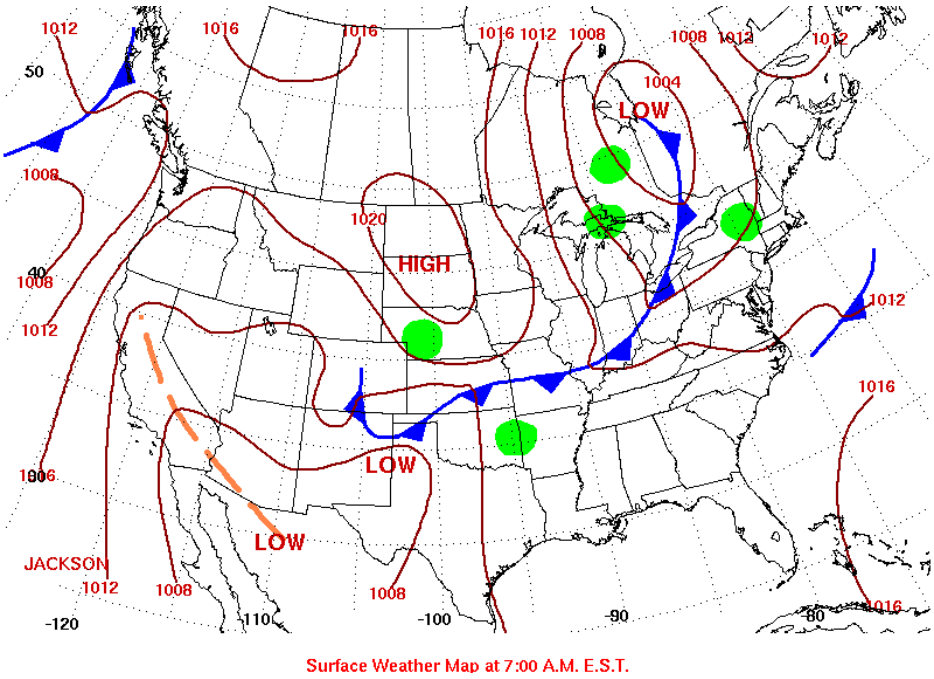

Figure 7. Surface weather map for 4:00 a.m. PST on June 16, 2008, a surrogate matching day to the smoke day of June 23, 2008. Source: National Weather Service.

Smoke Day: June 27, 2008

Summary: The maximum 1-hr average ozone concentration was 0.129 ppm. While some meteorological conditions satisfied the rules of thumb for high ozone on this day, other rules of thumb were not (See **Table 3**). In addition, peak 1-hr ozone concentrations of only 0.084 ppm, well below the 1-hr standard, occurred on the matching non-smoke impact day. This suggests that ozone concentrations in excess of the 1-hr standard would not have been expected on this day in the absence of smoke.

Table 3. Meteorological conditions for the smoke impact day, June 27, 2008, and the matching day, July 9, 2007. Green indicates that a criterion for high ozone was not met. Note that, in general, all or nearly all criteria must be met for high ozone concentrations to occur.

Meteorological Parameter	Criteria for 8-hour Ozone Above 0.095 ppm	Event Date (June 27, 2008)	Matching Surrogate Date (July 9, 2007)
12Z KOAK 925 mb-Temp	≥25°C	24°C	22°C
12Z KSAC 500-mb Height	≥5850 m	5850 m	5870 m
KSAC High Temperature	≥93°F	90°F	90°F
9 to 11 a.m. PDT KSAC Wind Speed	<4 knots	0 knots	8 knots
9 to 11 a.m. PDT KSAC Wind Dir.	>150° and <270°	--	203°
9 to 11 a.m. PDT KSUU Wind Speed	<15 knots	12 knots	17 knots
9 to 11 a.m. PDT KSFO Wind Speed	<10 knots	4 knots	2 knots
12 to 6 p.m. PDT KSAC Wind Speed	<6 knots	6 knots	10 knots
12Z KSFO – KSAC Gradient	<3.0 mb	1.6 mb	2.4 mb
00Z KSFO – KSAC Gradient	<4.0 mb	3.0 mb	2.7 mb
12Z KSAC – KRNO Gradient	<-2.0 mb	-4.9 mb	-0.4 mb
00Z KSAC – KRNO Gradient	<0.0 mb	-3.0 mb	1.7 mb
Max. 8-hr Avg. Ozone Conc.		0.112 ppm	0.069 ppm
Max. 1-hr Ozone Conc.		0.129 ppm	0.084 ppm

Meteorology Details

Large-Scale Pattern: A broad upper-level ridge of high pressure was located along the west coast of the United States, with a cutoff upper-level low-pressure system located southwest of California over the Pacific (see **Figure 8**). These two systems were located on either side of Sacramento. A thermal trough at the surface extended from far southeastern California northwestward to San Francisco and continued north to the Oregon border (see **Figure 9**). These patterns are somewhat conducive to high ozone levels; however, the high-pressure ridge was only moderate in strength, as indicated by the modest height of the 500-mb pressure level

of 5,820 m above msl. The upper-level and surface pressure patterns for the matching day of July 9, 2008, are shown in **Figures 10 and 11**, respectively.

Temperatures: 925 mb and surface temperatures were both below the thresholds for high ozone.

Local Winds: Winds were calm at KSAC and weakly onshore at KSUU and KSFO during the morning hours. Winds increased from the southwest during the afternoon hours at KSAC, indicating a developing Delta breeze. The morning winds were conducive to high ozone concentrations, but the afternoon winds were not.

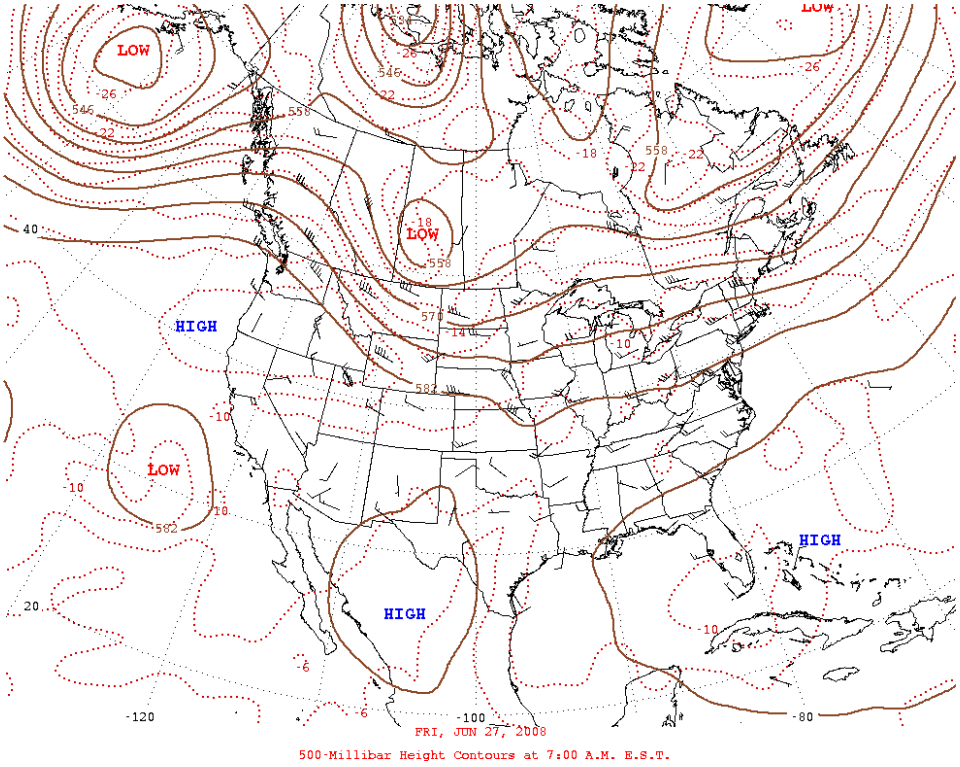

Figure 8. Map of 500-mb heights on a smoke day at 4:00 a.m. PST on June 27, 2008. Source: National Weather Service.

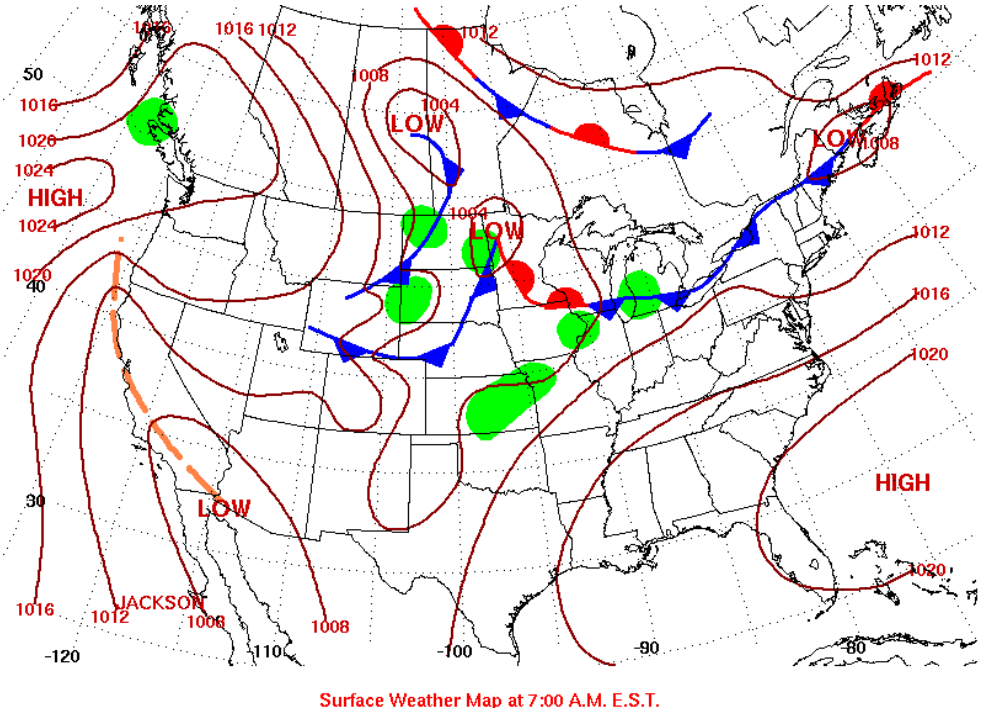

Figure 9. Surface weather map for 12Z on June 27, 2008, a smoke day. Source: National Weather Service.

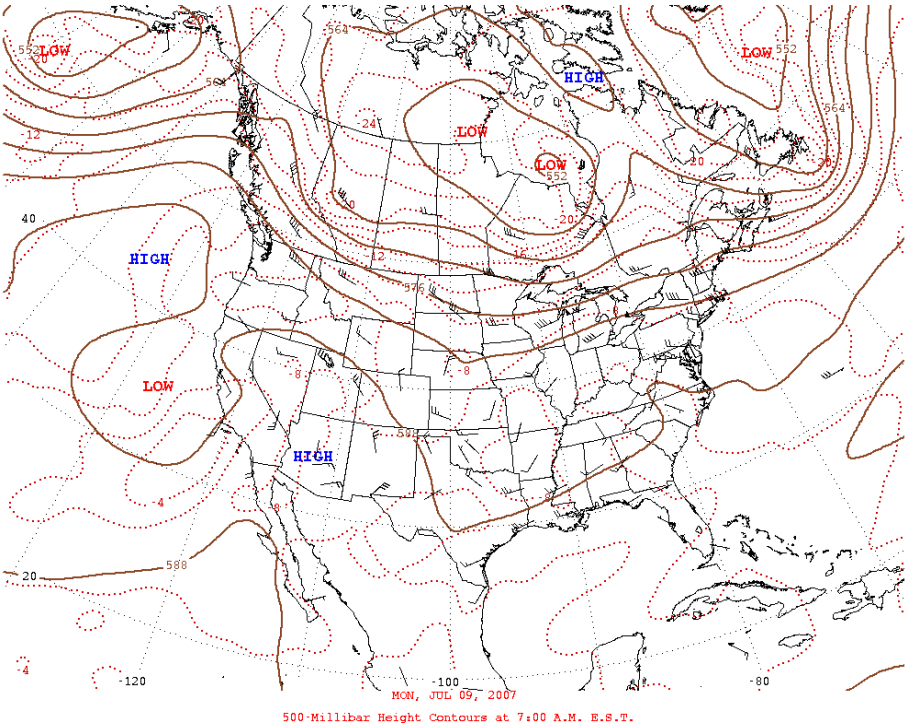

Figure 10. Map of 500-mb heights 4:00 a.m. PST on July 9, 2007, a surrogate matching day to the smoke day of June 27, 2008. Source: National Weather Service.

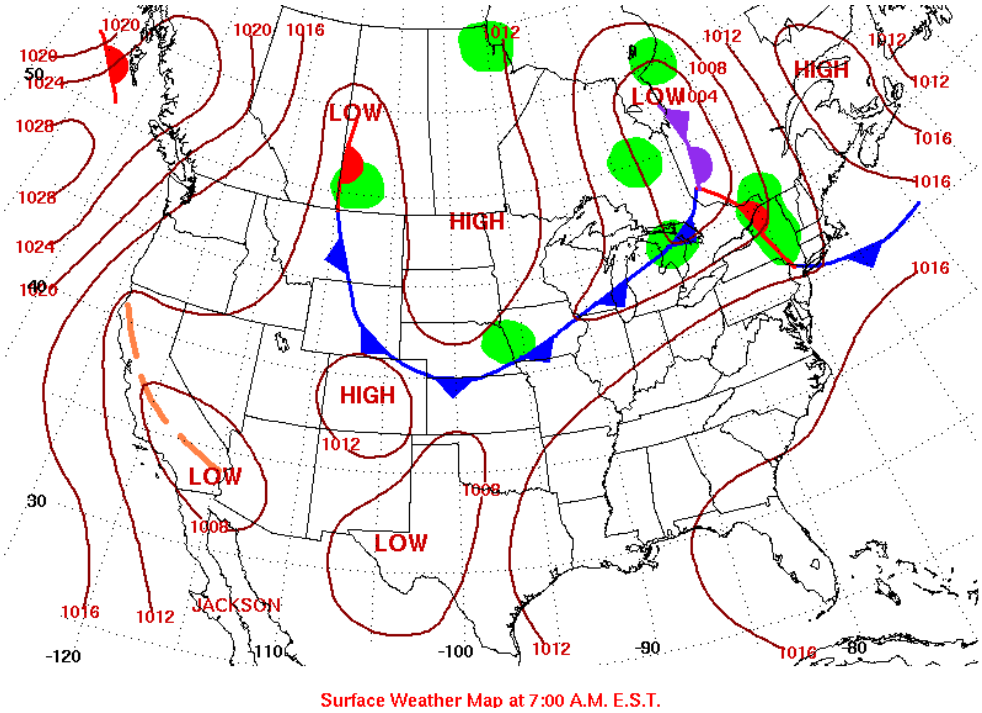

Figure 11. Surface weather map for 4:00 a.m. PST on July 9, 2007, a surrogate matching day to the smoke day of June 27, 2008. Source: National Weather Service.

Smoke Day: July 7, 2008

Summary: The observed daily maximum 1-hr average ozone concentration was 0.166 ppm. As shown in **Table 4**, all of the meteorological conditions satisfied the rules of thumb for high ozone, meaning that, even without smoke, conditions were favorable for 8-hr ozone concentrations above 0.095 ppm; historically, an average maximum 1-hr concentration of 0.118 ppm occurred on days with 8-hr concentrations above 0.095 ppm. A peak 1-hr ozone concentration of 0.111 ppm, which is below the national standard, occurred on the matching day (June 22, 2006). However, it should be noted that concentrations below the 1-hr standard on the matching day were likely due to moderate northerly winds in the morning; northerly winds did not occur on July 7. This suggests that 1-hr ozone concentrations above the standard were likely to occur on July 7, even in the absence of smoke.

Table 4. Meteorological conditions for the smoke impact day, July 7, 2008, and the matching day, June 22, 2006. Green indicates that a criterion for high ozone was not met. Note that, in general, all or nearly all criteria must be met for high ozone concentrations to occur.

Meteorological Parameter	Criteria for 8-hour Ozone Above 0.095 ppm	Event Date (July 7, 2008)	Surrogate Date (June 22, 2006)
12Z KOAK 925 mb Temp	≥25°C	29°C	28°C
12Z KSAC 500-mb Height	≥5850 m	5880 m	5920 m
KSAC High Temperature	≥93°F	102°F	102°F
9 to 11 a.m. PDT KSAC Wind Speed	<4 knots	1 knot	7 knots
9 to 11 a.m. PDT KSAC Wind Dir.	>150° and <270°	190°	352°
9 to 11 a.m. PDT KSUU Wind Speed	<15 knots	5 knots	6 knots
9 to 11 a.m. PDT KSFO Wind Speed	<10 knots	4 knots	4 knots
12 to 6 p.m. PDT KSAC Wind Speed	<6 knots	2 knots	4 knots
12Z KSFO – KSAC Gradient	<3.0 mb	1.9 mb	1.5 mb
00Z KSFO – KSAC Gradient	<4.0 mb	1.8 mb	1.2 mb
12Z KSAC – KRNO Gradient	<-2.0 mb	-6.2 mb	-7.1 mb
00Z KSAC – KRNO Gradient	<0.0 mb	-4.9 mb	-4.0 mb
Max. 8-hr Avg. Ozone Conc.		0.114 ppm	0.091 ppm
Max. 1-hr Ozone Conc.		0.166 ppm	0.111 ppm

Meteorology Details

Large-Scale Pattern: An upper-level high-pressure system was centered off the shore of California and extended eastward over the Sacramento area (see **Figure 12**). At the surface, a thermal trough extended from the northern Gulf of Mexico to a position west of Sacramento near Fairfield (see **Figure 13**). These conditions are favorable for high ozone levels. The upper-level and surface pressure patterns for the matching day of June 22, 2006, are shown in **Figures 14 and 15**, respectively.

Temperatures: With the upper-level high-pressure system over Sacramento, aloft and surface temperatures were well above the thresholds for high ozone levels.

Local Winds: Morning winds were light at KSAC, KSUU, and KSFO. Afternoon winds at KSAC remained light and generally variable before becoming southwesterly during the evening, indicating a late, weak Delta breeze. The light winds were conducive to high ozone levels.

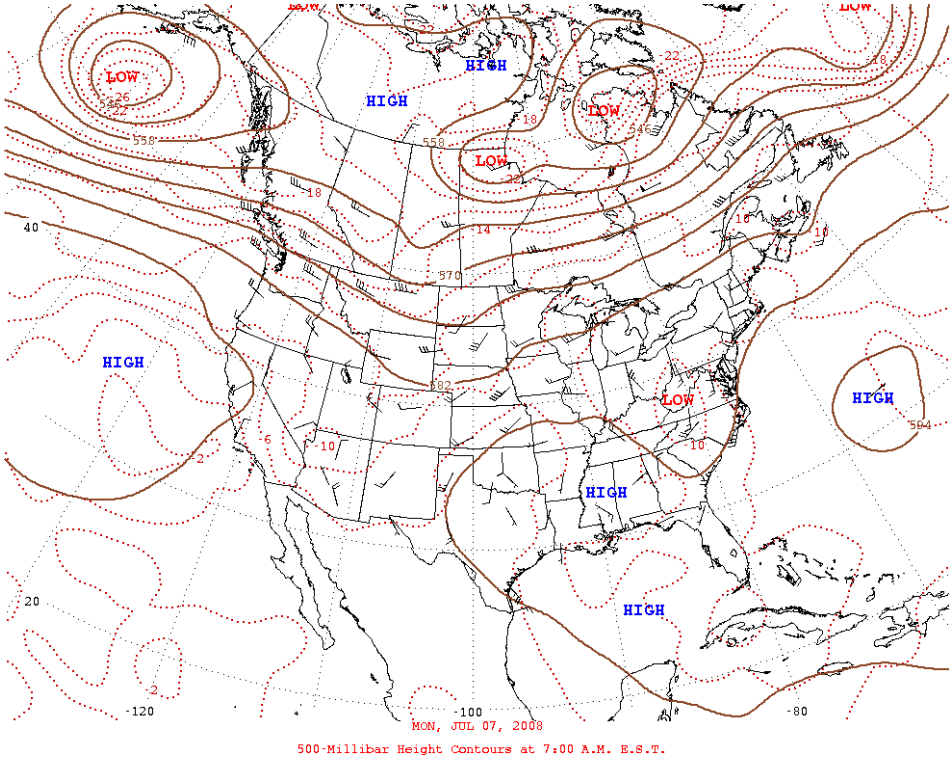

Figure 12. Map of 500-mb heights on a smoke day at 4:00 a.m. PST on July 7, 2008. Source: National Weather Service.

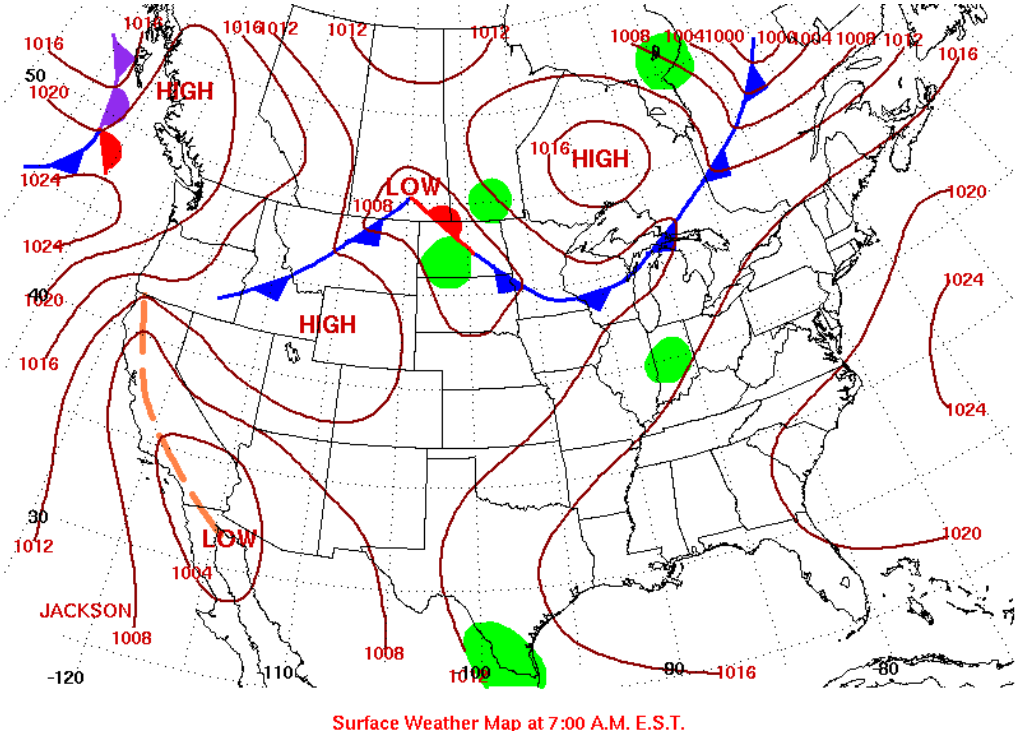

Figure 13. Surface weather map for 4:00 a.m. PST on July 7, 2008, a smoke day. Source: National Weather Service.

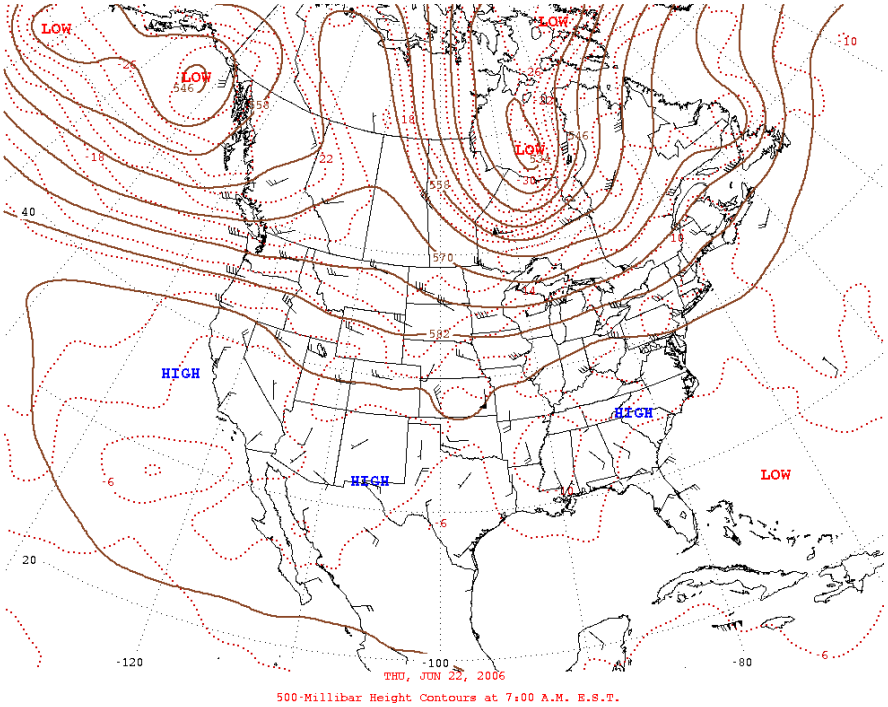

Figure 14. Map of 500-mb heights at 4:00 a.m. PST on June 22, 2006, a surrogate matching day to the smoke day of July 7, 2008. Source: National Weather Service.

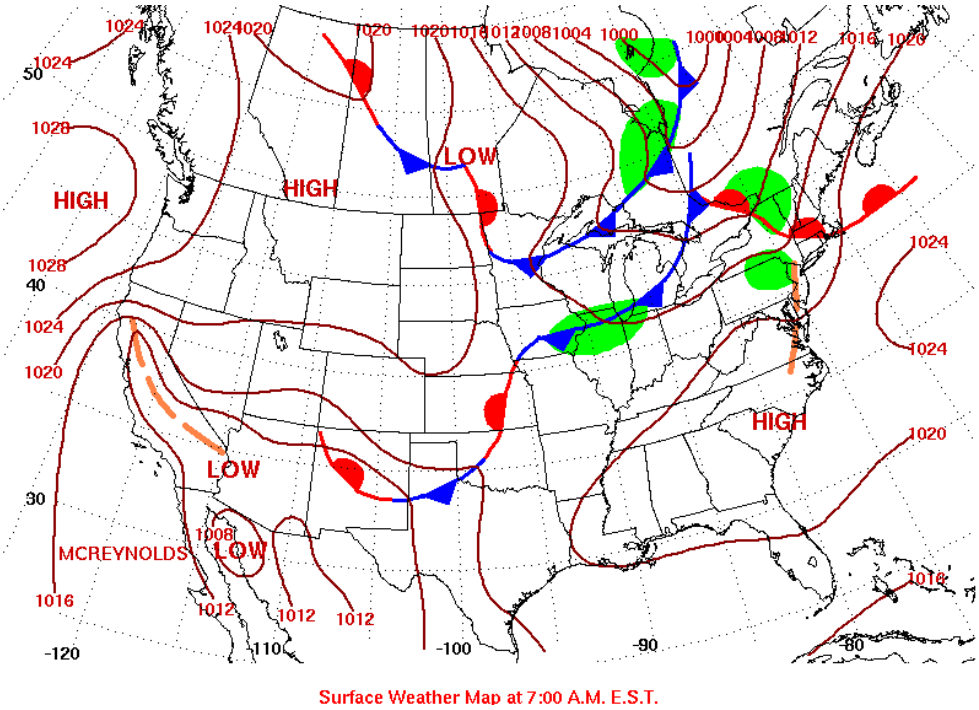

Figure 15. Surface weather map for 4:00 a.m. PST on June 22, 2006, a surrogate matching day to the smoke day on July 7, 2008. Source: National Weather Service.

Smoke Day: July 10, 2008

Summary: Highly complex meteorological and air quality conditions present on July 10, 2008, introduced considerable uncertainty regarding the impact of smoke on ozone levels in Sacramento. The observed daily maximum 1-hr average ozone concentration was 0.150 ppm. As shown in **Table 5**, most of the meteorological conditions satisfied the rules of thumb for high ozone levels. However, the synoptic pattern was not ideal for high ozone concentrations because there was a short-wave trough of low pressure passing through northern California (see **Figure 16**). In addition, only a peak 1-hr ozone concentration of 0.091 ppm, which is below the 1-hr standard, occurred on the matching day (June 28, 2009). We suspect that the relatively modest ozone concentrations on the matching day were due to strong vertical mixing generated by hot surface temperatures. Hot surface temperatures were not observed on July 10, 2008, probably because of smoke blocking the sun (see "Temperatures" below). This suggests that, in the absence of smoke, ozone levels likely would not have exceeded the 1-hr standard on July 10, 2008.

Table 5. Meteorological conditions for the smoke impact day, July 10, 2008, and the matching day, June 28, 2009. Green indicates that a criterion for high ozone was not met. Note that, in general, all or nearly all criteria must be met for high ozone concentrations to occur.

Meteorological Parameter	Criteria for 8-hour Ozone Above 0.95 ppm	Event Date (July 10, 2008)	Matching Surrogate Date (June 28, 2009)
12Z KOAK 925 mb-Temp	≥25°C	34°C	30°C
12Z KSAC 500-mb Height	≥5850 m	5890 m	5900 m
KSAC High Temperature	≥93°F	93°F[a]	108°F
9 to 11 a.m. PDT KSAC Wind Speed	<4 knots	0 knots	0 knots
9 to 11 a.m. PDT KSAC Wind Dir.	>150° and <270°	--	--
9 to 11 a.m. PDT KSUU Wind Speed	<15 knots	11 knots	2 knots
9 to 11 a.m. PDT KSFO Wind Speed	<10 knots	4 knots	4 knots
12 to 6 p.m. PDT KSAC Wind Speed	<6 knots	6 knots	4 knots
12Z KSFO – KSAC Gradient	<3.0 mb	2.5 mb	1.4 mb
00Z KSFO – KSAC Gradient	<4.0 mb	3.3 mb	2.1 mb
12Z KSAC – KRNO Gradient	<-2.0 mb	-6.2 mb	-6.0 mb
00Z KSAC – KRNO Gradient	<0.0 mb	-3 mb	-2.9 mb
Max. 8-hr Avg. Ozone Conc.		0.115 ppm	0.078 ppm
Max. 1-hr Ozone Conc.		0.150 ppm	0.091 ppm

[a] Reduced visibility due to reported smoke and haze may have contributed to the relatively cool high temperature.

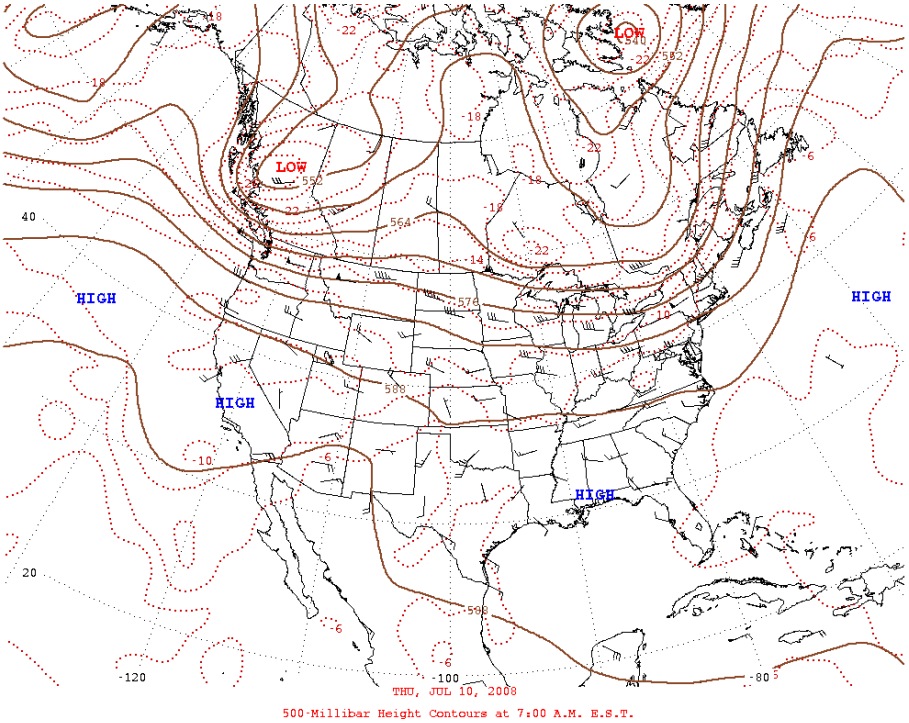

Figure 16. Map of 500-mb heights on a smoke day at 4:00 a.m. PST on July 10, 2008. Source: National Weather Service.

Meteorology Details

Large-Scale Pattern: An upper-level ridge of high pressure was located west of California, with a weak upper-level trough of low pressure passing through Northern California. At the surface, a thermal trough extended from the northern Gulf of California northward through the Sacramento region and into northern California (see **Figure 17**). The upper-level and surface pressure patterns for the matching day of June 28, 2009, are shown in **Figures 18 and 19**, respectively.

Temperatures: The 925-mb temperature was well above the threshold for high ozone levels in Sacramento. The combination of warm aloft temperatures with relatively mild surface temperatures acts to reduce vertical mixing. Reduced mixing is conducive to high ozone concentrations. The relatively mild surface temperatures were likely due to smoke blocking the sunlight, as indicated by the smoke-induced haze and reduction in visibility that were reported for most of the day in Sacramento. It is not clear how the reduced visibility impacted the photochemical reactions that form ozone.

Local Winds: During the morning hours, calm winds were reported at KSAC, with onshore winds reported at KSUU and light winds at KSFO. Afternoon winds gradually increased from the southwest at KSAC, indicating a light afternoon Delta breeze. These conditions are conducive for high ozone levels.

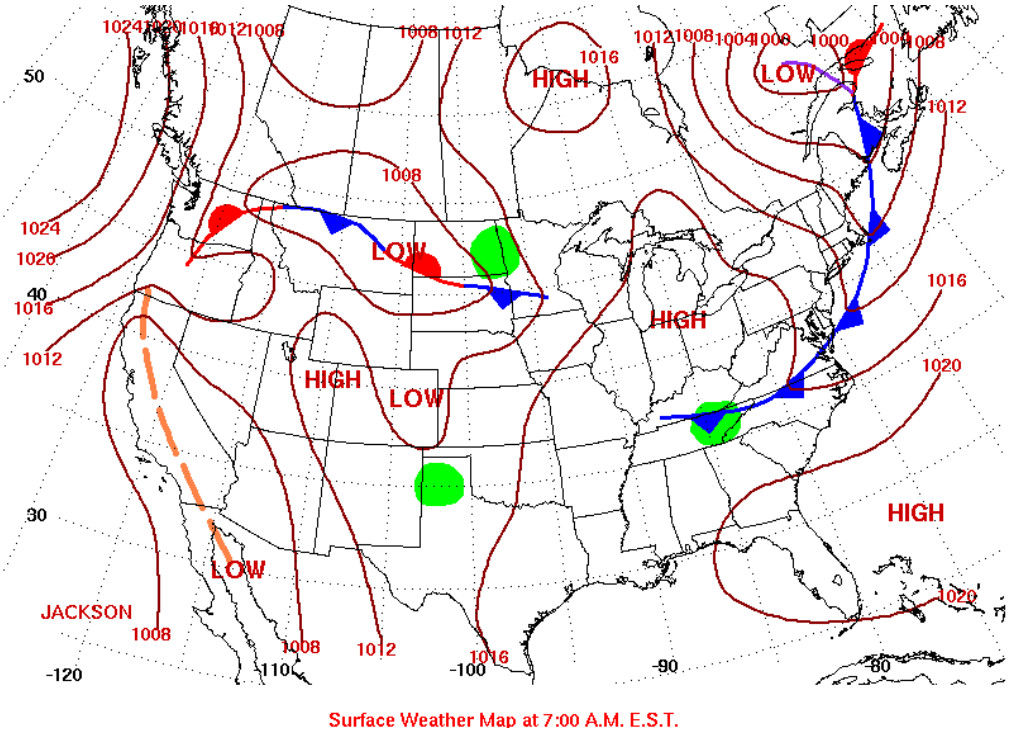

Figure 17. Surface weather map for 4:00 a.m. PST on July 10, 2008, a smoke day. Source: National Weather Service.

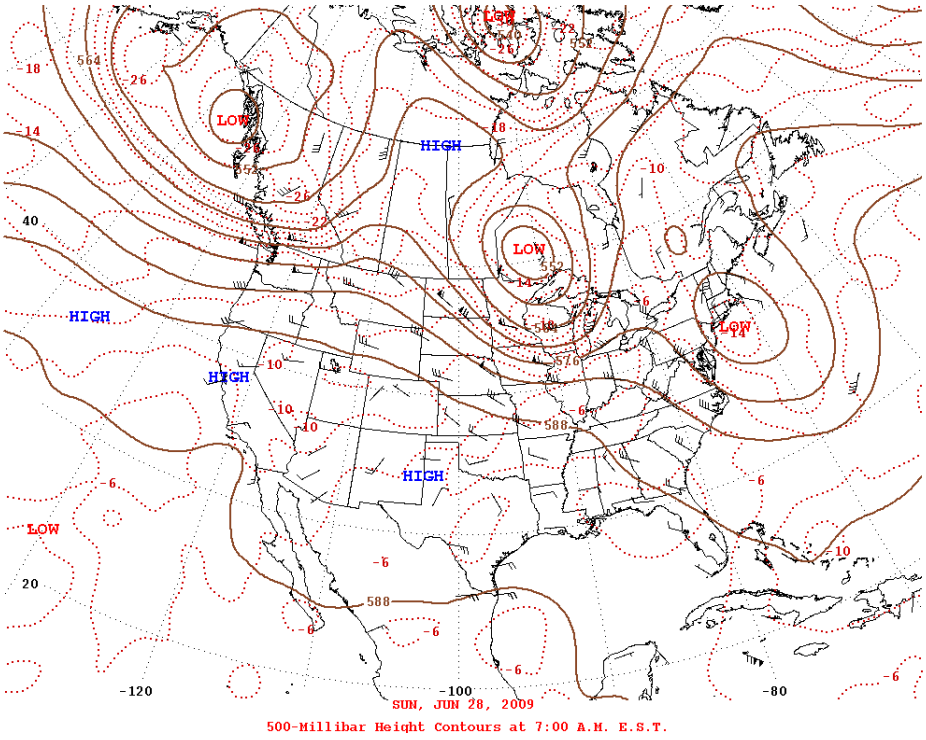

Figure 18. Map of 500-mb heights at 4:00 a.m. PST on June 28, 2009, a surrogate matching day to the smoke day of July 10, 2008. Source: National Weather Service.

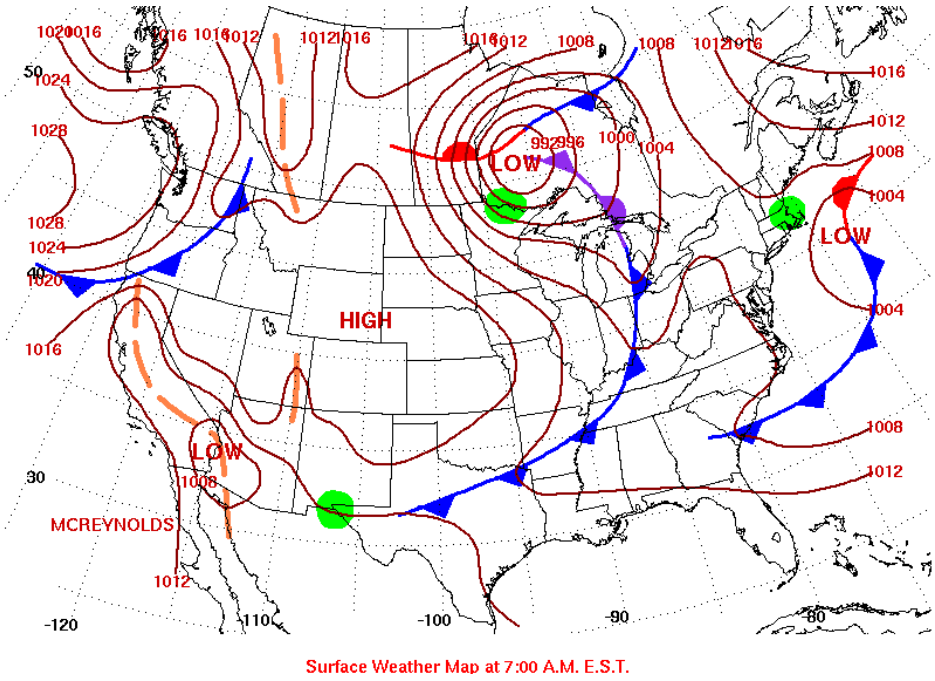

Figure 19. Surface weather map for at 4:00 a.m. PST on June 28, 2009, a surrogate matching day to the smoke day of July 10, 2008. Source: National Weather Service.