Help protect Air Quality the air we share

Exceptional Event Documentation for the May 4, 2013, 8-Hour Ozone NAAQS Exceedance in Clark County Caused by a Wildland Fire Event

June 2015
Final Draft

ACKNOWLEDGMENTS

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ACRONYMS AND ABBREVIATIONS

Acronyms

AERONET	Aerosol Robotic Network
AOD	Aerosol Optical Depth
AOT	Aerosol Optical Thickness
AQI	Air Quality Index
CAA	Clean Air Act
CFR	Code of Federal Regulations
DAQ	Clark County Department of Air Quality
EER	Exceptional Events Rule
EPA	U.S. Environmental Protection Agency
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory Model
MDA8	Maximum daily 8-hour average
NAAQS	National Ambient Air Quality Standards
NOAA	National Oceanic and Atmospheric Administration

Abbreviations

°C	degrees Celsius
CO	carbon monoxide
mb	millibars
MSL	mean sea level
NO_x	oxides of nitrogen
O_3	ozone
$PM_{2.5}$	particulate matter less than 2.5 microns in diameter
ppb	parts per billion
VOC	volatile organic compound

1.0 INTRODUCTION

On May 4, 2013, elevated ozone concentrations and exceedances of the ozone (O_3) National Ambient Air Quality Standards (NAAQS) were recorded across the Clark County air quality monitoring network. The Clark County Department of Air Quality (DAQ) has determined these exceedances were caused by ozone precursor emissions produced by smoke plumes from the Springs Fire in California, making them subject to the Exceptional Events Rule (EER), Title 40, Part 50 of the Code of Federal Regulations (40 CFR 50).

1.1 STATEMENT OF PURPOSE

The EER governs the review and handling of air quality monitoring data influenced by events for which the normal planning and regulatory process established by the Clean Air Act (CAA) is not appropriate (*Federal Register*, vol. 72, p. 13560). The U.S. Environmental Protection Agency (EPA) intended the rule to

> [i]mplement section 319(b)(3)(B) and 107(d)(3) authority to exclude air quality monitoring data from regulatory determinations related to exceedances or violations of the National Ambient Air Quality Standards (NAAQS) and avoid designating an area as nonattainment, redesignating an area as nonattainment, or reclassifying an existing nonattainment area to a higher classification if a State adequately demonstrates that an exceptional event has caused an exceedance or violation of a NAAQS.

This document petitions the EPA Region 9 administrator to exclude the data gathered on May 4, 2013, at specific Clark County ozone monitors from normal CAA planning and regulatory requirements because of an exceptional event. It demonstrates that the NAAQS violations would not have occurred but for the Springs Fire in California.

1.2 SCOPE OF DEMONSTRATION

On October 9, 2013, DAQ flagged Clark County ozone data from May 4, 2013, in EPA’s Air Quality System (AQS) to indicate that any NAAQS exceedances were likely caused by ozone precursor emissions produced by smoke plumes from a wildfire. The procedures and criteria states must use in petitioning EPA to exclude data from regulatory considerations because of an exceptional event are set forth in the EER, as outlined below.

Section 2 describes a conceptual model for ozone air pollution and wildfire impacts in Clark County, based on technical studies completed to date. It covers topography, land use, and meteorology in the context of conditions leading to elevated ozone concentrations, then summarizes the role of local emissions and transport into southern Nevada.

Section 3 describes the “clear causal relationship” between the NAAQS concentrations and the exceptional event, including laboratory speciation, historical fluctuation, smoke trajectories, and wildfire impacts on pollutant concentrations. It demonstrates compliance with the following criteria, required by the EER to exclude air quality monitoring data from the normal planning and regulatory process established by the CAA:

1. The event satisfies the criteria set forth in 40 CFR 50.1(j).

2. There is a clear causal relationship between the measurements under consideration and the event that is claimed to have affected air quality in the area.

3. The event is associated with measured concentrations in excess of normal historical fluctuations, including background.

4. There would have been no exceedance or violation but for the event.

5. The submittal includes documentation that the public comment process was followed.

Section 4 provides evidence for the "but for" argument. It uses concentration calculations in lieu of measured concentrations to show that the exceedance would not have occurred but for the event.

The EER further requires that Clark County prove it took reasonable and appropriate actions to inform the public of deteriorating air quality caused by wildfire smoke plumes and a possible exceedance of the ozone NAAQS. Section 5 documents these actions.

Table 1-1. EER Required Elements and Demonstration

EER Element	Section
Regional background and conceptual model	Section 2.0
Clear causal relationship between exceedance and event	Section 3.0
Concentration is in excess of historical fluctuation	Section 3.3
But For demonstration	Section 4.0
Public participation	Section 5.0

An effort was made to separate documentation and/or explanations of each EER element; however, some explanations can and should overlap.

This demonstration package underwent public review and comment before submittal to EPA.

1.3 COMPLIANCE WITH CRITERIA FOR EXCEPTIONAL EVENTS

40 CFR 50.1(j) defines an exceptional event as

> an event that affects air quality, is not reasonably controllable or preventable, is an event caused by human activity that is unlikely to recur at a particular location or a natural event, and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event. It does not include stagnation of air masses or meteorological inversions, a meteorological event involving high temperatures or lack of precipitation, or air pollution relating to source noncompliance.

However, EPA notes that natural events, which are one form of exceptional events, may recur, sometimes frequently. This is certainly true for natural events like Western wildfires.

1.3.1 Wildfire Season in the West

The wildfire season in 2013 was somewhat mild, with only 5.6 million acres burned across the U.S. According to the National Interagency Fire Center, slightly more than half (2.7 million) of those acres were in the West. Table 1-2 lists the number of fires and the acreage burned per state.

Although the wildfire season was relatively mild in historical terms, the state of California experienced several catastrophic fires in 2013. The Springs Fire was one of them, lasting 11 days and consuming over 24,000 acres.

Table 1-2. Fires in the West in 2013

State	# Fires	# Acres Burned
AZ	1,694	136,296
CA	8,457	590,391
CO	1,244	201,243
ID	1,560	754,549
MT	1,930	141,610
NM	1,064	233,037
NV	710	189,314
OR	2,164	250,009
UT	1,321	80,301
WA	1,200	105,402
WY	458	48,667
Total:	21,802	2,730,819

Source: http://www.nifc.gov/fireInfo/fireInfo_stats_YTD2013.html

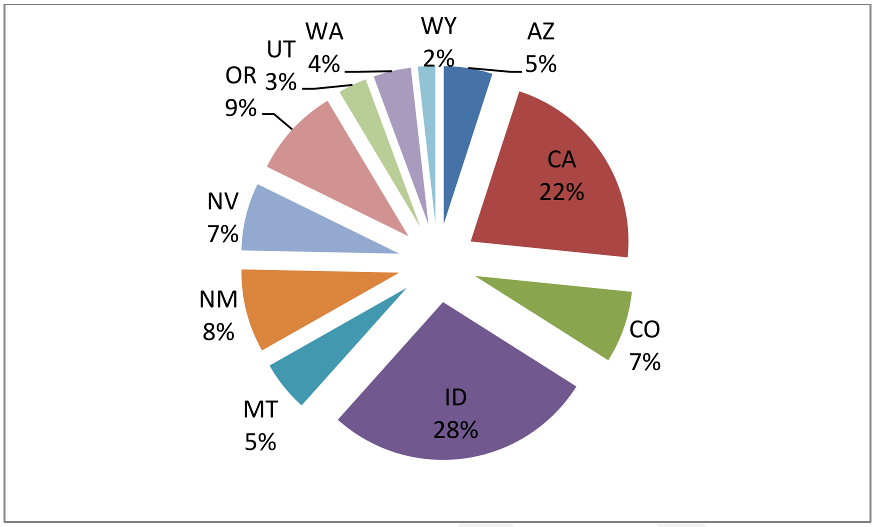


Figure 1-1. Percentage of Overall Acres Burned per State.

1.3.2 Springs Fire Near Camarillo, CA

On May 2, 2013, an explosive wildfire ignited in southern California near Camarillo. Fueled by unusually dry conditions and strong winds, the Springs Fire blazed through more than 24,000 acres of chaparral on the Santa Monica Mountains, forcing the closure of parts of Highway 101 and threatening thousands of homes in Camarillo, Newbury Park, and Thousand Oaks. A wind shift on May 3 pushed the smoke plume inland and toward southern Nevada.

Over 120 fire personnel and five engines were on the scene as a total of 24,250 acres burned. The fire was finally brought under control on May 11, 2013.

On May 3, a Pacific trough (i.e., low-pressure system) began to dig down and retrogress to the southwest. By May 4, the trough had moved far enough to the southwest to cause a directional change in flow from the southwest at all levels. By May 5, the system had dug deep enough to the southwest to cause another directional shift from the south-southwest.

On May 4, 2013, regional transport overwhelmed any local contribution to elevated ozone levels. Surface smoke impacts in Clark County were documented through laboratory analysis of samples of particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) to determine concentrations of wildfire markers (e.g., levoglucosan).

This one-day episode was characterized by the greatest number of sites exceeding the ozone NAAQS: the maximum daily 8-hour average (MDA8) reached 84 parts per billion (ppb). Table 1-3 lists the maximum ozone levels at each monitoring site on May 4, as well as on the days before and after. Figure 1-2 depicts the diurnal ozone cycles for May 3–May 5.

Table 1-3. Maximum 8-Hour O_3 Concentrations (ppb)

Site	May 2013						
	1	2	3	4	5	6	7
Apex	59	65	59	73	73	52	55
Mesquite	58	57	50	63	65	49	51
Paul Meyer	64	62	60	80	71	51	53
Walter Johnson	63	63	60	80	70	50	51
Palo Verde	64	61	58	82	69	51	49
Joe Neal	63	63	63	77	71	51	54
Winterwood	60	62	58	76	71	48	51
Jerome Mack	58	61	57	74	69	46	50
Boulder City	59	62	57	71	71	50	53
Jean	64	65	61	84	74	51	55
J.D. Smith	60	62	61	74	70	50	52

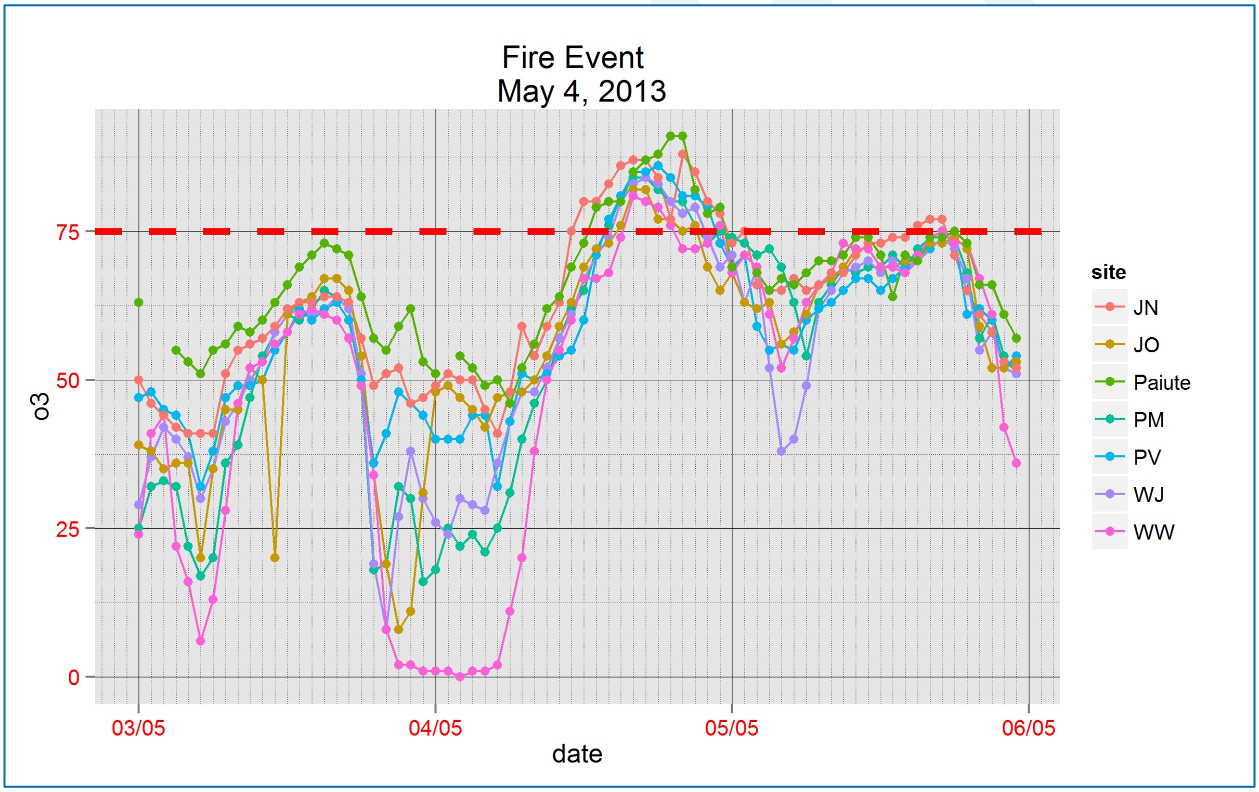


Figure 1-2. Diurnal Ozone Cycles around May 4.

Figure 1-3 is a satellite image showing the location of the Springs Fire. During the first days of the event, the wind came from the east, blowing the smoke plume over the Pacific Ocean (Figure 1-3); however, the winds shifted on Saturday and blew the plume inland (Figure 1-4). Smoke plumes covered most of the Central Valley and southern California (Figure 1-5) for the next several days.

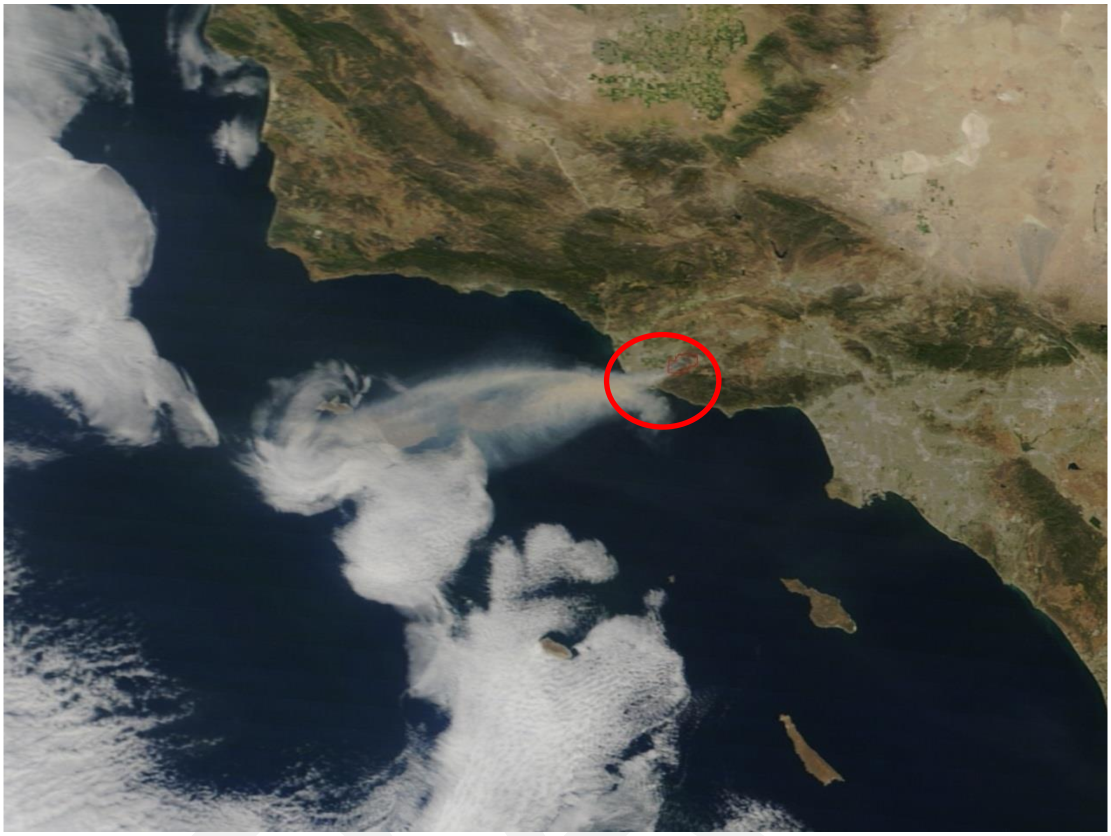


Figure 1-3. Springs Fire Location.

Figure 1-4. Major Wind Shift on May 3.

Figure 1-5. Smoke Plumes over California.

Source: http://maps.ngdc.noaa.gov/viewers/firedetects/

Figure 1-6 shows the location of the Barstow (BA), Mojave Preserve (MO), and Jean (JN) monitoring sites in relation to the Springs Fire. These stations were in the path of the air parcels, according to the back trajectory depicted in Figure 1-7. The graph in Figure 1-8 shows the diurnal patterns for the Barstow, Mojave Preserve, and Jean monitoring sites prior to, during, and after the event. Note the Barstow site was impacted first, followed by the Mojave Preserve site, then finally the Jean site and the Las Vegas Valley. The sites closest to the fire had the highest hourly values. Figure 1-9 maps the highest hourly values across the Clark County monitoring network on May 4, including the Paiute monitoring site just outside the valley, which registered a concentration of 91 ppb.

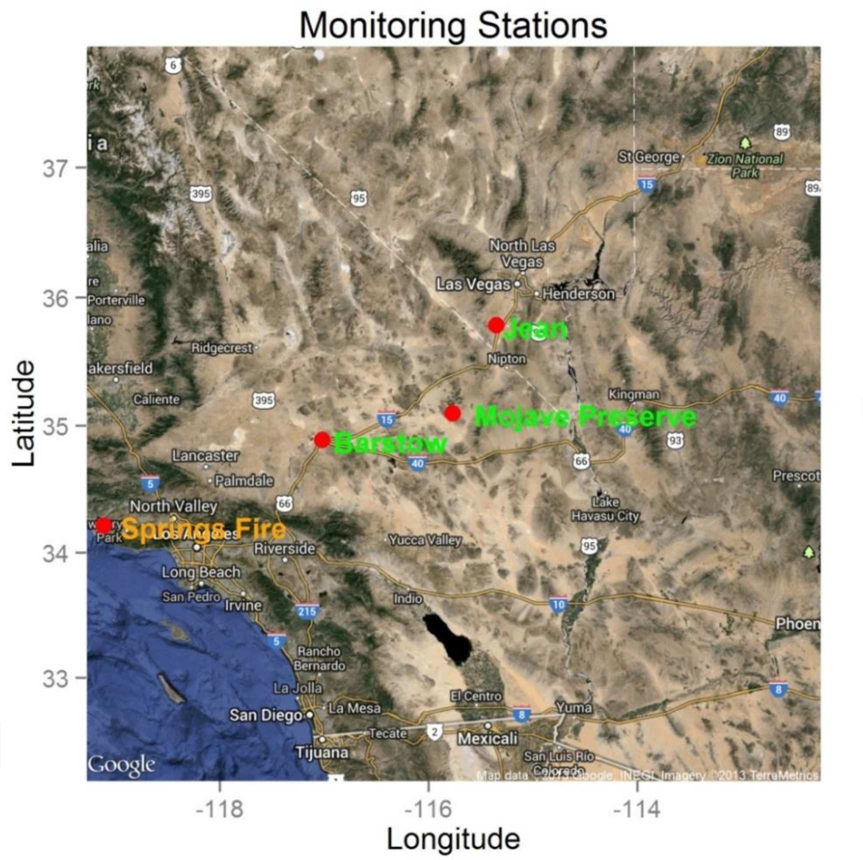


Figure 1-6. Location of Monitoring Stations in Relation to Springs Fire.

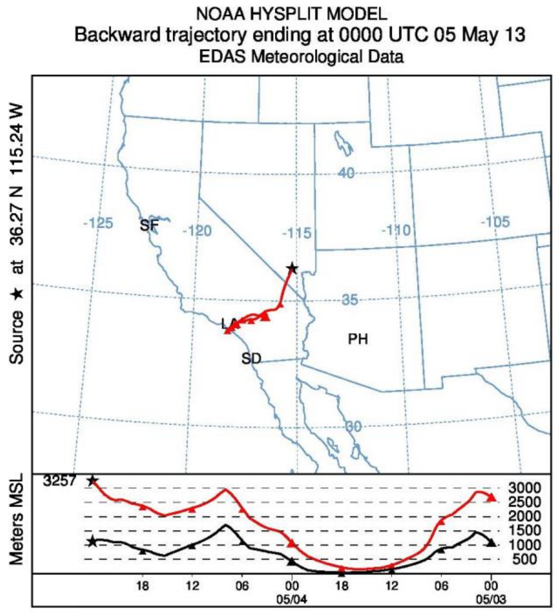


Figure 1-7. Back Trajectory from Springs Fire.

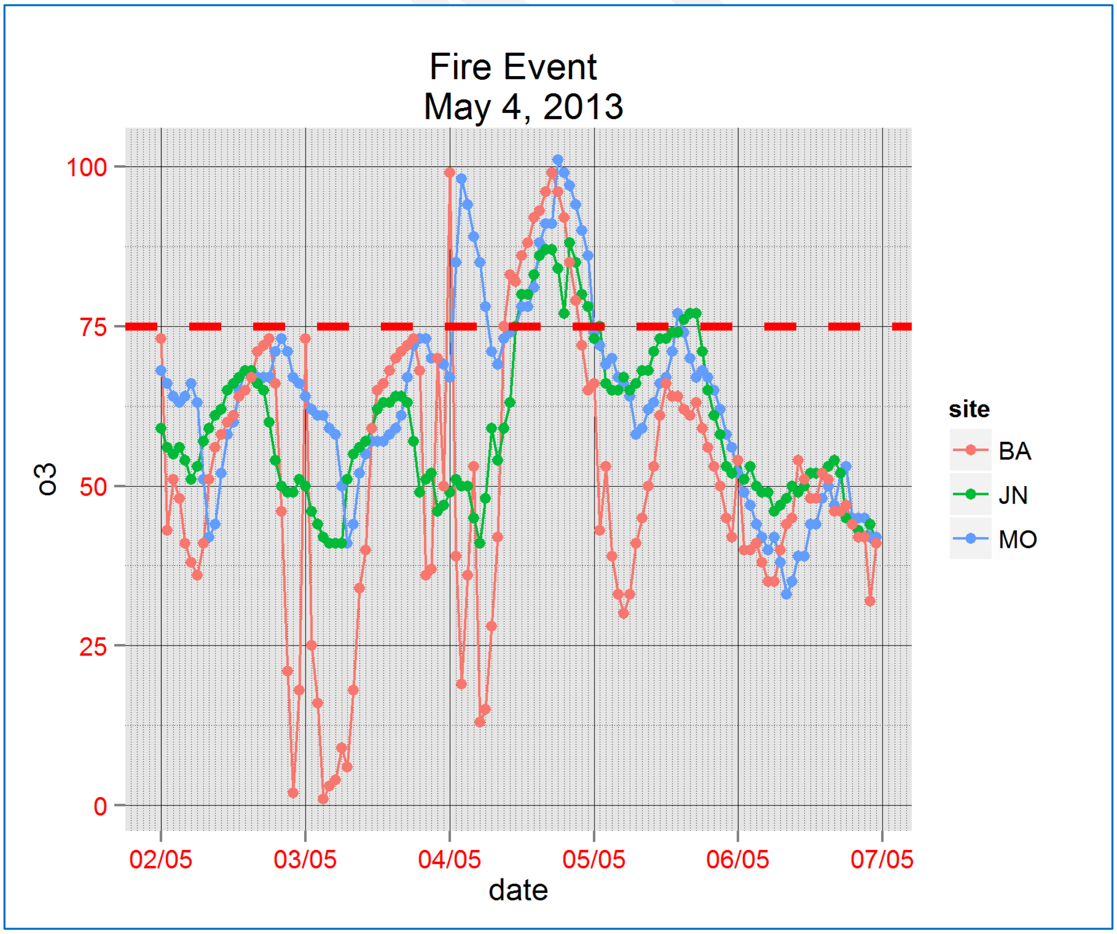


Figure 1-8. Diurnal patterns for BA, MO, and JN.

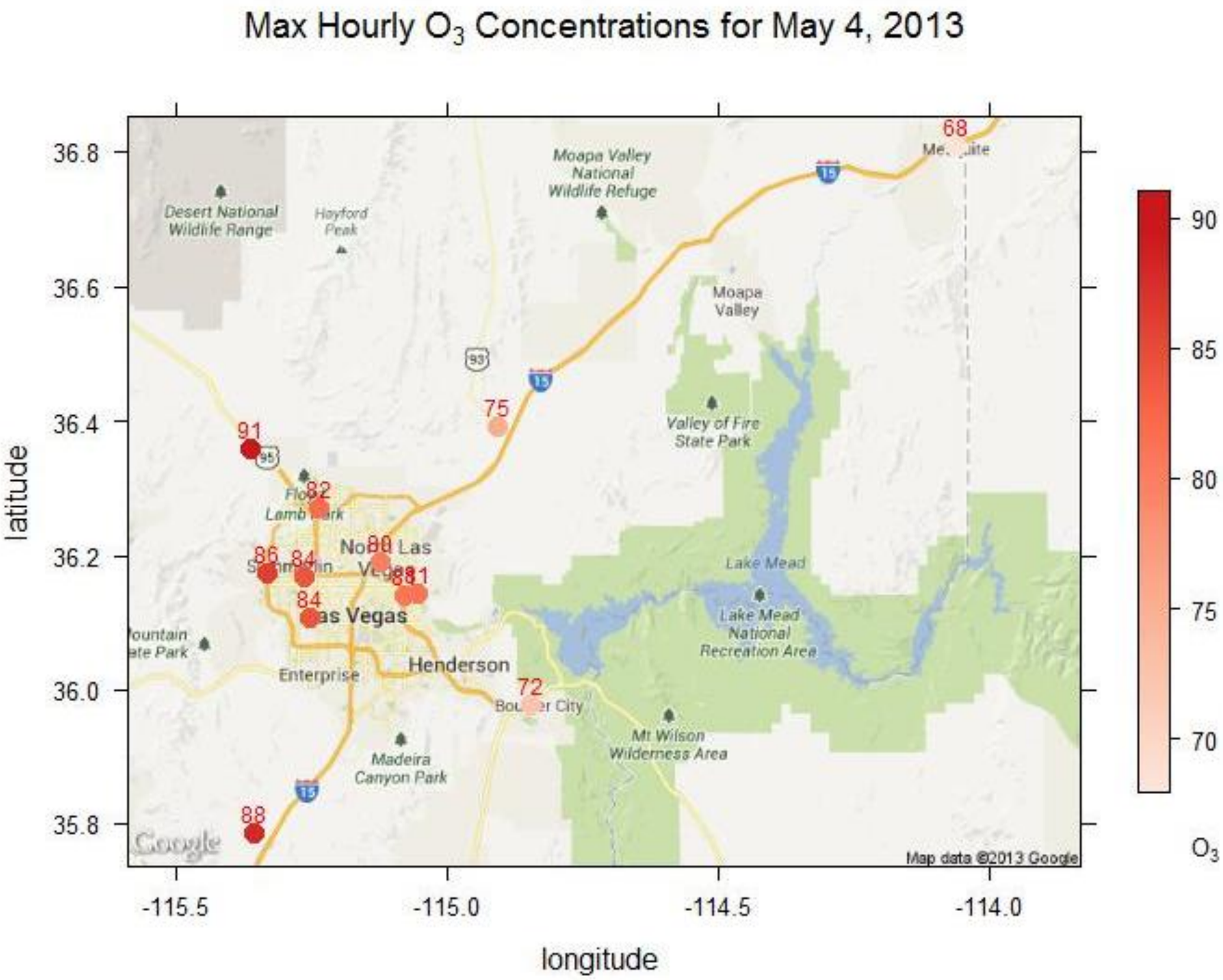


Figure 1-9. Ozone Concentrations on May 4, 2013.

The pollution roses in Figures 1-10 through 1-12 show a westerly wind in Barstow, a southwest flow in Mojave Preserve, and a southern flow into Jean. These winds came from the direction of the fire and the smoke plumes.

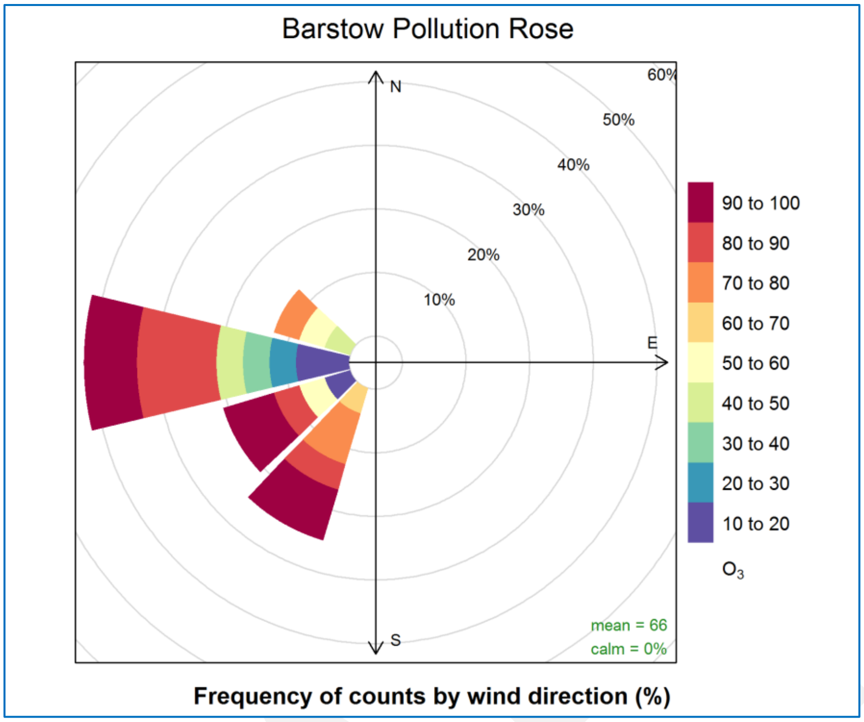


Figure 1-10. Barstow Pollution Rose.

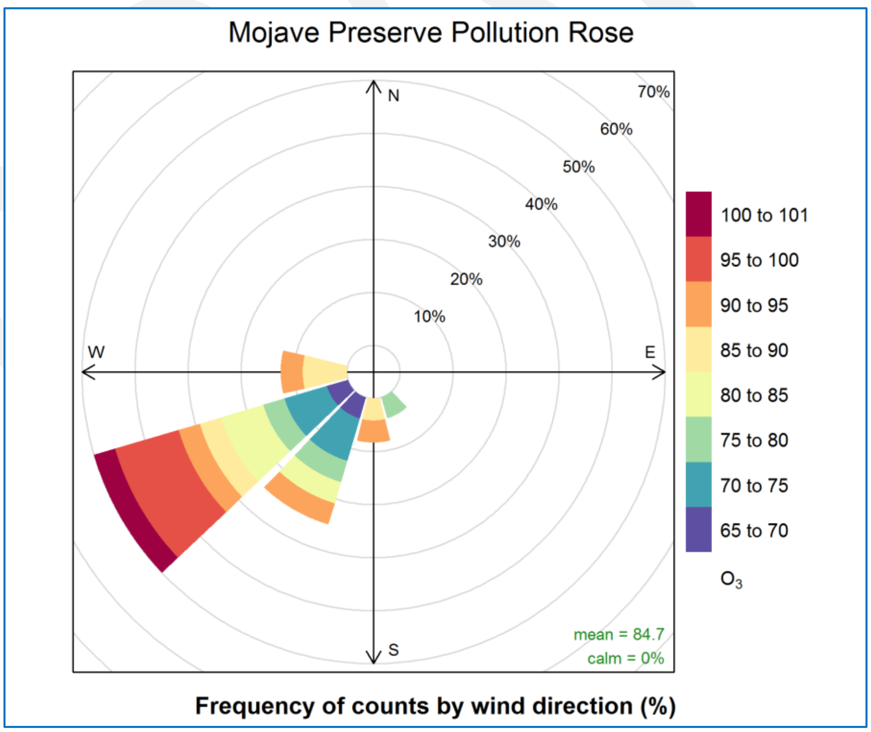


Figure 1-11. Mojave Preserve Pollution Rose.

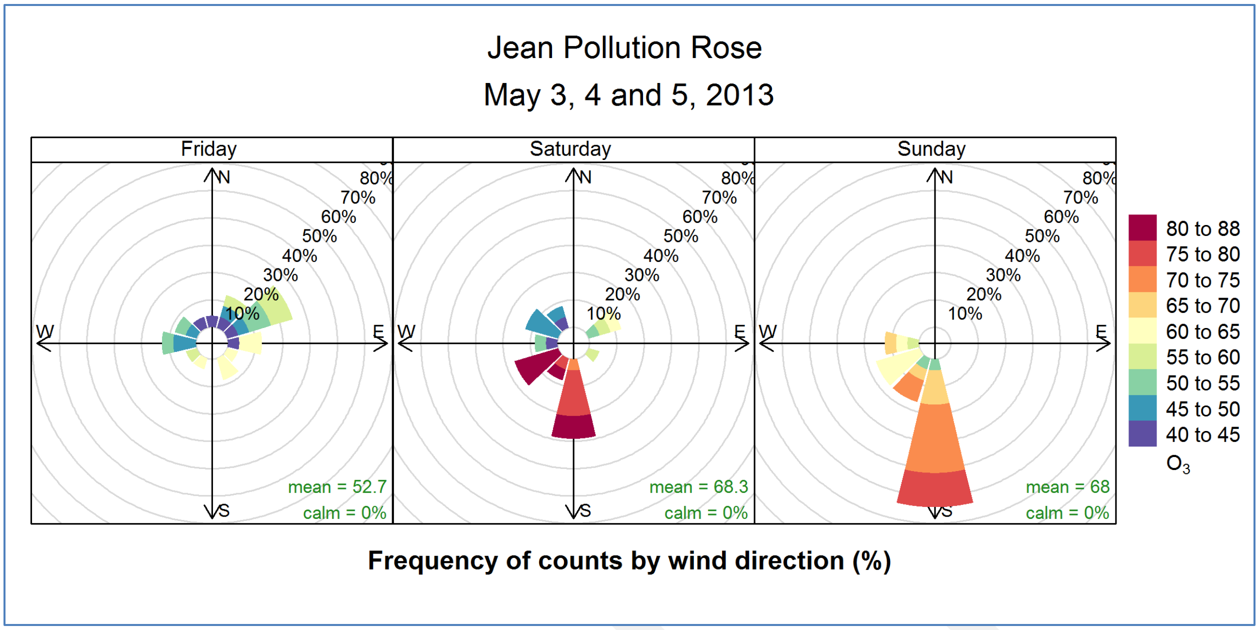


Figure 1-12. Jean Pollution Roses.

1.4 PREVIOUS RESEARCH ON OZONE FORMATION AND SMOKE IMPACTS[1]

Wildfires can generate both NO_x and VOC emissions, with different burning stages generating different types of emissions. Biogenic VOCs are generated by vegetation throughout the burning cycle. NO_x is generated primarily during the hot, flaming stage of the fire, and small reactive hydrocarbons, such as ethane and acetylene, are generated during the smoldering phase (Finlayson-Pitts and Pitts 2000; Jaffe et al. 2008).

Ozone concentrations may be suppressed near fires despite the increase in ozone precursors wildfires generate. Bytnerowicz et al. (2010), Finlayson-Pitts and Pitts (2000), and Sandberg et al. (2002) give two reasons for this: (1) thick smoke can prevent sufficient ultraviolet light from reaching the surface, inhibiting photochemical reactions, and (2) the wildfire plume typically contains high NO_x concentrations, which can titrate ozone concentrations. Downwind of the fire or at the top of the plume (Sith et al., 1981), away from fresh NO_x sources and with reduced aerosol optical depth (AOD), considerable amounts of ozone can be generated. The plume does not have to be very far downwind of fire emissions to generate ozone:Sandberg (2002) cites a study in which Sith et al. (1981) found ozone beginning 10 kilometers downwind of wildfires in plumes less than one hour old. Ozone and ozone precursors can also be transported quite far from a wildfire site (Finlayson-Pitts and Pitts 2000; Jaffe et al. 2008). This shows that, similar to the impacts of anthropogenic emissions in urban airsheds, the highest ozone concentrations due to wildfires are often seen downwind of the area of greatest precursor emissions.

[1] "Exceptional Events Demonstration for 1-Hour Ozone Exceedances in the Sacramento Regional Nonattainment Area Due to 2008 Wildfires" (CARB 2011).

The impact of wildfires on ozone concentrations at both the local and regional level has been extensively evaluated in recent years. Field observations of ozone formation in smoke plumes from fires date back nearly 25 years when aircraft measurements detected elevated ozone at the edge of forest fire smoke plumes far downwind (Sandberg 2002). More recently, aircraft flights through smoke plumes have demonstrated increased ozone concentrations of 15–30 ppb in California (Bush 2008), while ozonesonde measurements in Texas found enhanced ozone aloft (ranging from 25–100 ppb) attributable to long-range transport of smoke plumes from Canada and Alaska (Morris 2006).

In addition, air quality modeling has shown increased levels of ozone from a number of large fires. McKeen (2002) found that Canadian fires in 1995 enhanced ozone concentrations by 10–30 ppb throughout a large region of the central and eastern United States. Lamb (2007) found similar results simulating the impacts of fires in the Pacific Northwest in 2006, with increases of over 30 ppb. Junquera (2005) further found that within 10 kilometers of a fire, ozone concentrations could be enhanced by up to 60 ppb. Finally, in one of the most recent studies, Pfister (2008) simulated the large 2007 fires in both northern and southern California. The author found ozone increases of approximately 15 ppb in many locations and concluded: “Our findings demonstrate a clear impact of wildfires on surface ozone nearby and potentially far downwind from the fire location, and show that intense wildfire periods frequently can cause ozone levels to exceed current health standards” (Pfister 2008).

2.0 CONCEPTUAL MODEL OF OZONE AIR POLLUTION

2.1 TOPOGRAPHY AND METEOROLOGY

Located in southern Nevada, Clark County consists of 8,091 square miles characterized by basin and range topography. It is one of the nation's largest counties, with an area bigger than the states of Connecticut and Delaware combined. The Las Vegas Valley sits in a broad desert basin surrounded by mountains rising from 2,000 feet to over 10,000 feet above the valley floor. The relief map in Figure 2-1 illustrates the basins and mountain ranges surrounding the valley. Terrain within the Las Vegas Valley rises significantly, from approximately 1,200 feet at Lake Mead to 2,000 feet in downtown Las Vegas to over 2,800 feet in the suburbs on the west side of the valley, near the Spring Mountain Range.

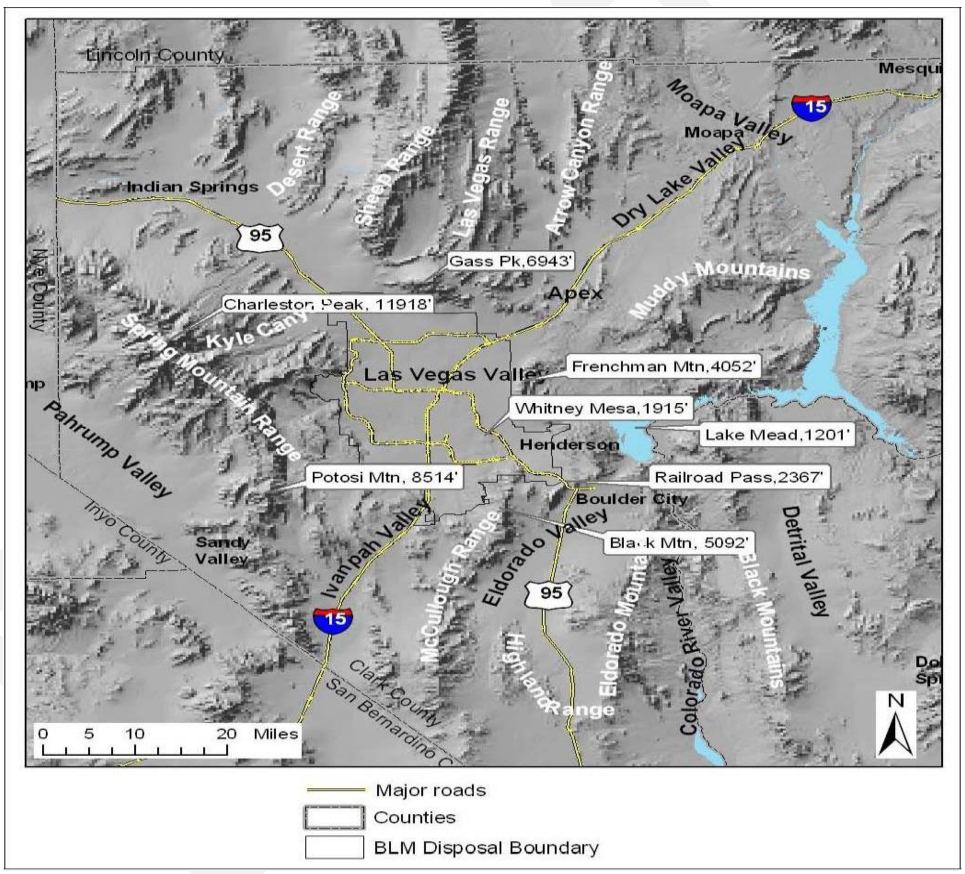


Figure 2-1. Mountain Ranges and Basins Surrounding the Las Vegas Valley.

Although located in the Mojave Desert, Clark County has four well-defined seasons. Summers display the classic characteristics of the desert Southwest: daily high temperatures in the lower elevations often exceed 100ºF, with lows in the 70s. The summer heat is usually tempered by low relative humidity, which may increase for several weeks during July and August in association with moist monsoonal wind flows from the south. Average annual rainfall in the valley, as measured at McCarran International Airport, is approximately 4.5 inches. Table 2-1 lists temperature and rainfall averages in Clark County from 1981–2010.

Table 2-1. Monthly Averages for Temperature and Rainfall (1981–2010)

Month	Maximum (°F)	Minimum (°F)	Average (°F)	Rainfall (inch)
January	58	39.4	48.7	0.54
February	62.5	43.4	52.9	0.76
March	70.3	49.4	59.9	0.44
April	78.3	56.1	67.2	0.15
May	88.9	65.8	77.3	0.12
June	98.7	74.6	86.7	0.07
July	104.2	80.9	92.5	0.4
August	102	79.3	90.6	0.33
September	94	71.1	82.6	0.25
October	80.6	58.5	69.5	0.27
November	66.3	46.5	56.4	0.36
December	56.6	38.7	47.7	0.5

Source: http://www.ncdc.noaa.gov

2.2 POPULATION AND LAND USE

The population of Clark County is just over two million. More than 95 percent reside in the Las Vegas Valley, which encompasses the cities of Las Vegas, North Las Vegas, and Henderson, along with portions of Boulder City near Hoover Dam. Figure 2-2 depicts land use and vegetation in Clark County, along with the two major transportation routes, Interstate 15 and U.S. Highway 95.

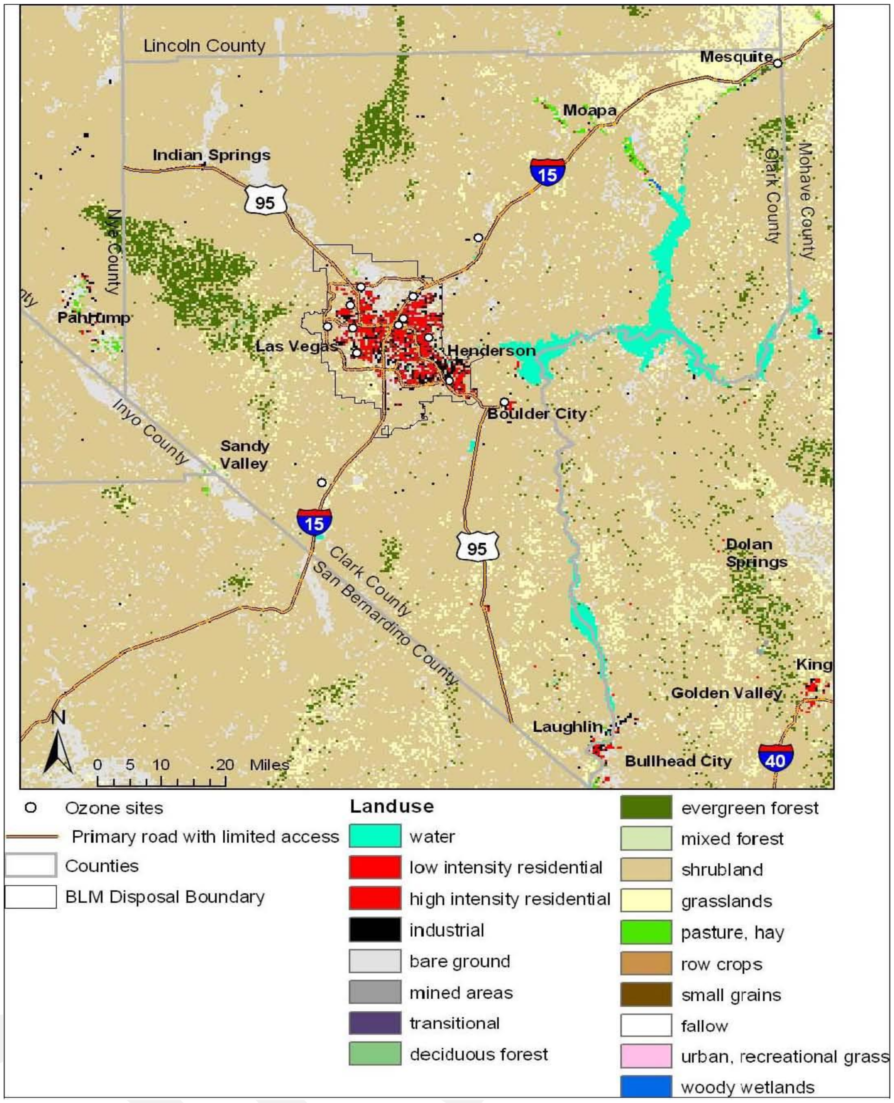


Figure 2-2. Land Use and Vegetation in Clark County.

2.3 OZONE AIR POLLUTION IN CLARK COUNTY

In 2006, the Clark County Department of Air Quality (DAQ) embarked on a research study to characterize and identify meteorological features that affect the timing and locations of elevated ozone levels in Clark County (DAQEM 2006a).

In the study, synoptic weather patterns during the ozone season (May–August) were analyzed using 500 millibar (mb) constant-pressure maps. Specific measured weather parameters included the 500 mb height, and the ambient air temperature at the 700 mb level at the Desert Rock National Weather Service (NWS) upper-air site were used. Temperatures aloft at the 700 mb level indicate the mixing potential (stability) of the regional air mass dominating the area at the time of measurement: warmer air at 700 mb (~10,000 feet [3,000 meters]) indicates a stable atmosphere and poor dispersion conditions, while cooler air aloft is associated with more vigorous vertical mixing of pollutants and better dispersion. From the analysis, it was determined that weather patterns could be characterized into five basic weather types: Pacific Trough, Interior Trough, Pacific Ridge, Interior Ridge, and Flat Ridge. The characteristics and criteria for each weather type are described below.

2.3.1 Pacific Trough

The axis of the long-wave 500 mb trough, or series of short-wave troughs, is located off or along the Pacific Coast, producing falling 500 mb heights and wind increases from a westerly to southwesterly flow. By convention, the lowest 500 mb heights during this weather type are west of the Sierra Nevada Mountains. This type of trough influences atmospheric dispersion conditions in the interior southwestern U.S. by slowly eroding the strength and longevity of stable anti-cyclonic air masses, which results in the breaking down of the broad-scale subsidence needed to sustain poor dispersion conditions. Also by convention, the Pacific Trough designated weather type includes zonal flow situations characterized by light to moderate straight west-to-east flow across the western U.S. The southerly component of the onshore flow characteristic of the Pacific Trough may also allow for increased moisture aloft over the interior regions. In general, the 700 mb temperature at the Desert Rock upper-air station is less than 10ºC during Pacific Trough occurrences.

2.3.2 Interior Trough

When the axis of a long- or short-wave trough, or of a closed cyclonic system, resides in the interior of the southwestern U.S., the designated synoptic weather type is an Interior Trough. In this type, the lowest 500 mb heights are east of the Sierra Nevada Mountains. The most significant characteristic of this pattern is the advent of cool air aloft in the interior Southwest and resultant well-mixed dispersion conditions. Temperatures at 700 mb are usually below 8ºC, and may be as low as 0ºC during the early part of the ozone season. When advected moisture is available aloft, considerable cloudiness and escalated precipitation may accompany the Interior Trough synoptic type.

2.3.3 Pacific Ridge

The Pacific Ridge synoptic weather type is directly associated with the mean eastern Pacific ridge, with the axis of highest pressure situated along or west of the Pacific coast. The convention for this feature requires that the highest 500 mb heights be located west of the Sierra Nevada Mountains. The maximum 500 mb heights usually exceed 5,900 m near the core of the ridge, but these heights may be considerably lower at the Desert Rock upper-air site.

Another convention for the Pacific Ridge designation requires that the 500 mb flow over southern Nevada be from a northerly direction (west-northwesterly to northeasterly), reflecting the counterclockwise motion around the anti-cyclonic air mass to the west. During the first half of the ozone season, the northerly flow aloft results in the advection of cooler, less stable air into the region; during the second half of the season, the northerly flow often brings in warmer, drier air. The Desert Rock 700 mb temperature may be as low 5ºC (in the early season) or as high as 12ºC (in the late season). The Pacific Ridge weather type usually marks the beginning of an anti-cyclonic situation and often will follow a cyclonic event, especially in the earlier part of the season. It is also not unusual for this type to be the result of the retro-gradating of a ridge located farther east. The Pacific Ridge weather type is usually more transient than other ridging situations and thus tends to occur for shorter durations, often as a transition into other, longer-lived anti-cyclonic regimes.

2.3.4 Interior Ridge

The primary characteristic of the Interior Ridge weather type is the existence of a discernible high-pressure ridge at the 500 mb level over the interior southwestern U.S. The convention for this feature is that the highest 500 mb heights be located east of the Sierra Nevada Mountains. The interior ridge typically occupies the Great Basin and Inter-Mountain region and is often centered around the Four Corners area, about 500 miles east of Las Vegas. The height of the 500 mb surface over the Desert Rock upper-air site is usually above 5,900 m, and can reach as high as 5,990 m. The 700 mb temperature in this pattern usually exceeds 12ºC, and can go as high as 16ºC. The warm temperatures aloft indicate strong air mass subsidence in the interior region, meaning valley capping and limited thermodynamic mixing prevail; however, because of the lack of cool air advection, the hottest local surface temperatures of the year are usually recorded during Interior Ridge events, although mixing-layer depths may be deeper due to intense surface heating. Flow aloft at Desert Rock is usually very light and potentially variable when the ridge axis is over southern Nevada, but easterly to southeasterly winds predominate when the ridge center is farther east.

2.3.1 Flat Ridge

When the eastern Pacific Ridge broadens to extend over the ocean and the interior West, with little transitory movement, the resulting weak anticyclonic air mass is classified as a Flat Ridge. In this pattern, all of the synoptic-scale energy lies well to the north and the pressure gradients, both at the surface and aloft, are very weak. The 500 mb surface may not always be as high as in the stronger ridging types (i.e., Pacific and Interior), but it is still typically greater than 5,900 m over most of the region. Because of the relatively weak anticyclonic pattern, significant air mass subsidence is prevalent; as a result, interior valleys remain capped and stable. This scenario is the most conducive to increased episodic pollution carryover from one day to the next.

2.4 SYNOPTIC WEATHER PATTERNS ASSOCIATED WITH THE EVENT

The 200, 500, and 850 mb time-series images for May 3–4, 2013, and the 500 mb chart for May 5, 2013, were examined to determine the synoptic weather patterns prior to, during, and after the May 4, 2013, event. The synoptic weather patterns are as follows.

<u>May 3</u>

Prior to the event, the four 200 mb and 500 mb time-series images in Figures 2-3 and 2-4 (Images 1–4) show a low-pressure Pacific Trough digging down and retrogressing to the southwest. The four 850 mb time-series images in Figure 2-5 (Images 1–4) show a disorganized low pressure developing over Clark County. All levels show a west-to-east regional airflow.

May 4

During the event, the Pacific Trough strengthened and continued to dig down and retrogressed to the southwest (see 200 mb time-series images in Figure 2-6 (Images 1–6). As a result, the directional flow repositioned from the southwest. The six 500 mb time-series images in Figure 2-7 (Images 1–6) show the formation of a closed low and a retrograding to the southwest over northern California. The 850 mb time-series images in Figure 2-8 (Images 1–6) show the formation of a closed low and a retrograding to the southwest off the California coastline. All levels show southwesterly-to-northeasterly regional airflow.

May 5

After the event, the four 500 mb time-series images in Figure 2-9 (Images 1–4) show that the closed low continued to deepen and move southwesterly. The deepening and repositioning of the closed low resulted in a shift of the directional airflow from south-southwesterly to north-northeasterly.

Conclusion

On May 3, a Pacific Trough began to dig down and retrogress back to the southwest. Consequently, on May 4 the trough (low-pressure system) moved far enough to the southwest to cause a directional change in flow from the southwest at all levels. By May 5, the low-pressure system had dug deep enough to the southwest to cause another directional shift from the south-southwest.

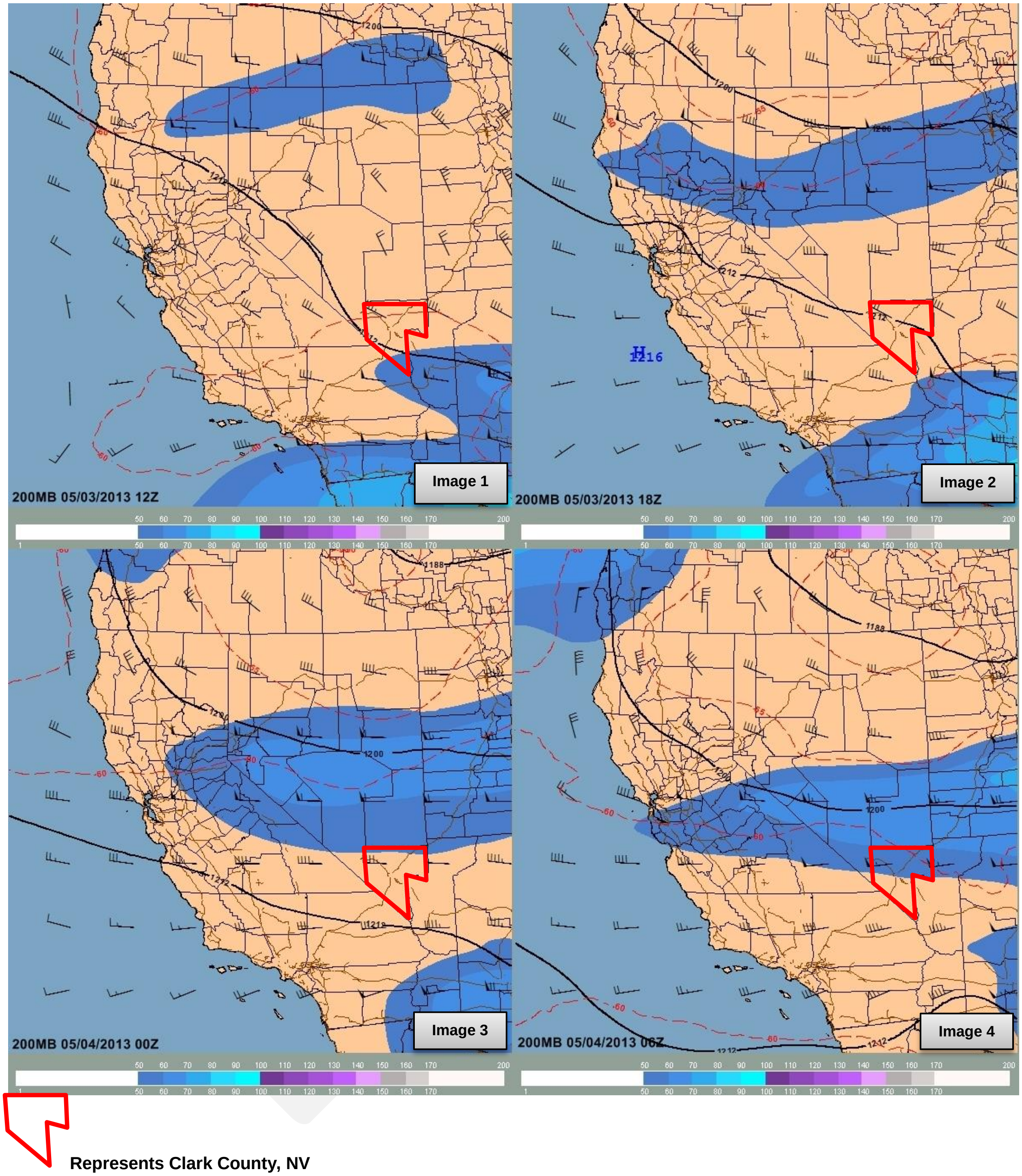
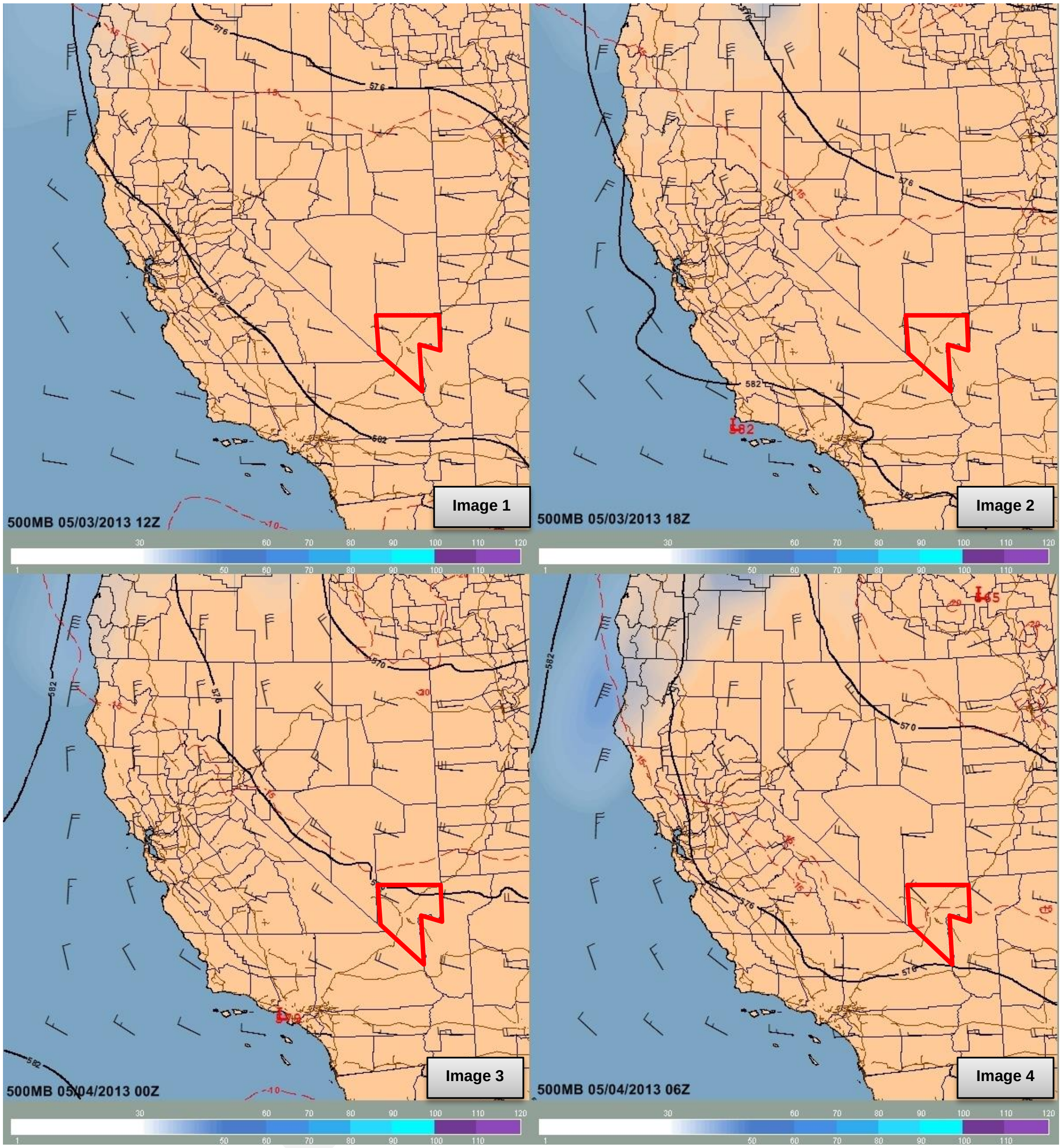


Figure 2-3. 200 mb Weather Images for May 3, 2013.



Represents Clark County, NV

Figure 2-4. 500 mb Weather Images for May 3, 2013.

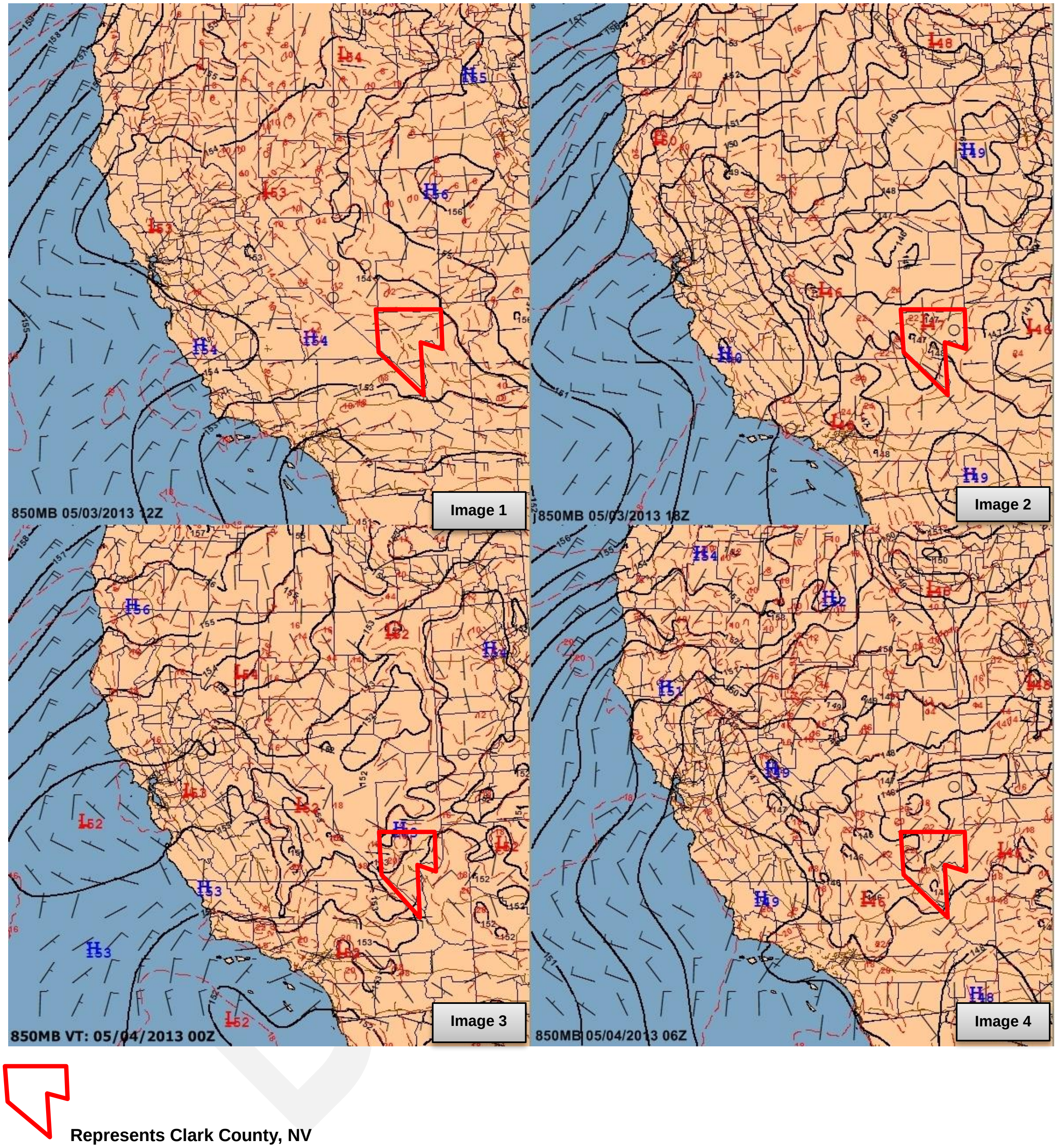


Figure 2-5. 850 mb Weather Images for May 3, 2013.

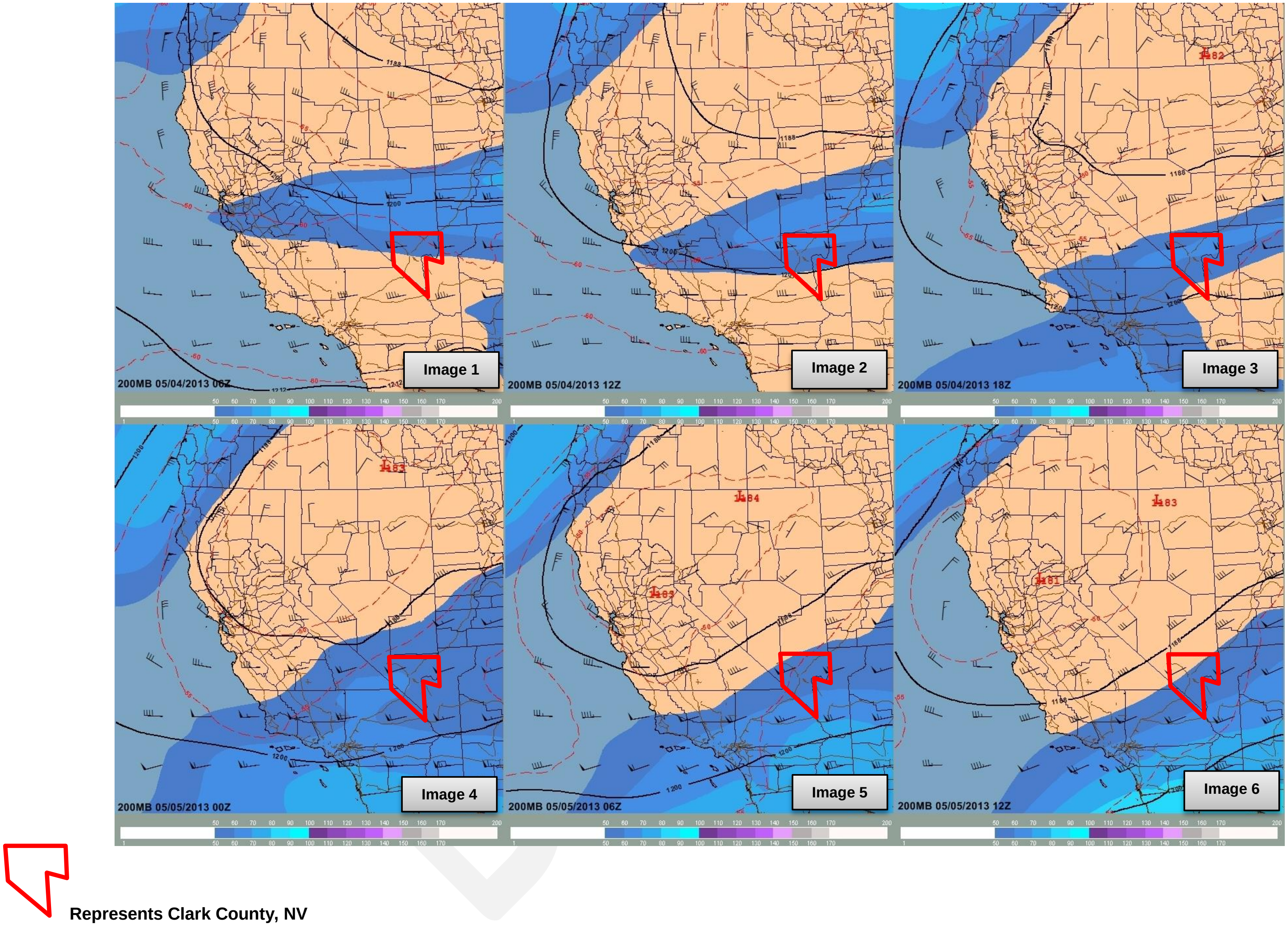
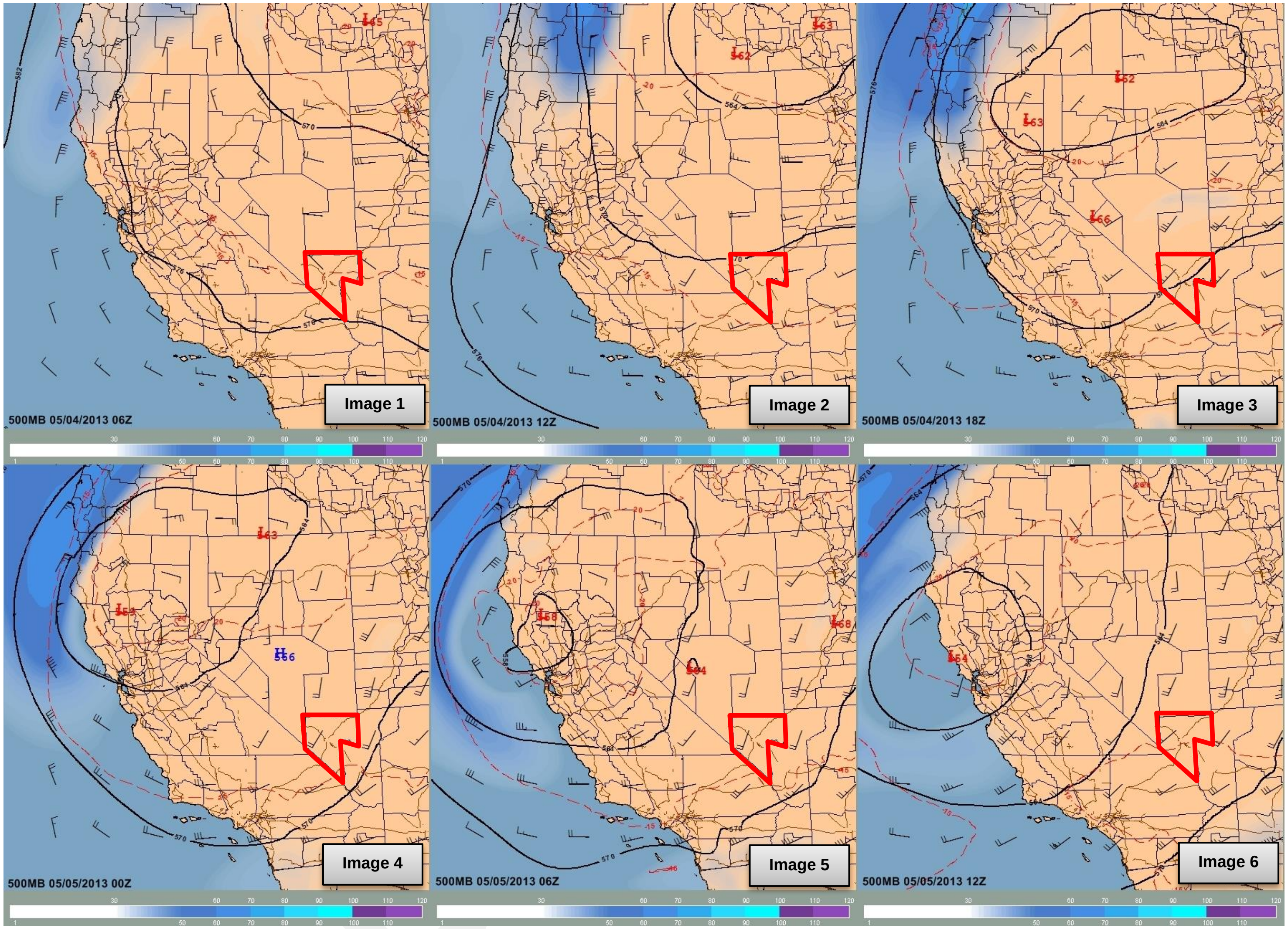
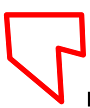


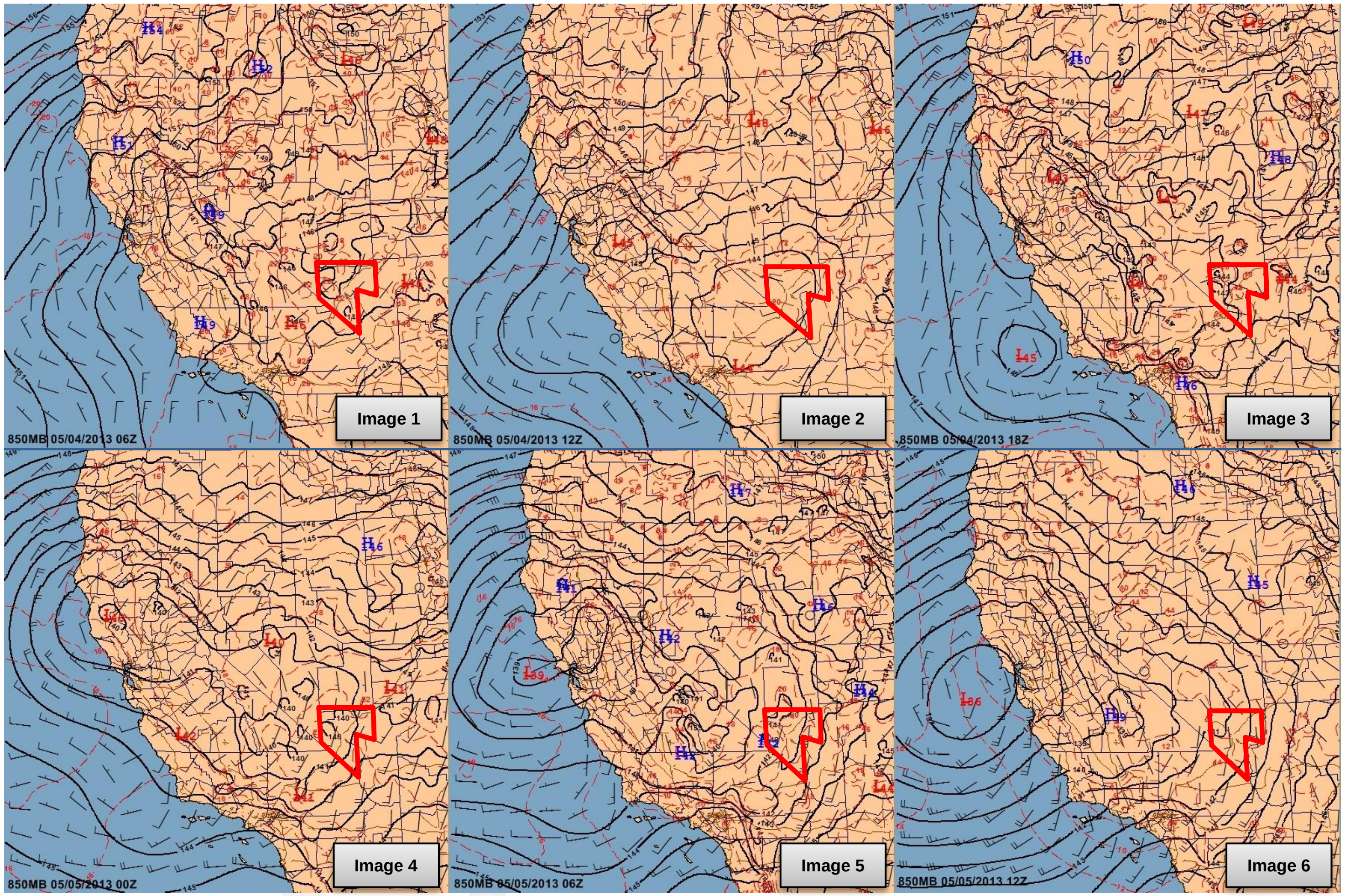
Figure 2-6. 200 mb Weather Images for May 4, 2013.





Represents Clark County, NV

Figure 2-7. 500 mb Weather Images for May 4, 2013.



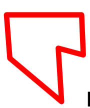

Represents Clark County, NV

Figure 2-8. 850 mb Weather Images for May 4, 2013.

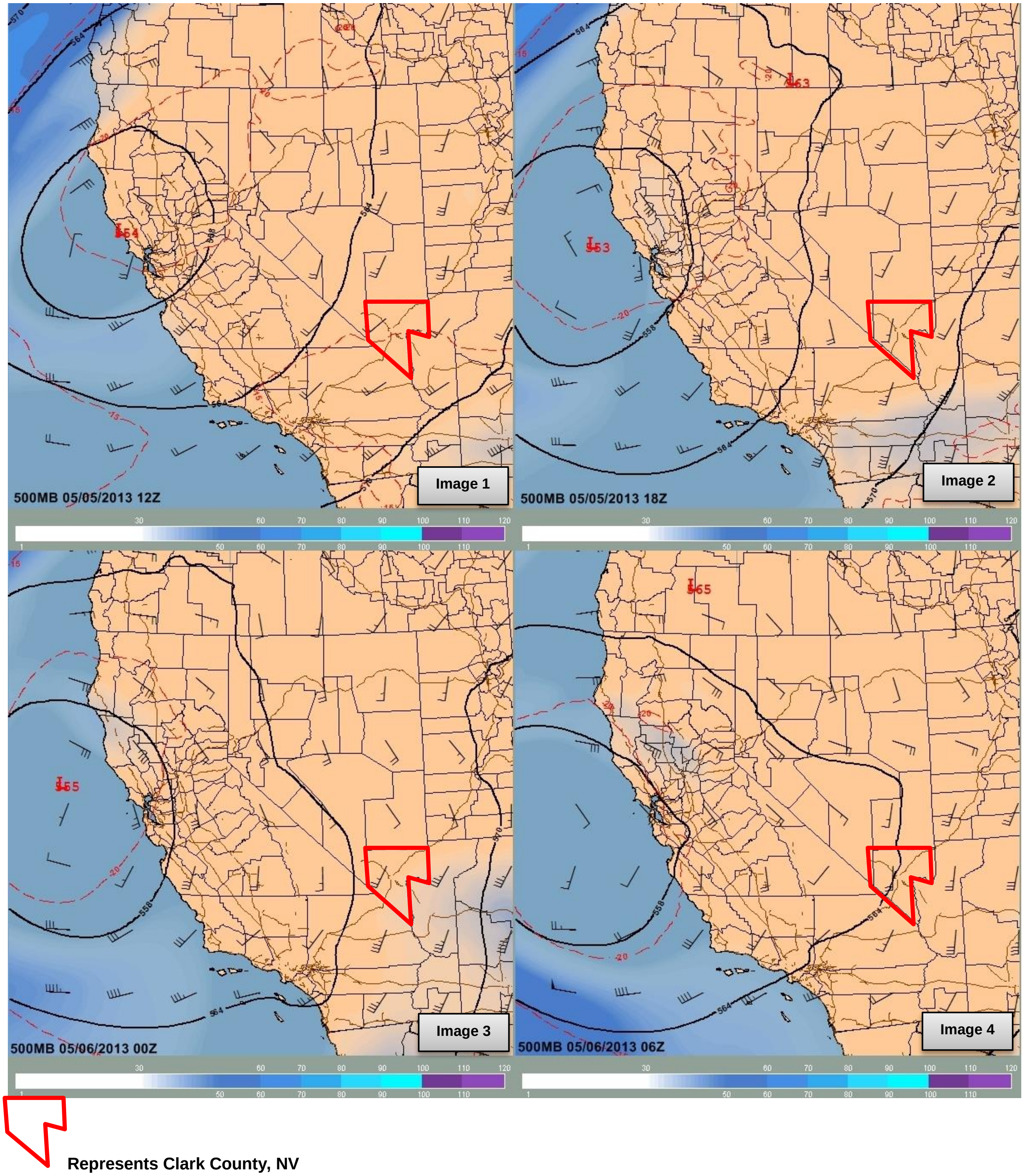


Figure 2-9. NOAA 500 mb Storm Prediction Images for May 5, 2013.

3.0 CLEAR CAUSAL RELATIONSHIP

3.1 SMOKE PLUME COMPOSITION

Smoke plumes from wildfires contain a variety of pollutants, including VOCs and NO_x (ozone precursors), and particulate organic and inorganic compounds. Plumes affect air quality not only through emissions of primary pollutants, e.g., CO, PM, VOCs, and NO_x, but also through production of secondary pollutants when VOCs and NO_x undergo photochemical processing during atmospheric transport, e.g., ozone and secondary organic aerosols. Table 3-1 lists the range of pollutants emitted, expressed as emission factors, which are defined as the mass of compounds released per mass of dry fuel consumed. The table demonstrates that significant amounts of VOCs are released during wildfires; in fact, total VOC emissions exceed those of $PM_{2.5}$, accounting for 1–2 percent of carbon fuel burned.

Table 3-1. Chemical Composition and Emission Factors for Wildfires

Compound or Compound Class	Emission Factors (g/kg)	
	Temperate Forest	Temperate Rangeland
$PM_{2.5}$	11.7	9.7
Organic carbon (wt. percent of $PM_{2.5}$)	45-55	40-70
Elemental carbon (wt. percent of $PM_{2.5}$)	4-8	4-10
Elemental Species (wt. percent of $PM_{2.5}$):	~3	~6
• Potassium (K, wt. percent of $PM_{2.5}$)	~1	~3
• Chloride (Cl, wt. percent of $PM_{2.5}$)	0.3	2
CO	89.6 ± 13.2	69 ± 17
CO_2	1,619 ± 112	1,684 ± 45
Alkanes (C2-C10)	0.8	0.4
Alkenes (C2-C9)	2.2	1.8
Aromatics (BTEX)	0.64	0.42
Oxygenated VOCs:	10.9–12.9	N/A
• Methanol	0.31–2.03	0.14
• Formic acid	1.17	N/A
• Acetic acid	3.11	N/A
• Formaldehyde	2.25	N/A
• Acetaldehyde	0.24	0.25
• Acetone	0.347	0.25
• Acrolein (propenal)	0.123	0.08
• Furan	0.445	0.1
• 2-methyl-furan	0.521	N/A
• 3-methyl-furan	0.052	N/A
• 2,5-dimethyl-furan	0.053	N/A
• Benzofuran	0.038	N/A

N/A = not available; BTEX = benzene, toluene, ethylbenzene, and xylenes.

3.2 CAUSAL RELATIONSHIP

3.2.1 Meteorological Conditions

On May 3, 2013, a Pacific Trough began to dig down and retrogress to the southwest. On May 4, the trough moved far enough to the southwest to cause a directional change in flow from the southwest at all levels. By May 5, the low-pressure system had dug deep enough to the southwest to cause another directional shift from the south-southwest.

3.2.2 Laboratory Analysis of $PM_{2.5}$ Samples

Concentrations of $PM_{2.5}$ track closely with those of levoglucosan, a key chemical tracer for biomass burning (Simoneit et al., 1999; Fraser and Lakshmanan, 2000). Levoglucosan, a 1,6-anhydride of glucose, is one of the major organic components of ambient PM from burning biomass (e.g., plants or wood); it is formed by the pyrolysis of cellulose at temperatures over 300ºC.

Researchers use individual chemical markers or chemical ratios to attribute ambient PM concentrations to specific sources, such as biomass combustion, vehicle emissions, or industrial sources. Ideally, these markers should be unique to the source, stable in the atmosphere, and present in measurable quantities. Levoglucosan is unique to the combustion of cellulose, relatively stable under atmospheric conditions, and emitted in quantities large enough for it to serve as an ideal tracer for general biomass burning.

$PM_{2.5}$ samples from the Clark County monitoring network (Figure 3.1) were analyzed for the presence of levoglucosan. Concentrations of levoglucosan were used to determine the composition of the biomass burned and, therefore, the area in which the wildfire likely originated. DAQ then examined the correlation between concentrations of $PM_{2.5}$, O_3, and levoglucosan to establish smoke impacts on the area at ground level.

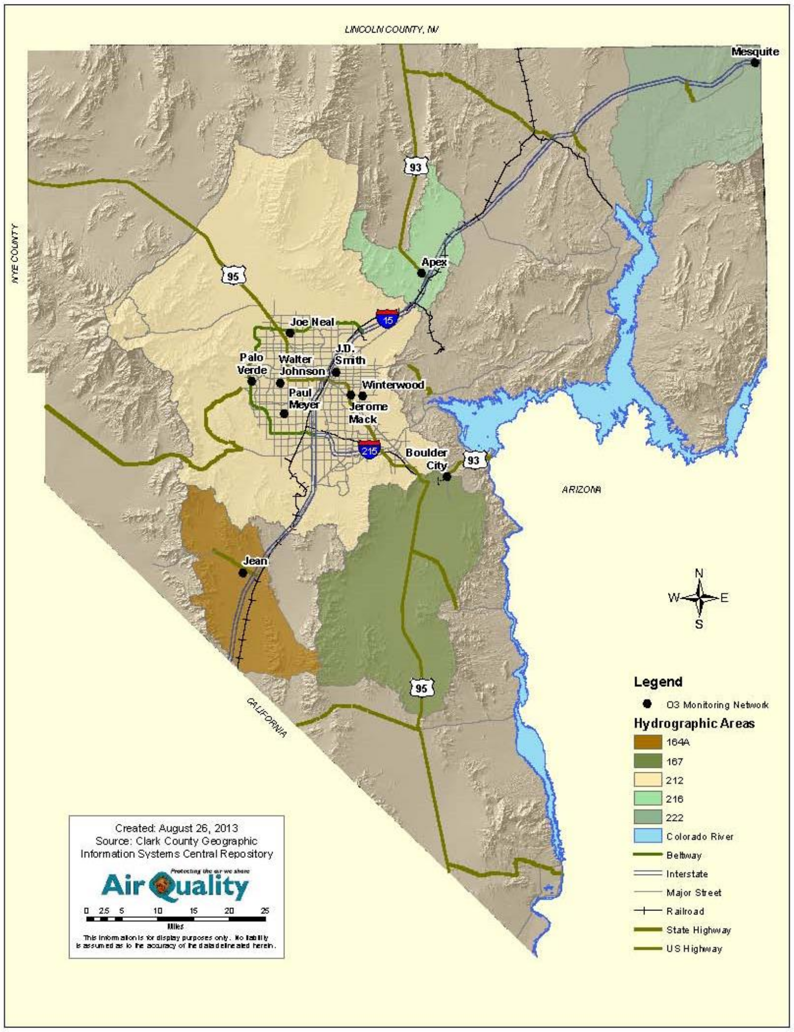


Figure 3-1. Clark County Ozone Monitoring Network.

In 2011, RTI International analyzed six $PM_{2.5}$ filters for traces of levoglucosan to determine the background concentrations at the Jean and Jerome Mack monitoring sites. Three days without any fire impacts—one in June, one in July, and one in August—were chosen for the analysis. Table 3-2 shows the filter numbers and dates.

Table 3-2. Filter and Sample Days

Month	Jerome Mack	Jean
June	FD-T0728928-110620	FD-T0728929-110620
July	FD-T0728978-110720	FD-T0728979-110720
August	FD-T0729017-110810	FD-T0729018-110810

The results of the analysis (outlined in Table 3-3) show that there were no detectable levoglucosan concentrations for non-fire days; therefore, the background concentration for levoglucosan during non-fire days is zero.

Table 3-3. Filter Analysis Results

Sample Name	µg/mL
FD-T0728928-110620	0.000
FD-T0728929-110620	0.000
FD-T0728978-110720	0.000
FD-T0728979-110720	0.000
FD-T0729017-110810	0.000
FD-T0729018-110810	0.000

During the wildfire event, DAQ collected ambient $PM_{2.5}$ samples at Jerome Mack, Jean, and Sunrise Acres. After gravimetric mass measurements, all filters were archived and kept in air-tight containers in a freezer. RTI International performed a speciation analysis for traces of levoglucosan. Results of the analyses are listed in Table 3-4. Levoglucosan concentrations were elevated during the event on May 4, with some residual levels the following day. The results show that the monitors were impacted by the smoke plume from the Springs Fire.

Table 3-4. Analyses Results for May Fire

Sample ID	Run Date	Levoglucosan (µg)
T1644750	4-May	0.305
T3536308	5-May	0.493
T3536310	6-May	0.048
T1644783	4-May	0.455
T1644787	4-May	0.388

Table 3-5 shows the concentration comparison between $PM_{2.5}$, levoglucosan, and O_3 (for Jean).

Table 3-5. Pollutant Concentrations

Jean			
Date	Levo	$PM_{2.5}$	O_3
4-May	0.388	17.84	84
5-May		21.57	74
6-May	0.048	14.95	51

Since levoglucosan is the most abundant, stable, and universal biomass burning emission marker, the correlation between $PM_{2.5}$, O_3 and levoglucosan concentrations were examined as shown in Figure 3-2. There is a very good correlation between ozone and levoglucosan on May 4, proving that the Las Vegas Valley was impacted at ground level by smoke plumes.

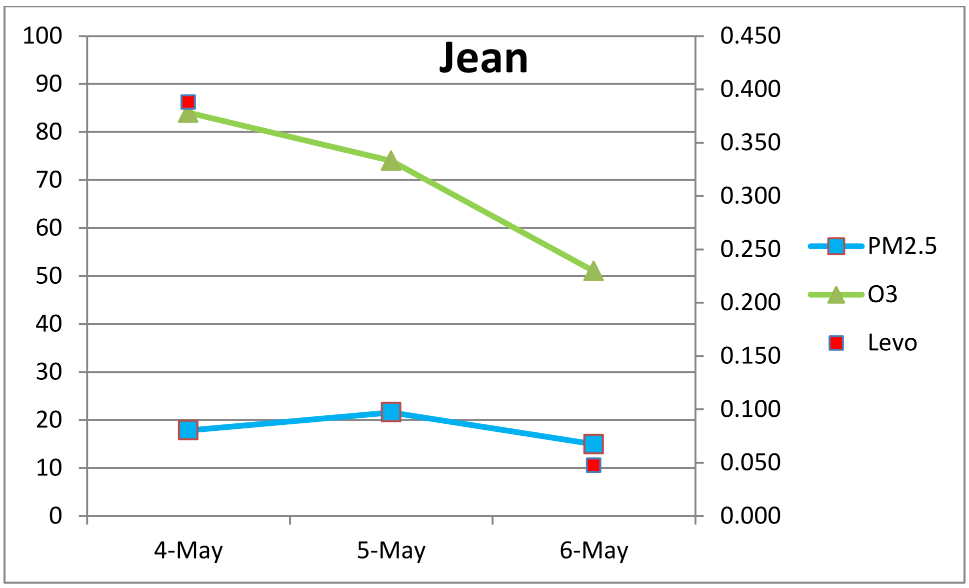


Figure 3-2. Correlation of Average Ozone and Levoglucosan Concentrations.

3.2.3 Smoke Plume Trajectory Model

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model computes simple air parcel trajectories. Its calculation method is a hybrid between the Lagrangian approach, which uses a moving frame of reference as the air parcels move from their initial location, and the Eulerian approach, which uses a fixed three-dimensional grid as a frame of reference. HYSPLIT back-trajectories show the path an air parcel took to reach an area. Applications include tracking and forecasting the release of radioactive material, volcanic ash, and wildfire smoke.

The HYSPLIT plots in Figure 3-3 show 24-hour back-trajectories for the afternoon hours on May 4. The highest ozone values occurred in the afternoon, starting at 1200. The 24-hour back-trajectories demonstrate that the air masses and smoke plume on May 4 originated from the Springs Fire in the Los Angeles area.

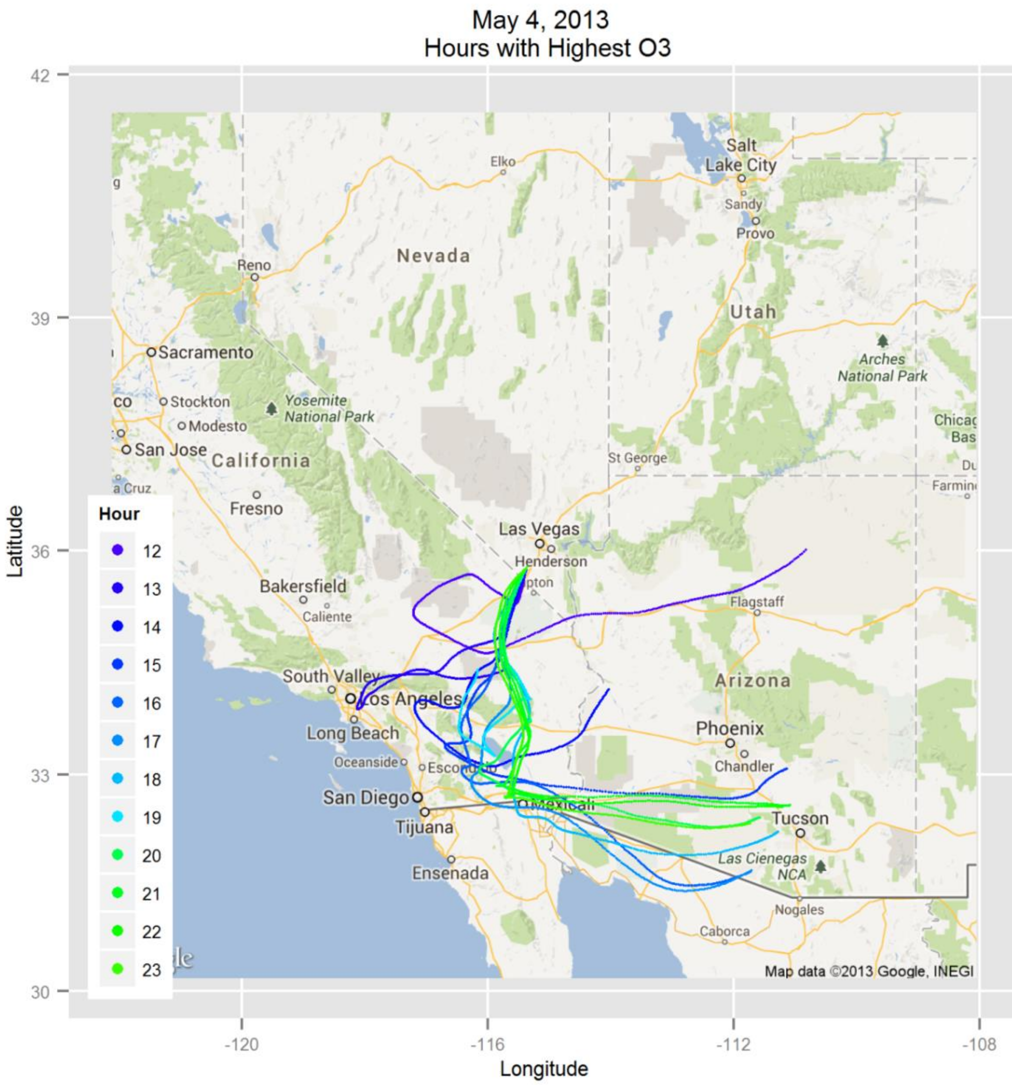


Figure 3-3. Back Trajectories, Pollutant Concentrations, and Wildfire Impacts.

Ozone concentrations started to increase at 1000 at all stations in the Las Vegas Valley and at Jean, with concentrations reaching 88 ppb at Jean at 2000. Such high ozone concentrations so early in the ozone season are very unusual for Clark County, but on May 4, a total of 6 out of 11 stations violated the ozone NAAQS in Clark County. Table 3-6 lists the hourly concentrations for the ozone monitors in the network, with exceeding values highlighted in orange.

Table 3-6. Ozone Concentrations on May 4

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Apex	44	30	33	35	40	30	36	39	50	53	58	64	70	71	72	73	73	74	73	72	75	72	57	61
Mesquite	25	26	16	19	21	16	19	32	37	42	52	55	56	60	63	63	65	65	61	61	65	68	49	59
Paul Meyer	18	25	22	24	21	25	31	40	46	50	57	62	65	72	76	81	84	84	82	80	80	76	73	75
Walter Johnson	26	24	30	29	28	36	43	48	48	52	57	61	67	71	74	80	83	84	83	80	78	79	74	69
Palo Verde	40	40	40	44	44	32	43	51	50	51	54	55	60	71	77	81	85	85	86	84	81	81	79	73
Joe Neal	48	49	47	45	42	47	48	48	50	54	59	63	69	72	73	76	82	82	77	77	75	76	69	65
Winterwood	1	1	0	1	1	2	11	20	38	50	55	60	67	67	68	74	81	80	79	76	72	72	73	76
Jerome Mack	1	1	1	1	1	6	10	22	39	48	54	60	65	66	67	75	81	80	74	73	71	73	71	73
Boulder City	53	54	53	56	56	45	38	46	50	56	58	63	68	71	70	71	70	72	72	70	69	71	70	71
Jean	49	51	50	50	45	41	48	59	54	59	63	75	80	80	83	86	87	87	84	77	88	85	80	78
J.D. Smith	5	5	9	18	11	9	14	35	47	53	56	61	68	70	70	77	80	80	76	75	67	71	67	70

Figures 3-4 through 3-13 illustrate the diurnal cycle at 10 ozone monitoring sites from May 1–8. On a normal day, ozone values climb in the morning, peak around noon, plateau through the afternoon, and recede in the early evening. The highest ozone concentrations occur during the most intense hours of sunlight, often referred to as the prime ozone cooking period. On May 4, however, the highest ozone concentrations occurred in the early afternoon, staying throughout the evening and into the night.

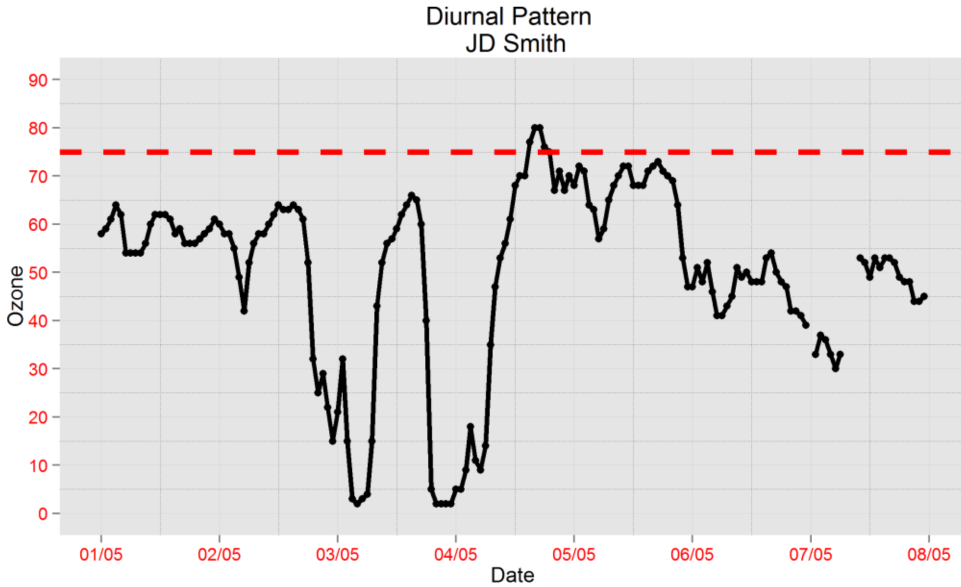


Figure 3-4. Diurnal Cycle for J.D. Smith.

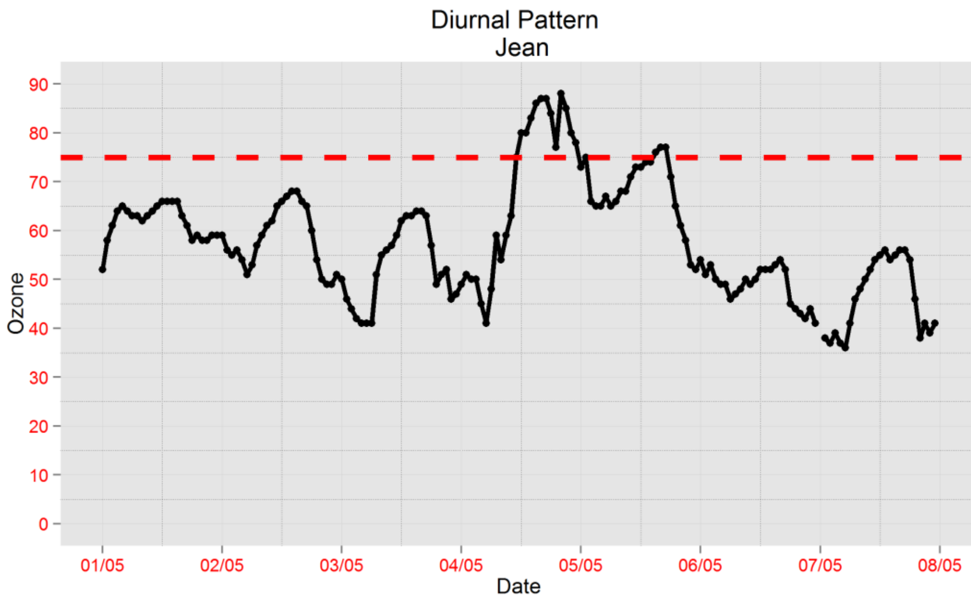


Figure 3-5. Diurnal Cycle for Jean.

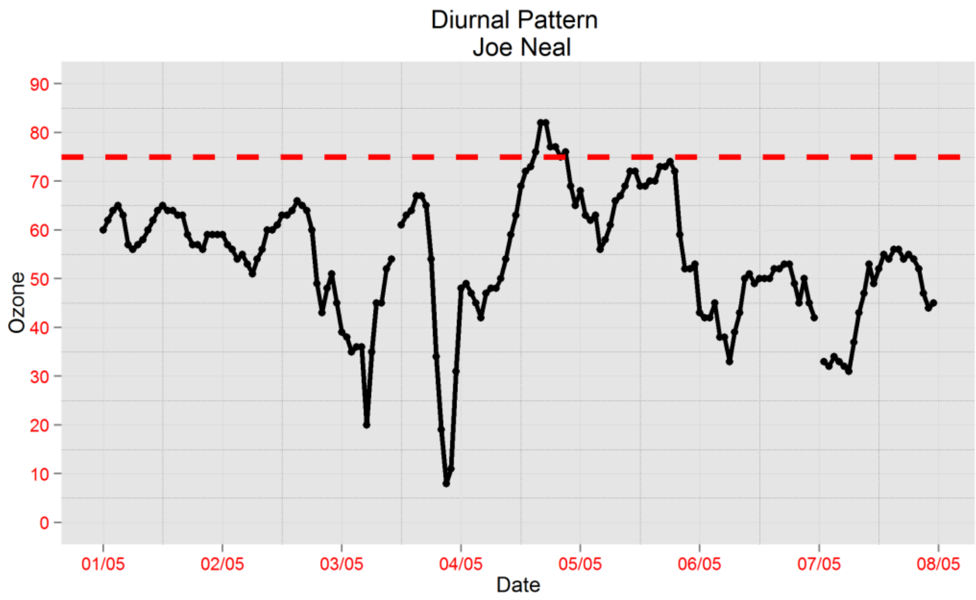


Figure 3-6. Diurnal Cycle for Joe Neal.

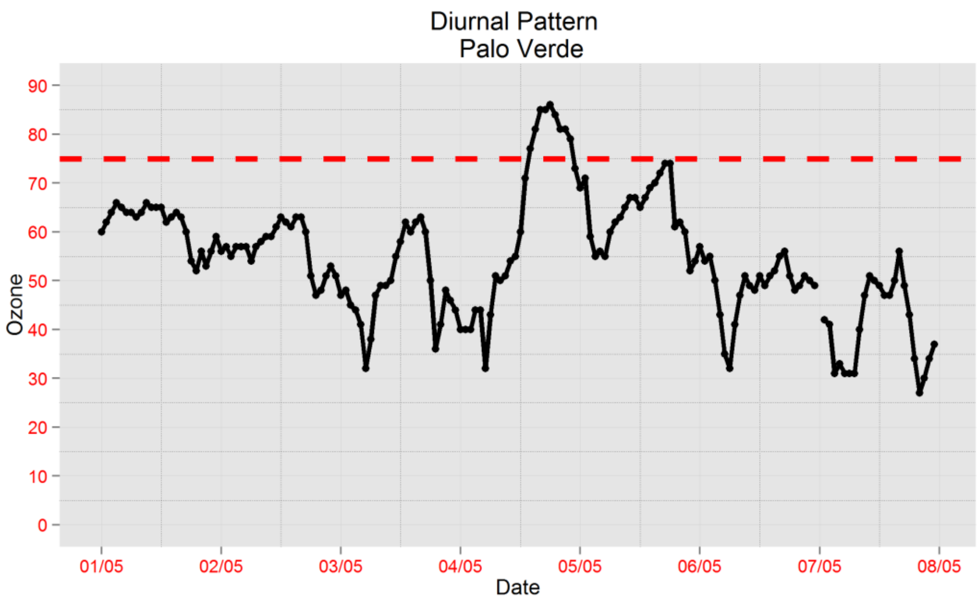


Figure 3-7. Diurnal Cycle for Palo Verde.

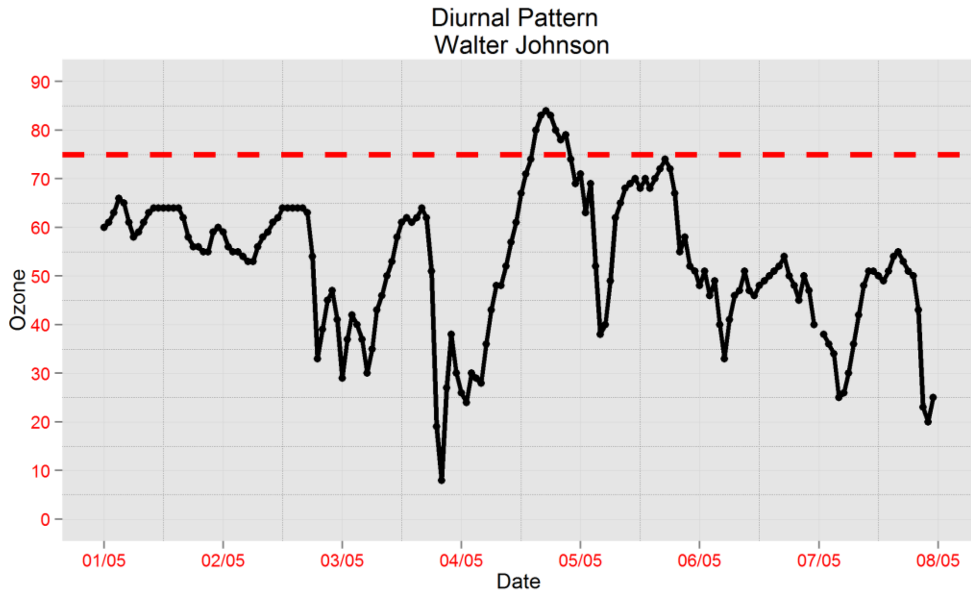


Figure 3-8. Diurnal Cycle for Walter Johnson.

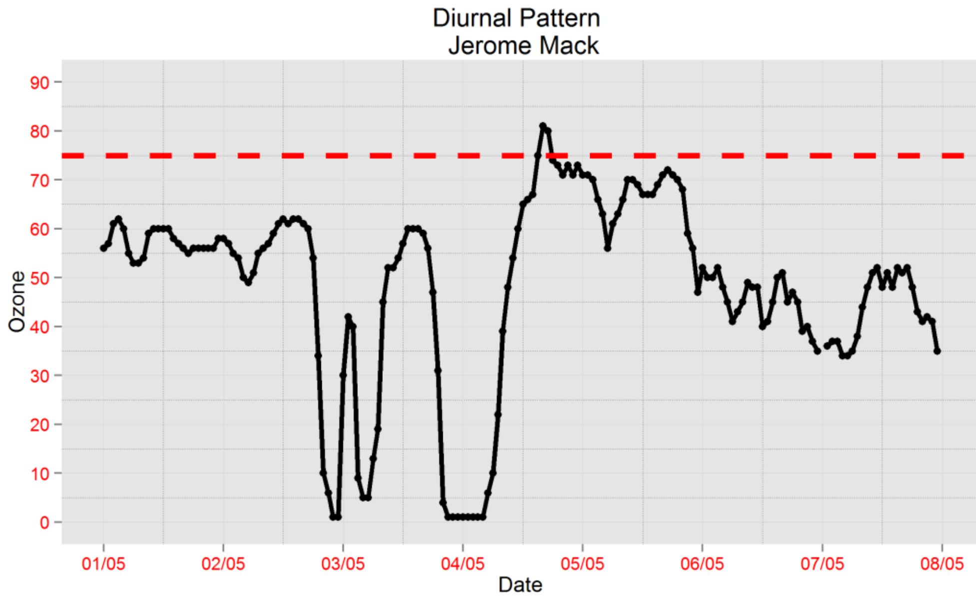


Figure 3-9. Diurnal Cycle for Jerome Mack.

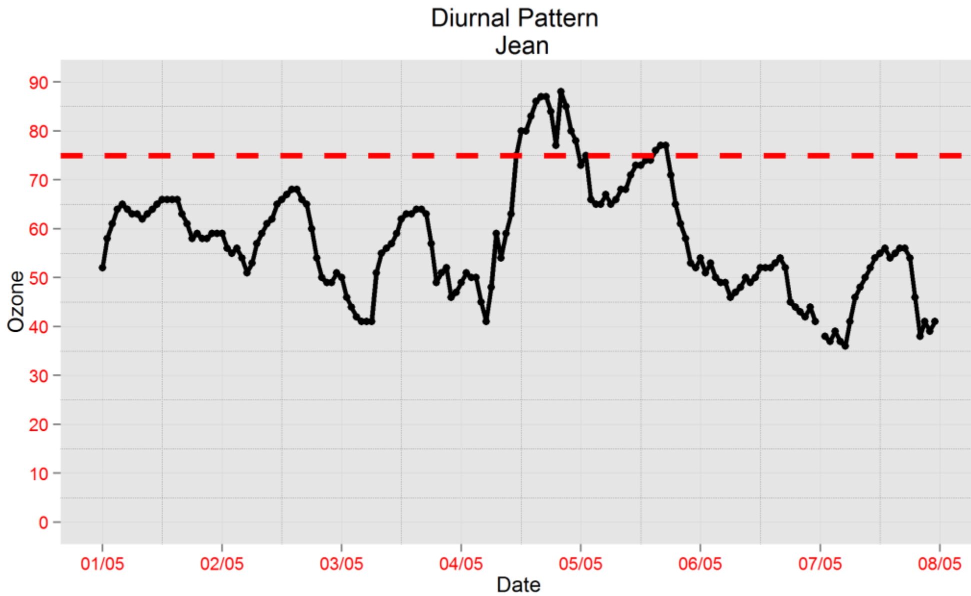


Figure 3-10. Diurnal Cycle for Jean.

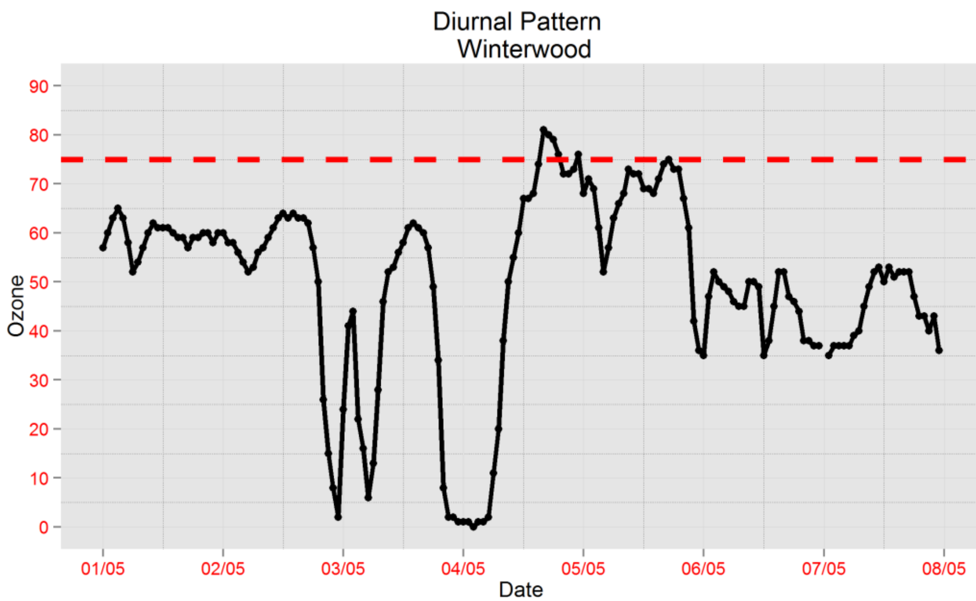


Figure 3-11. Diurnal Cycle for Winterwood.

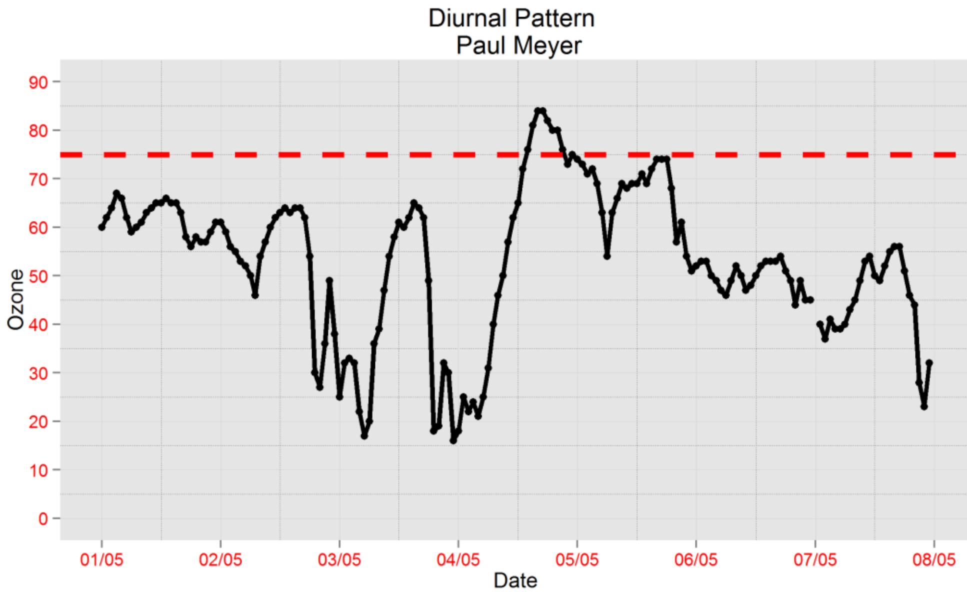


Figure 3-12. Diurnal Cycle for Paul Meyer.

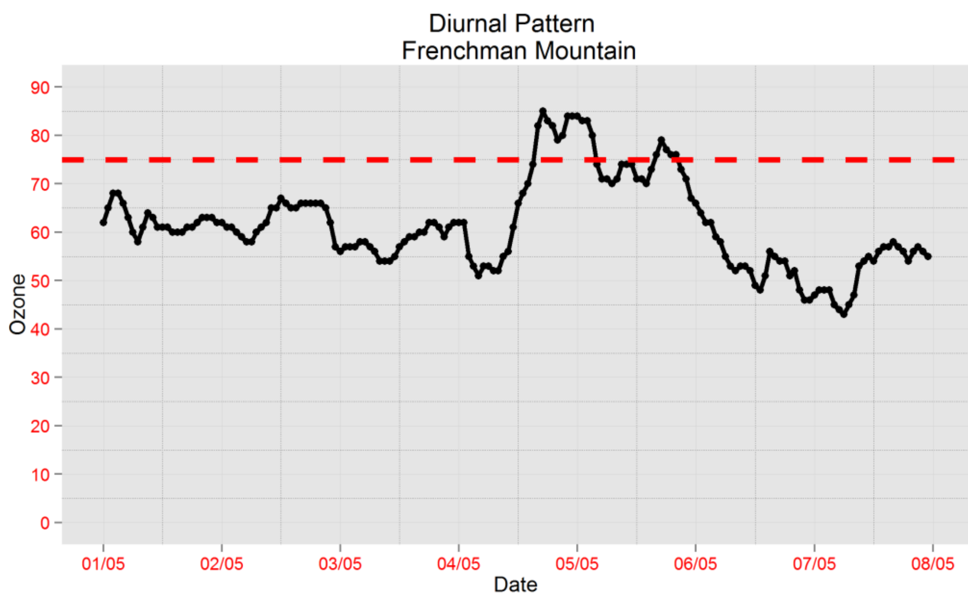


Figure 3-13. Diurnal Cycle for Frenchman Mountain.

To further illustrate that ozone concentrations on May 4 were due to an exceptional event, $PM_{2.5}$, CO, and O_3 concentrations were compared before, during, and after the event. The data show the relationship between the different pollutants; this provides strong evidence that the elevated concentrations were due to the smoke from the wildfire, since these pollutants are the products of combustion. Figures 3-14 and 3-15 show the normalized time series for O_3, CO, and $PM_{2.5}$ levels at the J.D. Smith and Jerome Mack stations. All values were elevated on May 3 and 4, and remained high through the evening of May 4 (Saturday). There was even residual $PM_{2.5}$ and O_3 on May 5.

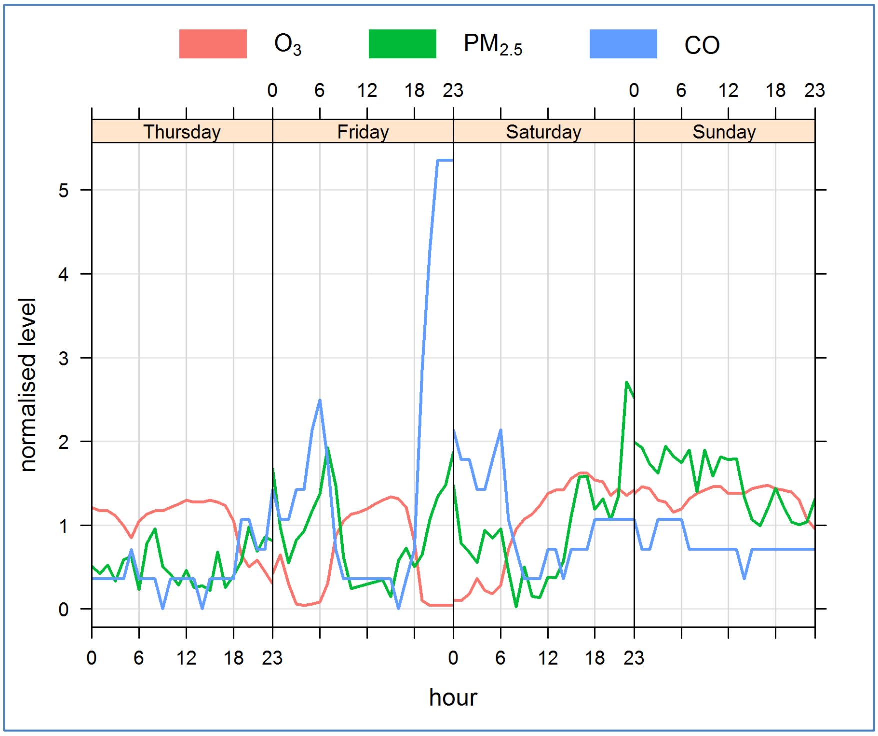


Figure 3-14. Diurnal Cycle at J.D. Smith (normalized).

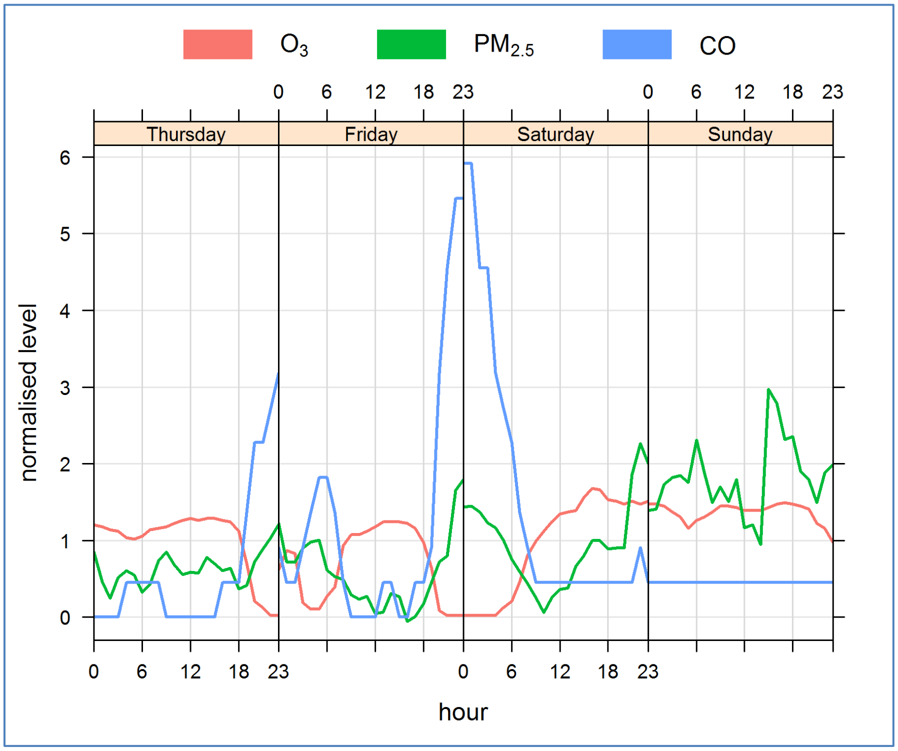


Figure 3-15. Diurnal Cycle at Jerome Mack (normalized).

Figures 3-16 and 3-17 show the relationship between O_3, $PM_{2.5,}$ and levoglucosan during the event at the Jerome Mack and Jean stations.

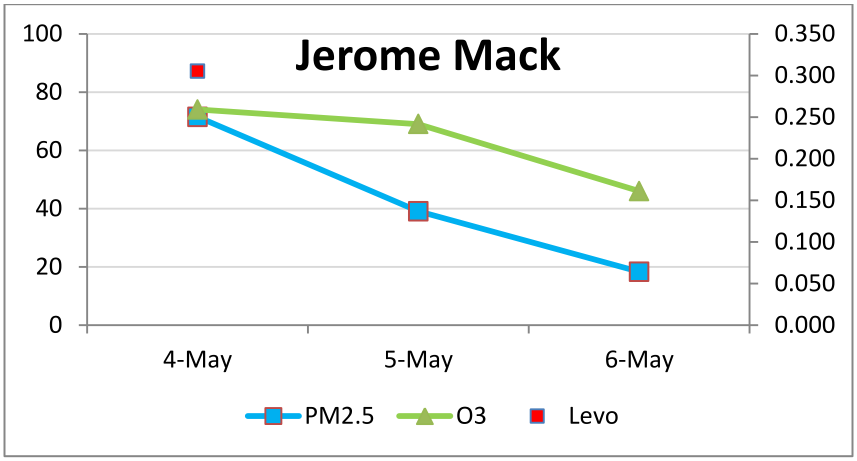


Figure 3-16. $PM_{2.5}$ and Levoglucosan Concentrations.

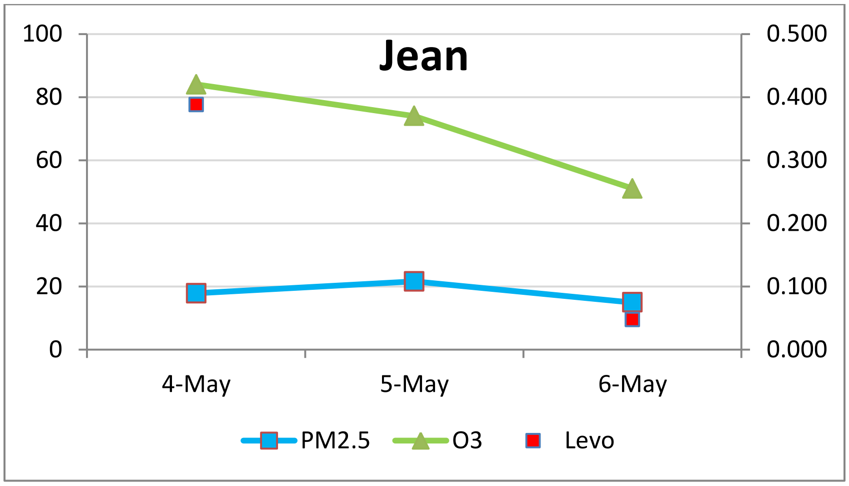


Figure 3-17. O_3 and Levoglucosan Concentrations.

At the J.D. Smith station, the O_3 and $PM_{2.5}$ concentrations indicated a strong correlation between these two pollutants.

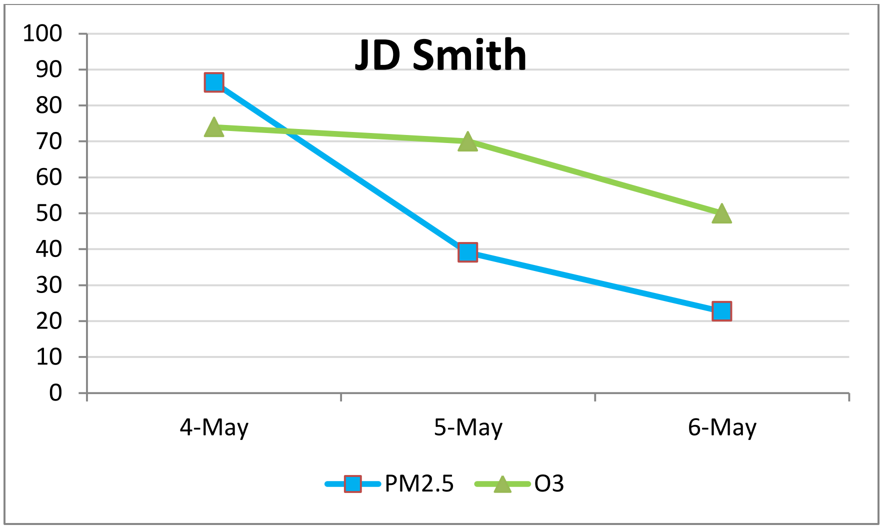


Figure 3-18. O_3 and $PM_{2.5}$ Concentrations.

Table 3-7 lists AQI values for CO, O_3, PM_{10}, and $PM_{2.5}$ from May 1–7, 2013. Figure 3-19 demonstrates how closely the AQI values for CO, O_3, and $PM_{2.5}$ tracked wildfire impacts. Concentrations of the three pollutants were elevated on wildfire days, providing strong evidence of contributions from the fire. Figure 3-20 shows the increase in pollutant concentrations during wildfire days; the concentration of O_3 increased by 81 percent, and the concentrations of CO and $PM_{2.5}$ increased by 16 and 80 percent, respectively.

Table 3-7. Pollutant AQI Values.

Date	PM_{10}	O_3	$PM_{2.5}$	CO
1-May	56	64	50	4
2-May	24	67	26	8
3-May	30	61	48	16
4-May	37	122	92	9
5-May	56	97	78	4
6-May	24	44	53	3
7-May	30	47	29	4

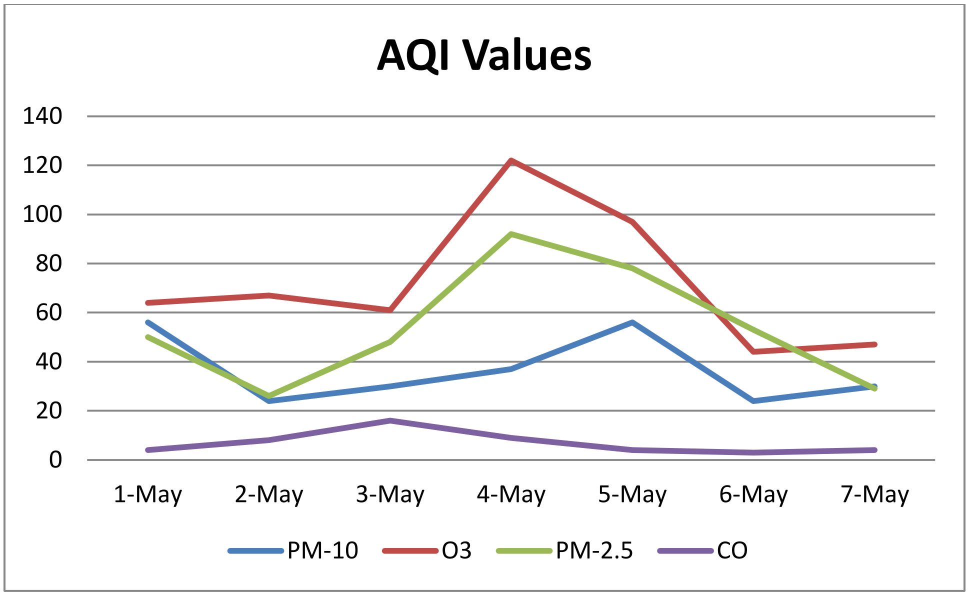


Figure 3-19. Correlation for May 1–7, 2013.

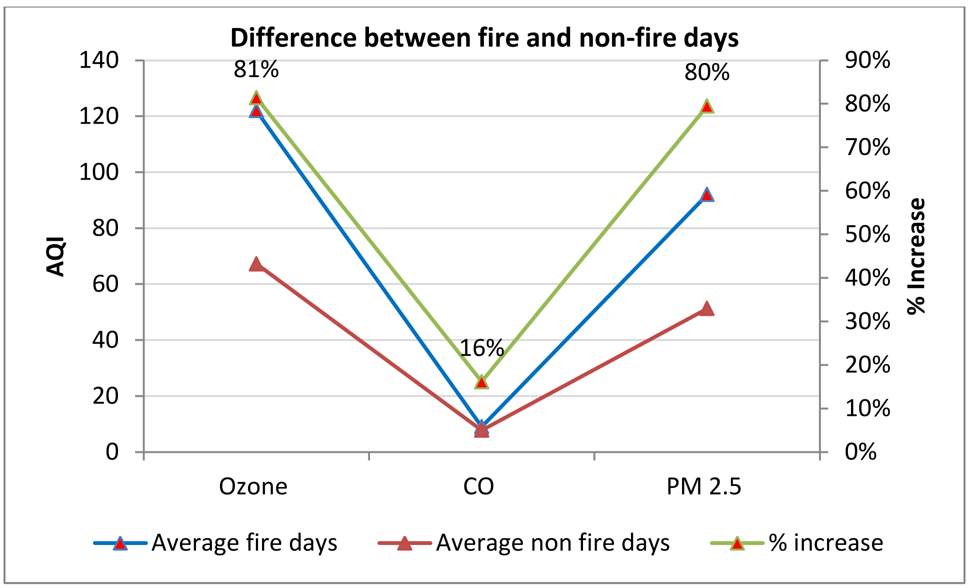


Figure 3-20. Difference in Fire and Nonfire Days.

The National Oceanic and Atmospheric Administration (NOAA) uses FLEXPART, a Lagrangian particle dispersion model with the GFS and WRF models, to produce tracer forecasts. Figure 3-21 is the model output from a run on May 4. This figure shows high CO concentrations near the Springs Fire and relatively high CO concentrations near Clark County, evidence that the plume reached the county.

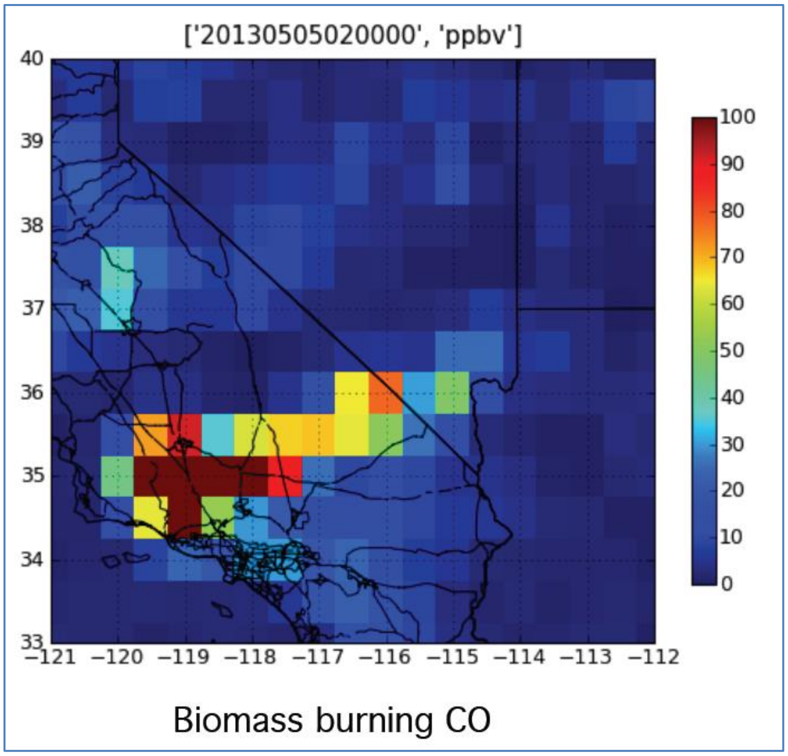


Figure 3-21. FLEXPART Output for CO on May 4, 2013.

3.3 OZONE CONCENTRATIONS RELATIVE TO HISTORICAL FLUCTUATIONS

In the EER preamble, EPA states that the magnitude of measured concentrations on days affected by an exceptional event relative to historical, temporally adjusted air quality levels can guide the level of analysis and documentation needed to demonstrate that the event affected air quality. For example, EPA acknowledges that less documentation or evidence may be required for extremely high concentrations relative to historical values (i.e., concentrations greater than the 95th percentile). This "weight of evidence" approach reflects how EPA has historically treated exceptional events.

On May 4, smoke plumes from the Springs Fire resulted in some of the highest ozone readings for the season throughout the Clark County air quality monitoring network. Hourly concentrations reached up to 88 ppb (Table 3-6) and one of the highest MDA8 readings of the season was recorded at Jean (Table 3-8), the background site.

Table 3-8. Four Highest Concentrations in 2013

Station	Highest		Second Highest		Third Highest		Fourth Highest	
	Date	Value	Date	Value	Date	Value	Date	Value
Apex	6/21/2013	**78**	4/30/2013	**74**	5/5/2013	**73**	5/4/2013	**73**
Paul Meyer	7/3/2013	**87**	5/4/2013	**80**	5/25/2013	**76**	6/21/2013	**75**
Walter Johnson	7/3/2013	**87**	5/4/2013	**80**	5/25/2013	**75**	7/19/2013	**74**
Palo Verde	7/3/2013	**83**	5/4/2013	**82**	5/25/2013	**76**	7/19/2013	**74**
Joe Neal	7/3/2013	**81**	6/21/2013	**77**	5/4/2013	**77**	7/20/2013	**76**
Winterwood	5/4/2013	**76**	6/21/2013	**75**	5/25/2013	**73**	5/21/2013	**71**
Jerome Mack	5/4/2013	**74**	5/25/2013	**73**	6/21/2013	**72**	5/21/2013	**69**
Boulder City	6/21/2013	**74**	5/22/2013	**72**	5/21/2013	**72**	6/22/2013	**71**
Jean	5/4/2013	**84**	5/21/2013	**78**	5/25/2013	**76**	6/21/2013	**75**
J.D. Smith	6/21/2013	**76**	5/25/2013	**74**	5/4/2013	**74**	6/5/2013	**72**

Ozone concentrations recorded during the wildfire event were compared to temporally adjusted air quality levels during the previous three years (2010-2012). A four-year historical analysis was considered reasonable, since attainment/non-attainment classifications are based on a three-year average; ozone concentrations before 2010 would not reflect emission control programs implemented recently.

The technical analyses provided in this document, the documentation on the location and extent of the Springs Fire, and the laboratory analysis of $PM_{2.5}$ samples that shows high concentrations of wildfire markers on May 4, 2013, together demonstrate that the elevated concentrations of ozone Clark County experienced on that day are exceptional relative to historical fluctuations and were caused by wildfire impacts.

Figures 3-22 through 3-27, which depict four years of MDA8 ozone data from five ozone monitoring sites in Clark County, show that concentrations on May 4 reflect an exceptional event. Ozone concentrations were exceptionally high in May 2012 compared with other years. Some of the high values were due to regional or international transport, such as ozone transport from Asia in the spring.

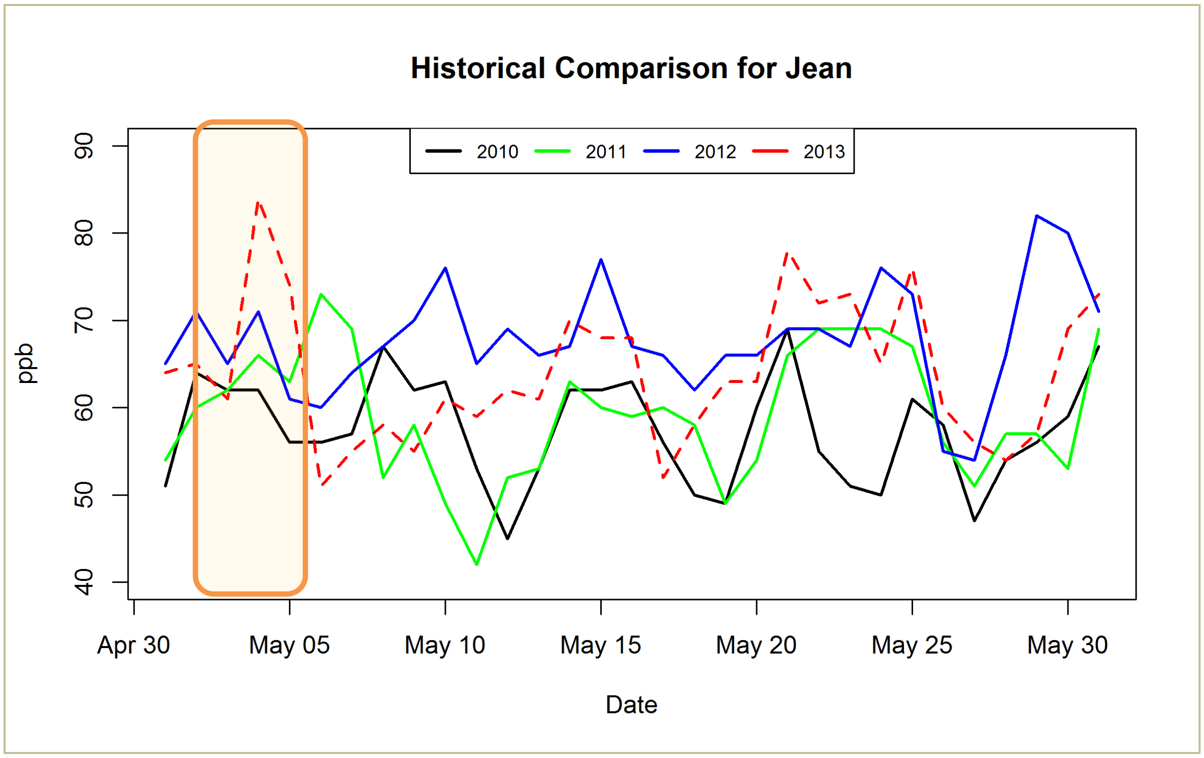


Figure 3-22. Four-Year Comparison for Jean.

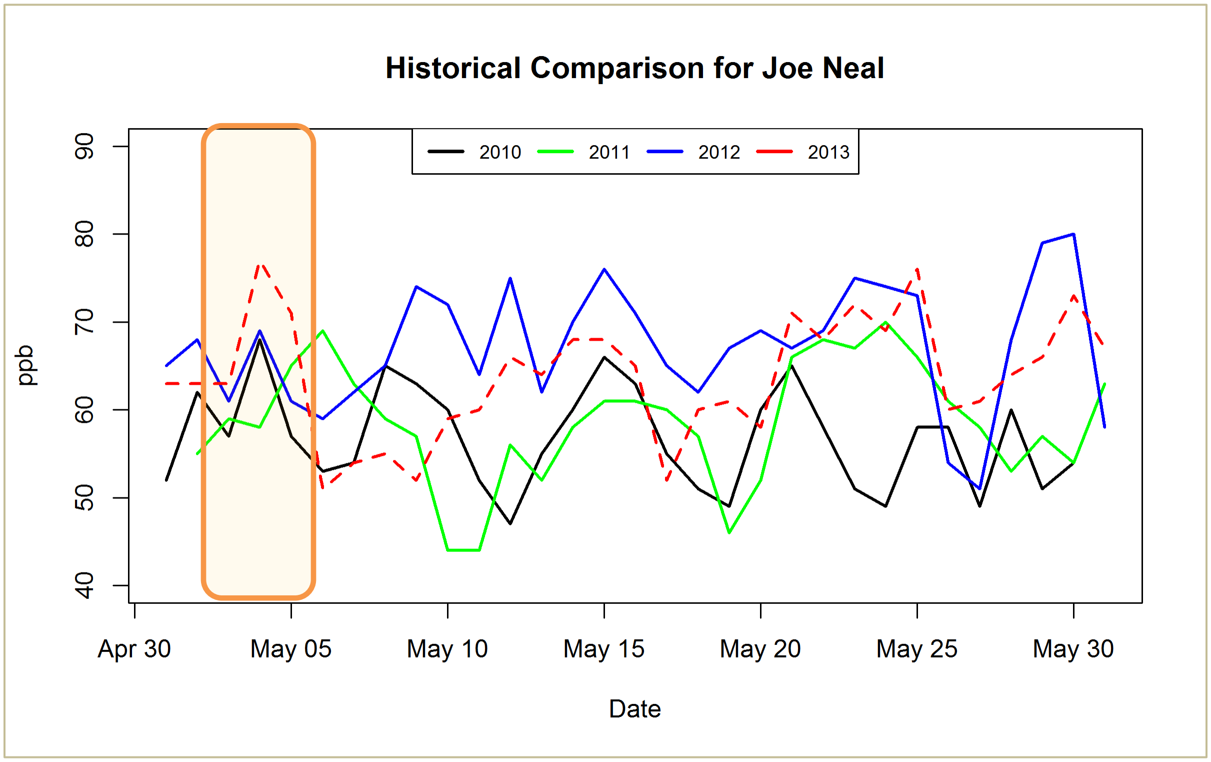


Figure 3-23. Four-Year Comparison for Joe Neal.

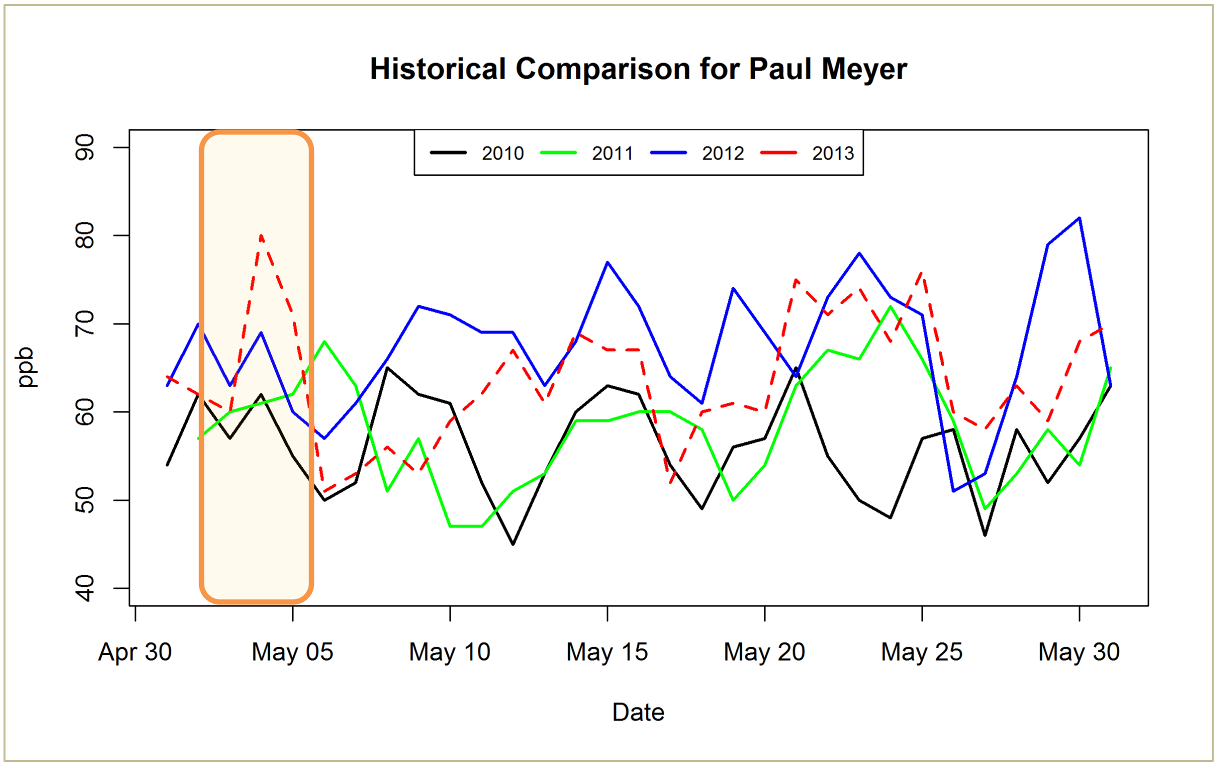


Figure 3-24. Four-Year Comparison for Paul Meyer.

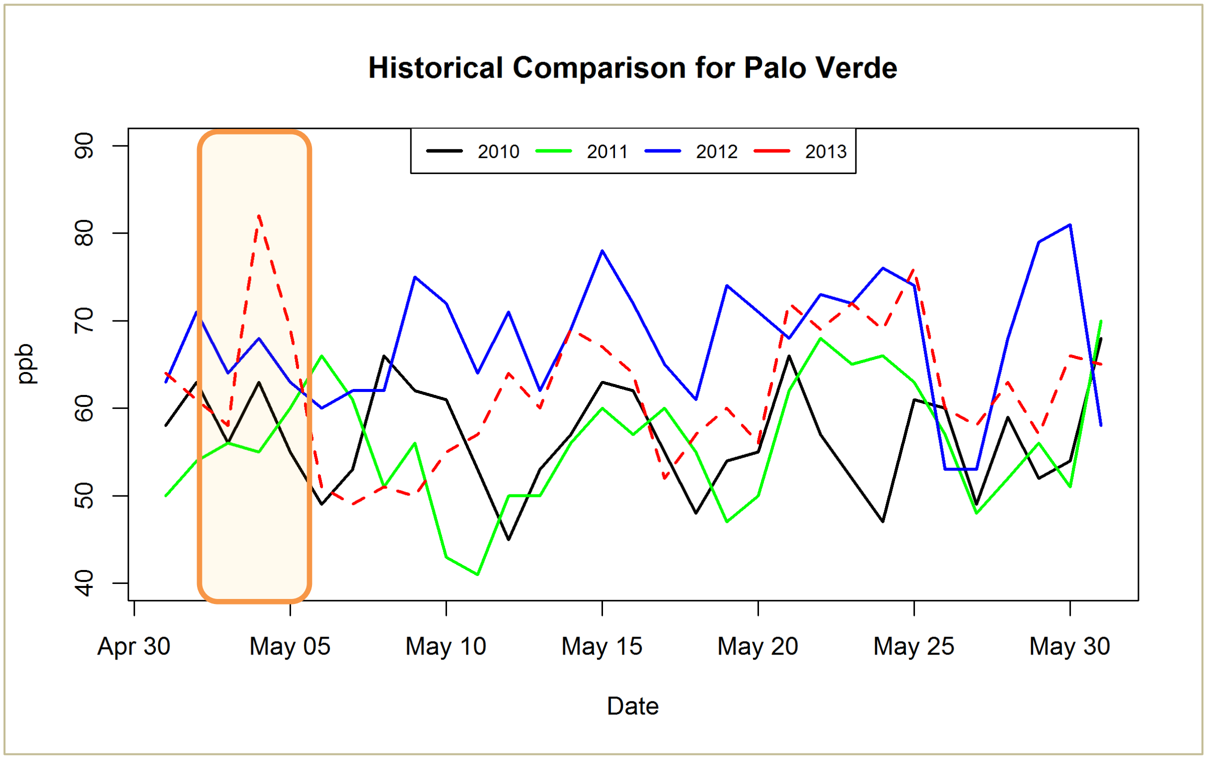


Figure 3-25. Four-Year Comparison for Palo Verde.

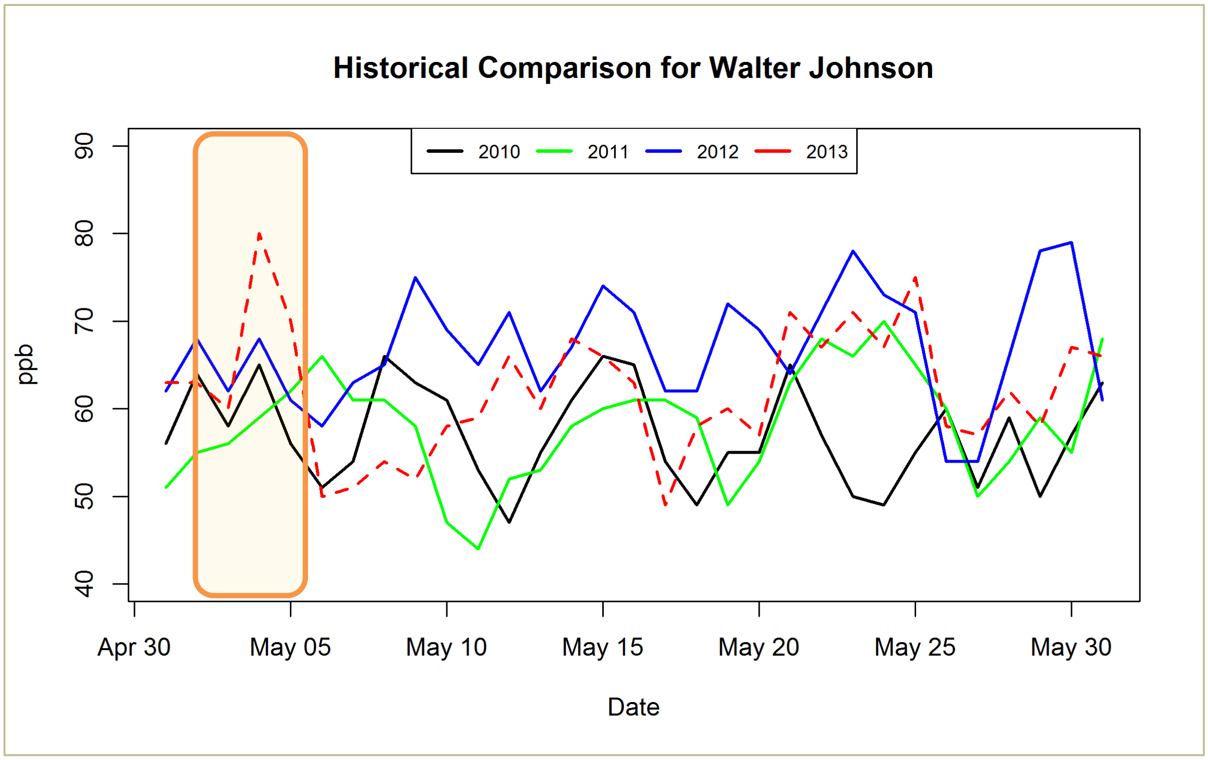


Figure 3-26. Four-Year Comparison for Walter Johnson.

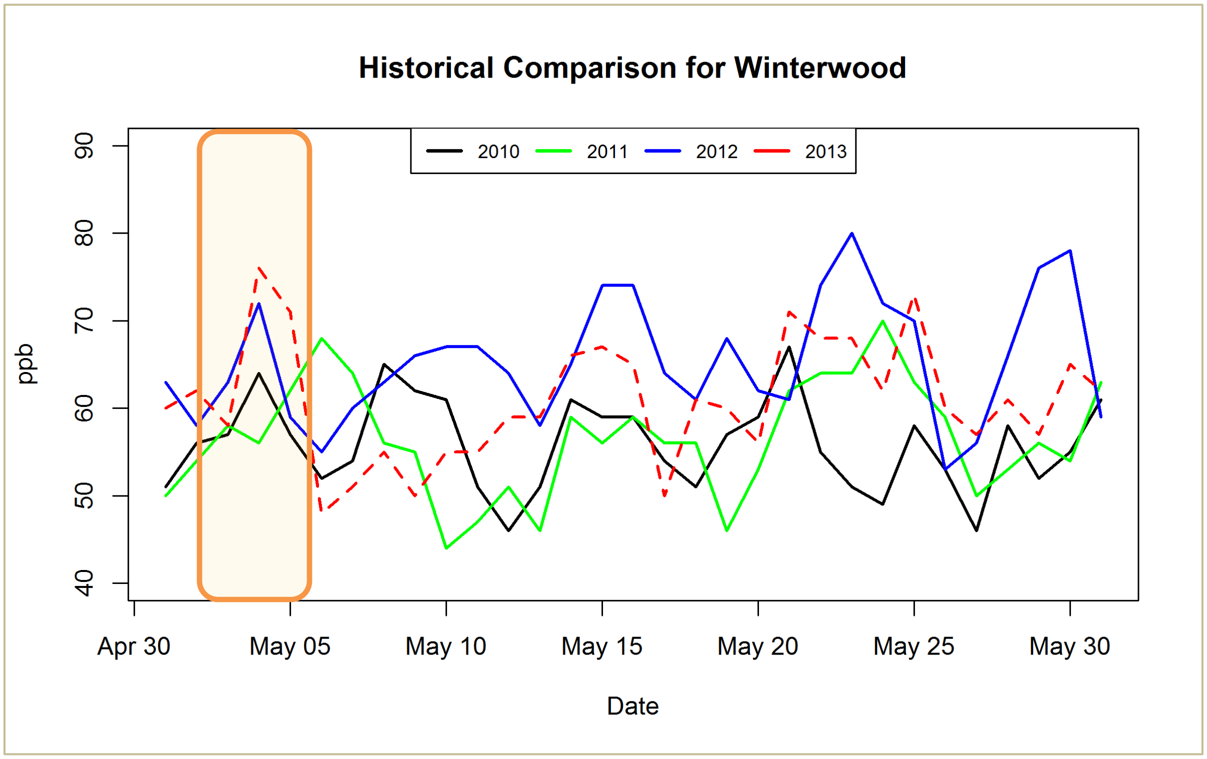


Figure 3-27. Four-Year Comparison for Winterwood.

To get a statistical perspective, average MDA8 ozone concentrations were calculated for all days in May over the three-year period of 2010–2012. These data were plotted against the MDA8 concentrations for May 2013 (Figure 3-28). The figure shows the MDA8 values for May 4 were much higher than the average of the values for the three previous years.

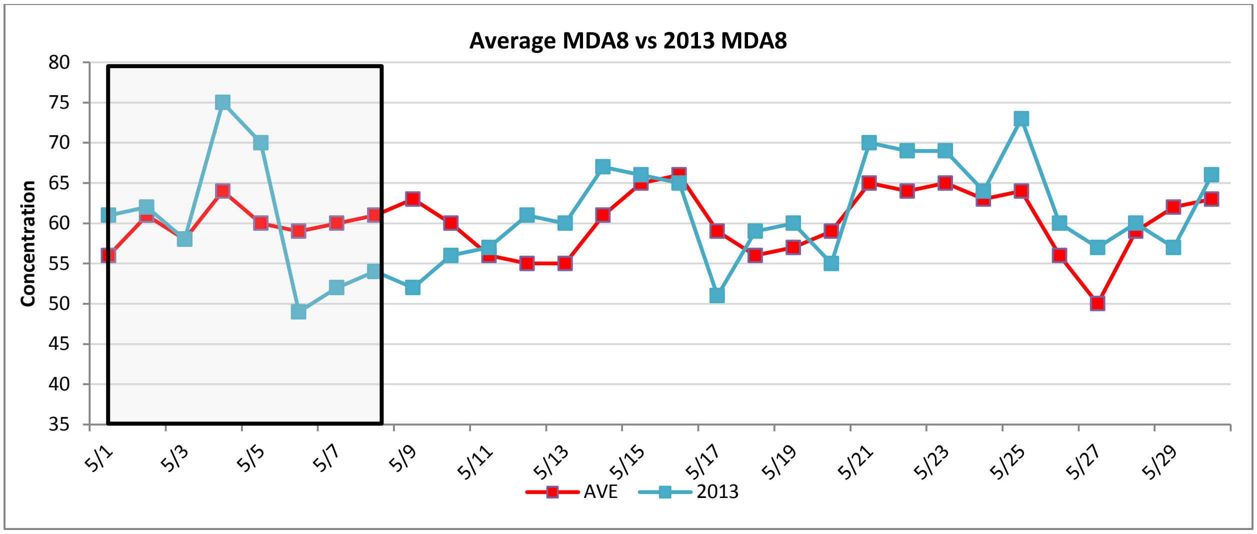


Figure 3-28. Three-Year Average vs. 2013.

During the seven-day period depicted in Figure 3-29, concentrations on May 4 were 10 ppb higher than the average on that day from 2010–2012.

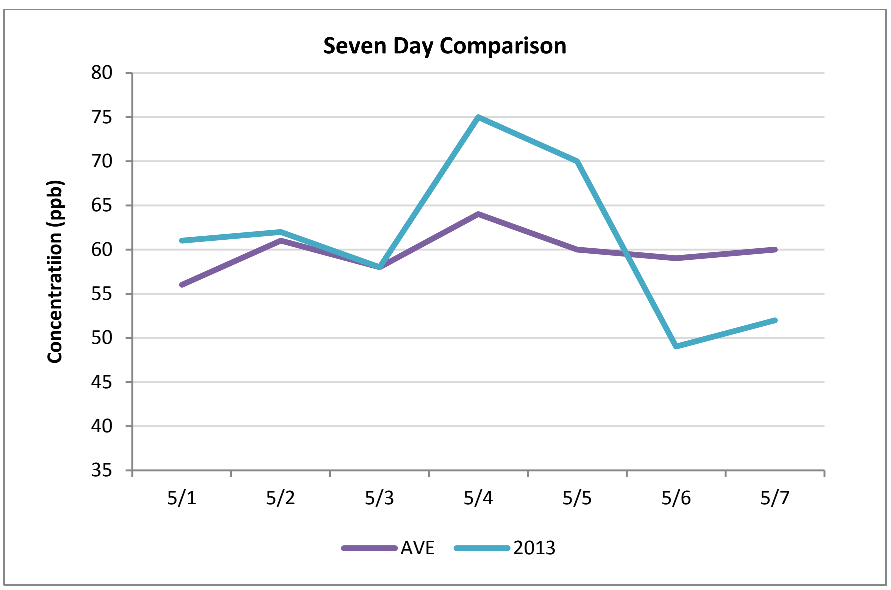


Figure 3-29. Seven-Day Period.

Figures 3-30 through 3-33 show the AQI values for O_3, $PM_{2.5}$, and CO from May 1 to May 7 of each year during a four-year period. As noted on page 3-18, the levels in some years were impacted by significant regional transport; however, O_3, $PM_{2.5}$, and CO never reached the AQI values they reached in 2013. The data show that concentrations on May 4 were exceptionally high.

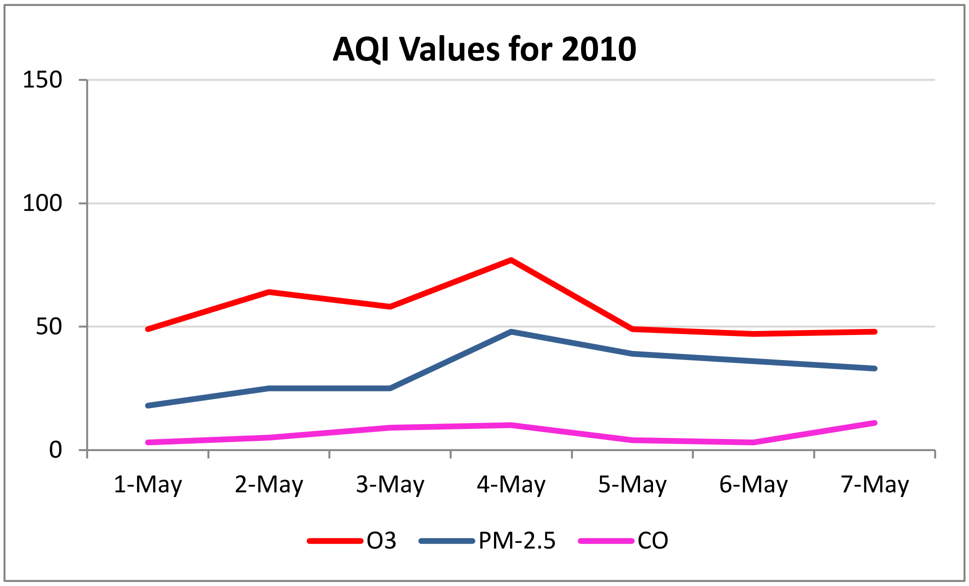


Figure 3-30. O_3, CO, and $PM_{2.5}$ Concentrations in 2010.

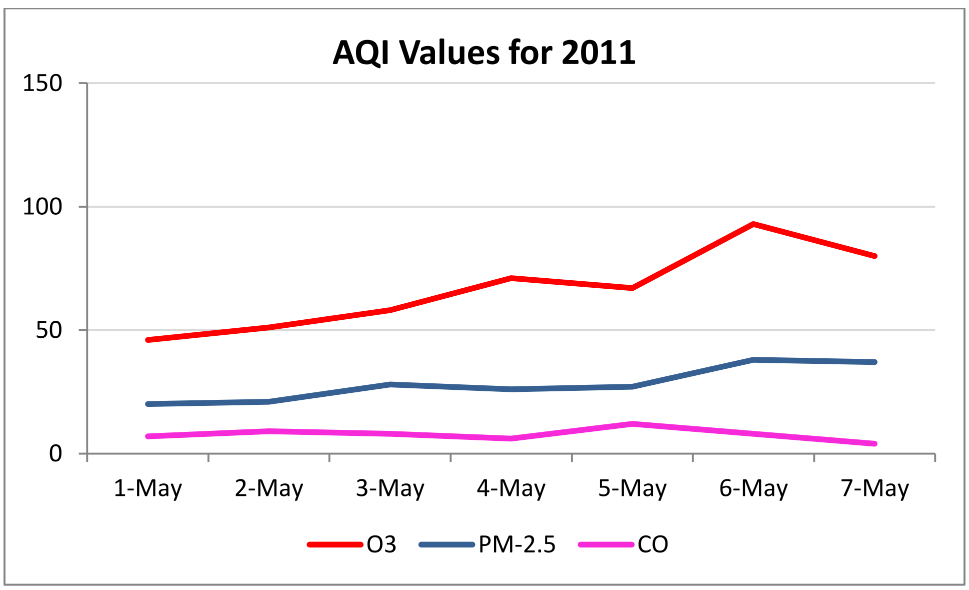


Figure 3-31. O_3, CO, and $PM_{2.5}$ Concentrations in 2011.

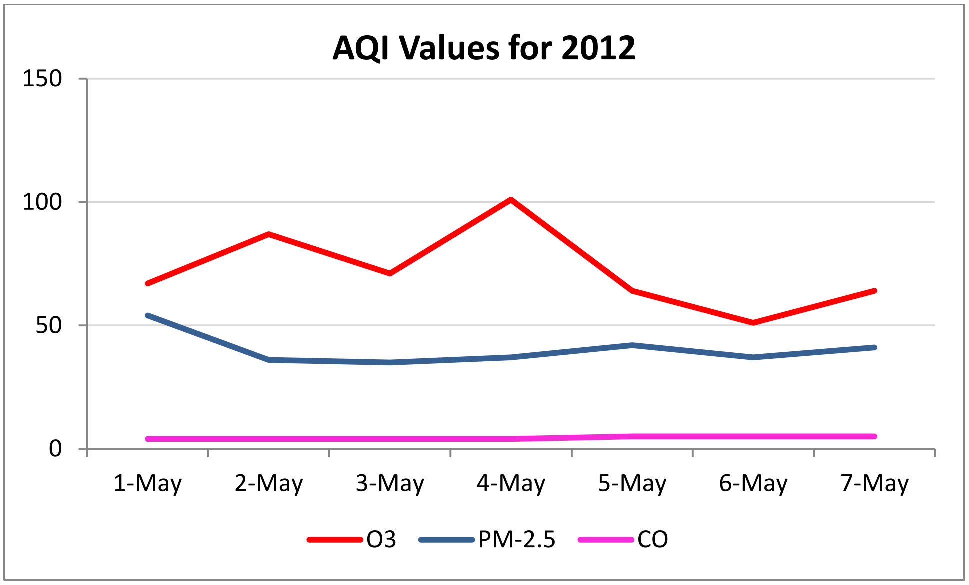


Figure 3-32. O_3, CO, and $PM_{2.5}$ Concentrations in 2012.

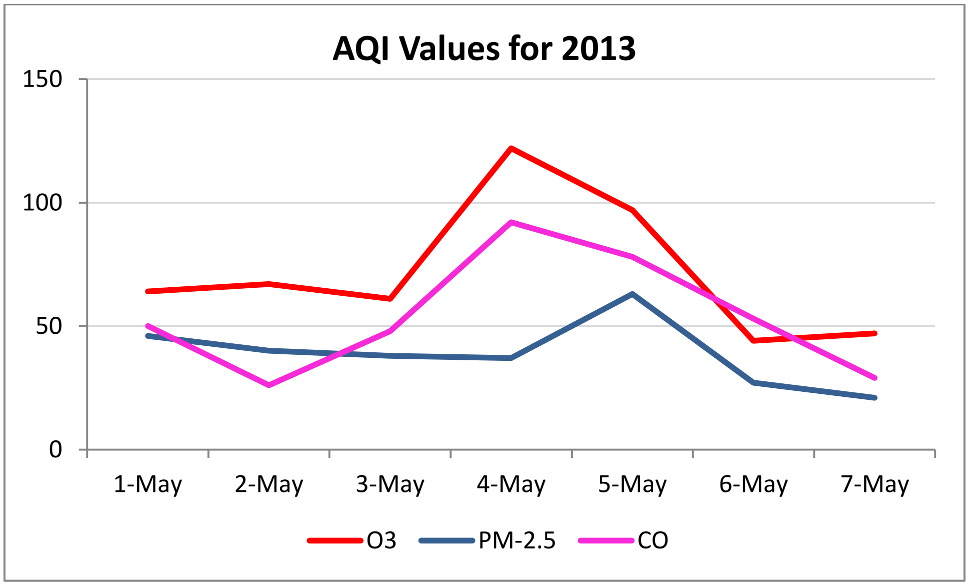


Figure 3-33. O_3, CO, and $PM_{2.5}$ Concentrations in 2013.

4.0 THE "BUT FOR" ARGUMENT

4.1 METEOROLOGICAL PARAMETERS AND VISIBILITY CAMERAS

Meteorology is an important variable affecting air quality. Weather data in Figure 4-1 show a remarkably consistent weather pattern before and after the exceptional event, when wind patterns maintained smoke plume impacts in southern Nevada during the wildfire episode. Local anthropogenic emissions of ozone precursor pollutants did not exceed normal weekday or weekend levels. The difference during this period is the accumulation of the wildfire smoke plume, exacerbating ozone concentrations in Clark County.

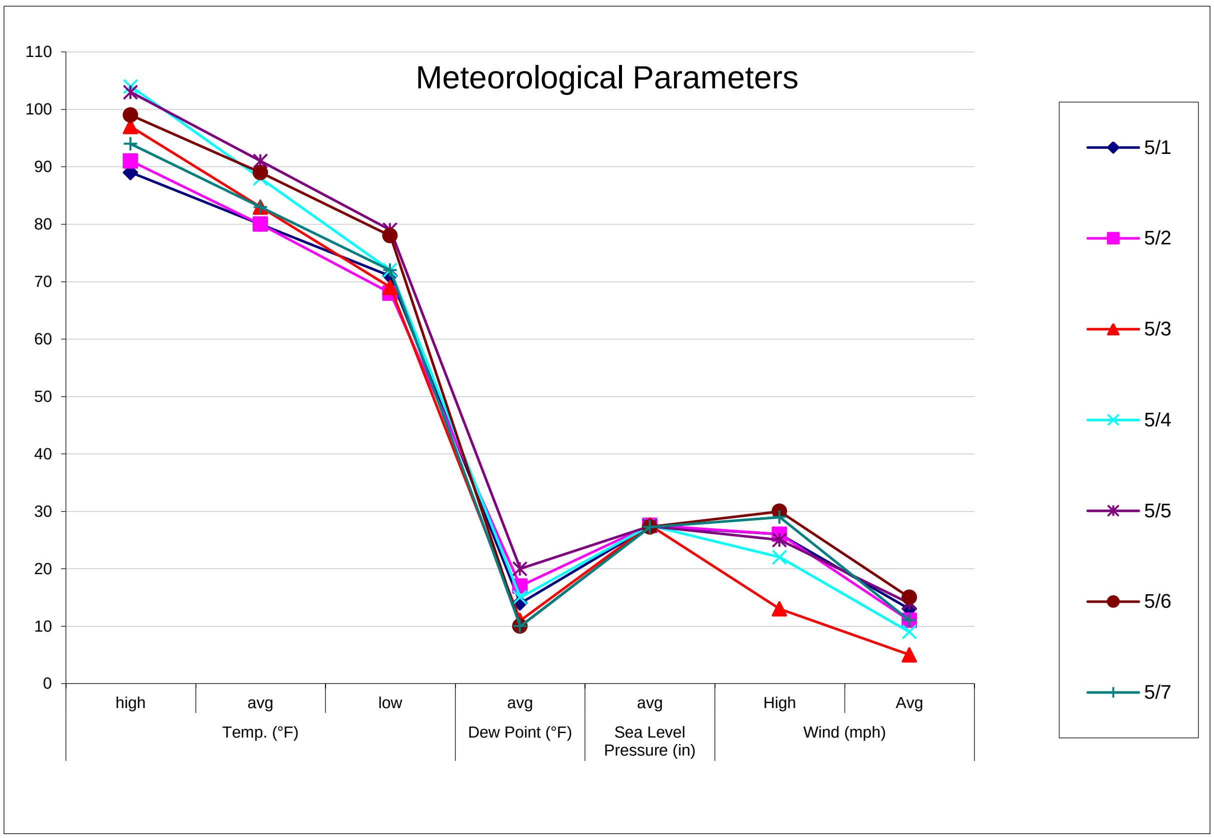


Figure 4-1. Weather Data for May 1–7, 2013.

Documentation in previous sections shows that the ozone exceedances on May 4, 2013, would not have occurred but for the fire event in southern California. The 24-hour forward trajectory in Figure 4-2 shows the path the smoke plume took, starting in California on May 3 and ending in Clark County on May 4.

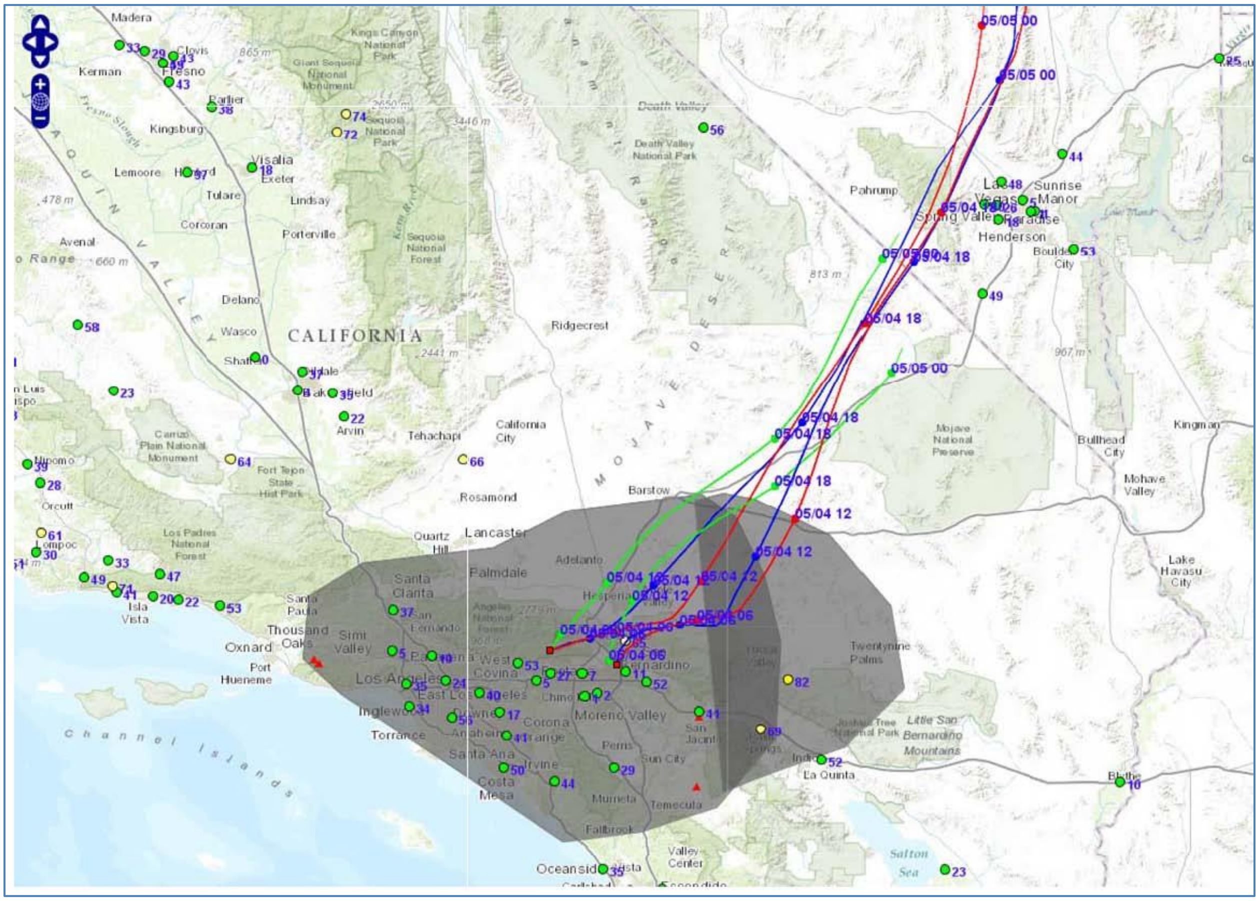


Figure 4-2. Forward Trajectory from Springs Fire area.

Visibility cameras at the North Las Vegas Airport capture pictures of the downtown area every 15 minutes. Figure 4-3 shows a picture taken on a non-fire day (May 14) at 1800 in which landmarks like Desert Hills and Potosi Mountain are clearly visible. In Figures 4-4 and 4-5, taken on the afternoon of May 4, the landmarks are not nearly as visible. These pictures show the impact of the Springs Fire smoke plume.

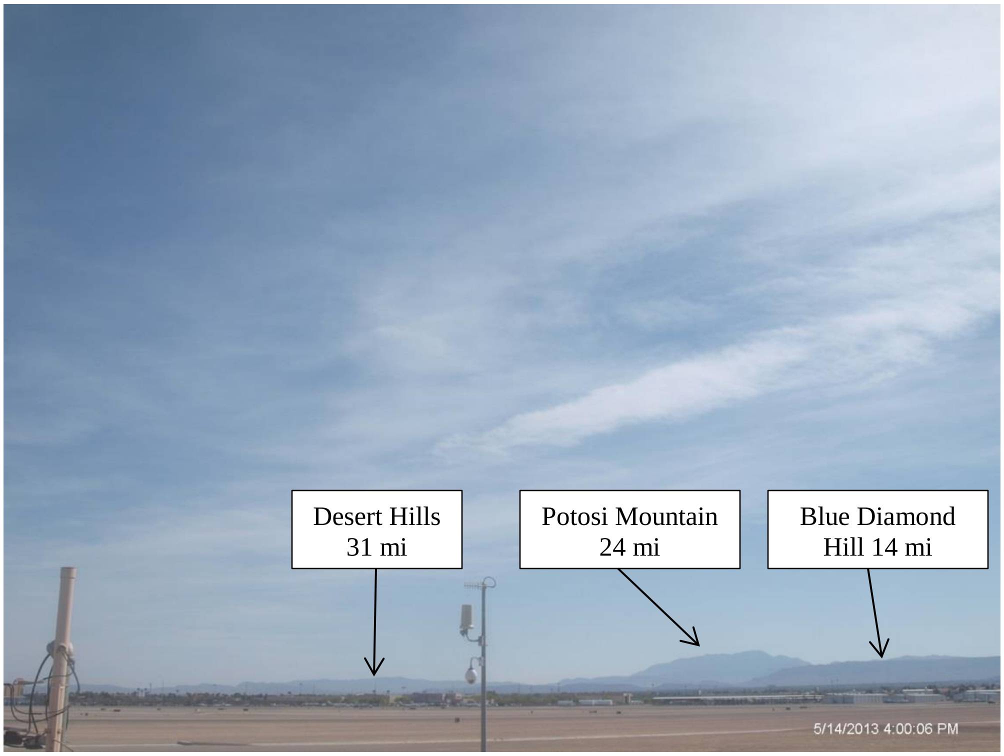


Figure 4-3. Visibility on Non-Fire Day.

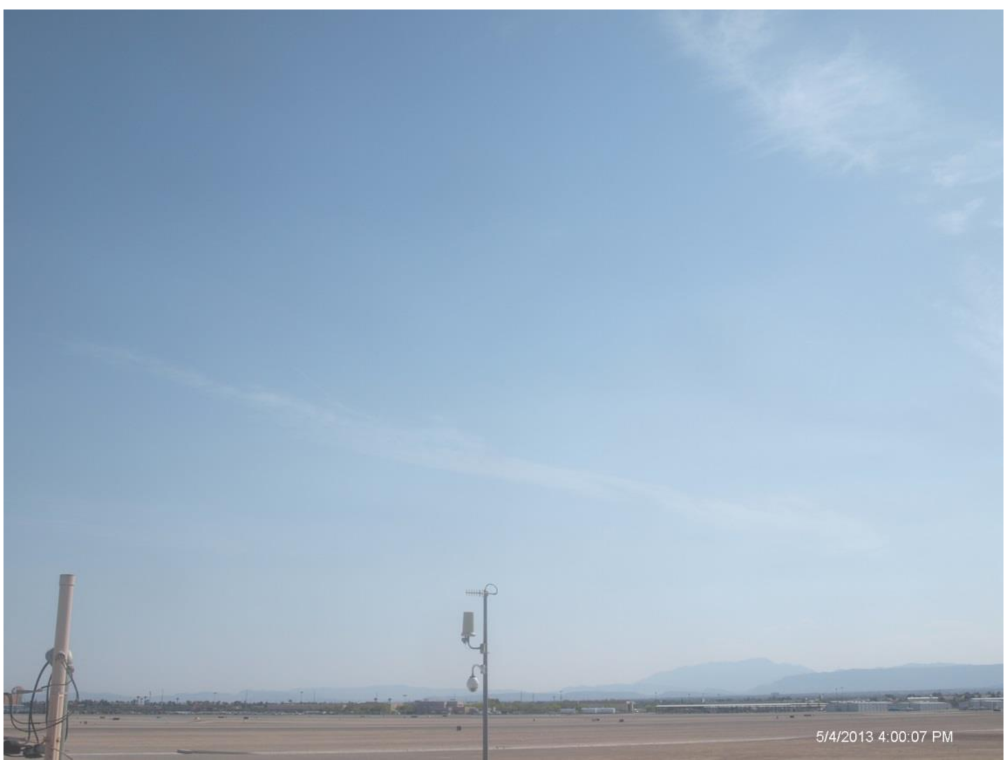


Figure 4-4. Visibility on May 4 at 16:00.

Figure 4-5. Visibility on May 4 at 18:00.

4.2 OZONE CONCENTRATION CALCULATIONS

Three methods were used to estimate ozone concentrations on May 4. Average concentrations are estimated using prior and next-day concentrations. Interpolation is a numerical analysis that creates new data points in a set of data. Lastly, the regression model predicts concentrations using a set of specific meteorological parameters.

4.2.1 Average Concentrations

In this method, the average daily ozone concentration is calculated for each monitoring site from May 2–6, excluding May 4. This average is then applied as a reasonable surrogate for what would have occurred on May 4 with consistent weather patterns and normal anthropogenic local emissions, but without smoke impacts. Table 4-1 provides the average calculated concentration for May 4. Under this approach, average ozone concentrations for the exceptional event day vary from 55–62 ppb throughout the monitoring network.

Table 4-1. Calculated O_3 Averages for May 4, 2013

Date	AP	MS	PM	WJ	PV	JO	WW	JM	BC	JN	JD
2-May	65	57	62	63	61	63	62	61	62	65	62
3-May	59	50	60	60	58	63	58	57	57	61	61
4-May	62	55	61	60	59	62	59	58	60	62	60
5-May	73	65	71	70	69	71	71	69	71	74	70
6-May	52	49	51	50	51	51	48	46	50	51	50

4.2.2 Interpolation

Interpolation is a method of constructing new data points within the range of a set of known data points. In this application, the data points for May 4 were assumed to be missing and linear interpolation was used to estimate their values. Table 4-2 shows this method yields a minimum concentration of 58 ppb and a maximum concentration of 68 ppb.

Table 4-2. Interpolated Values

Date	AP	MS	PM	WJ	PV	JO	WW	JM	BC	JN	JD
3-May	59	50	60	60	58	63	58	57	57	61	61
4-May	66	58	66	65	64	67	65	63	64	68	66
5-May	73	65	71	70	69	71	71	69	71	74	70

4.2.3 Regression Model

The third method explored was the use of a statistical regression model to predict ozone levels during the days of the exceptional event. An EPA statistical model was used as the initial framework for a generalized additive model, in which the sum of the functions of various predictor variables is used to predict daily maximum 8-hour ozone concentrations. The model does not assume that peak ozone is a linear function of each predictor; rather, it uses natural splines to model the functional dependence of ozone on predictor variables other than “day of week” and “year.” The original EPA model was modified through an iterative process to reflect local conditions in Clark County.

DAQ used EPA’s Omnibus Meteorological Data Set and the daily peak 8-hour ozone values for local and upwind areas in the Las Vegas Valley over five summer months between 2004 and 2008 that had no suspected wildfire days to develop a statistical model to identify wildfire events and study their relationship to high ozone episodes.

In general, trajectories should not be interpreted as accurate tracks of air parcels entering the specific area; however, patterns that emerge when analyzing a relatively large number of trajectories should provide a good indication of potential transport due to a prevailing large-scale flow regime. Using the back-trajectories in the Las Vegas Valley with the cluster analysis of the HYSPLIT model, seven clusters were calculated. A statistical model was then developed for each cluster by using polynomial regression equations with meteorological predictors and observed peak ozone mixing ratios. For a specific date, the predicted peak 8-hour ozone mixing ratio is calculated based on its predictors and assigned cluster.

4.2.3.1 Application to the Event

After carefully examining the backward trajectory of May 4 and the mean backward trajectory of each cluster, Cluster 2 was selected for the May 4 fire event. Table 4-3 lists the parameters used in the model for Cluster 2. Table 4-4 shows the results of the model, the wildfire could have contributed 10 ppb to the ozone concentration.

Table 4-3. Regression Model Parameters

Previous-day peak 8-hour O_3 in Clark County
Previous-day 8-hour O_3 in northern NV
Previous-day 8-hour O_3 in the Los Angeles area
Maximum surface temperature in Clark County
Average morning (7–10 a.m. LST) wind speed in Clark County
Average afternoon (1–4 p.m. LST) wind speed in Clark County
Morning (~1200 UTC) temperature at 850 mb (surface temperature)
Maximum mixing height (4 a.m.-4 p.m. LST)

Table 4-4. Regression Model Results

Date	Peak 8-hour O_3 (ppb)	Predicted Peak 8-hour O_3 (ppb)[1]	Predicted Wildfire Effect (ppb)
5/4/2013	84.9	74.57	10.33

4.3 SATELLITE IMAGERY

4.3.1 Aerosol Optical Depth and Aerosol Optical Thickness[2]

Optical measurements of light extinction can be used to represent aerosol content in the entire column of the atmosphere. This aerosol optical depth (AOD) expresses the quantity of light removed from a beam by scattering or absorption during its path through a medium (AOD is a unitless quantity). Aerosol Optical Thickness (AOT) is the degree to which aerosols prevent the transmission of light by absorption or scattering of light.

[2] http://disc.sci.gsfc.nasa.gov/giovanni/.

Table 4-5. AOD Values

Sample AOD values		Equivalent $PM_{2.5}$ values
0.02	Very clean isolated area	~ 1 μm^{-3}
0.2	Fairly clean urban area	~ 12 μm^{-3}
0.4	Somewhat polluted urban area	~ 24 μm^{-3}
0.6	Fairly polluted area	~ 36 μm^{-3}
1.5	Heavy biomass burning or dust event	~ 90 μm^{-3}

The higher the AOD value, the more polluted the area. Figure 4-6 demonstrates that the Las Vegas area AOD for May 4 was between 0.293 and 0.50, which implies the area is between fairly and somewhat polluted.

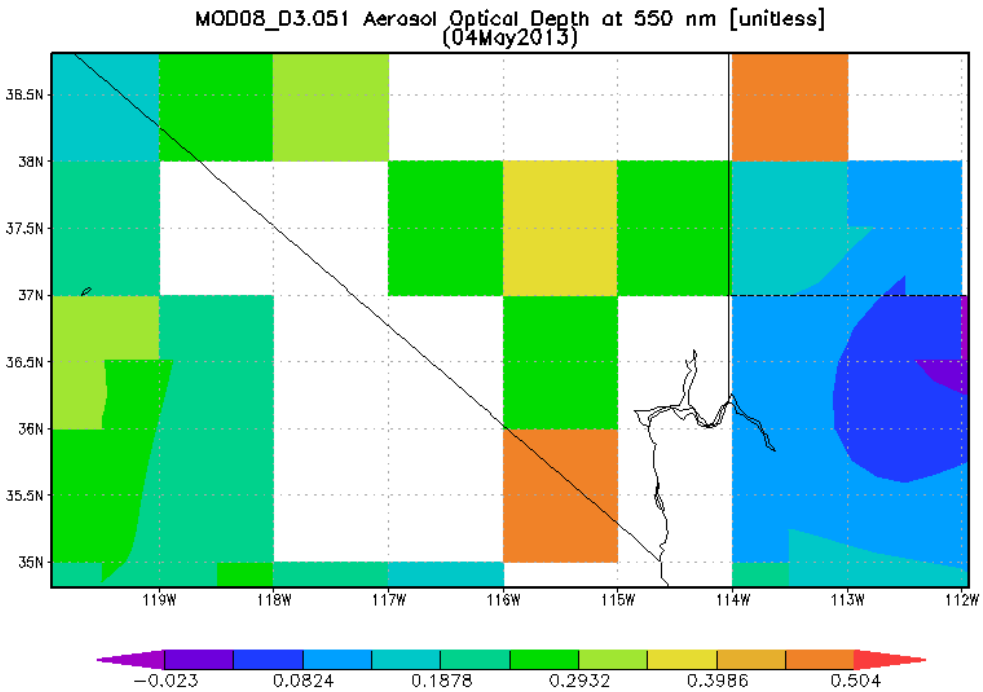


Figure 4-6. AOD for May 4.

4.3.1.1 Ultraviolet Aerosol Index

The Ultraviolet (UV) Aerosol Index represents detection of UV-absorbing aerosols, such as dust and soot. Positive values for the index generally represent absorbing aerosols (dust and smoke), while small or negative values represent nonabsorbing aerosols. Figure 4-7, the UV Aerosol Index for the Clark County area on May 4, shows there was a great deal of dust and smoke.

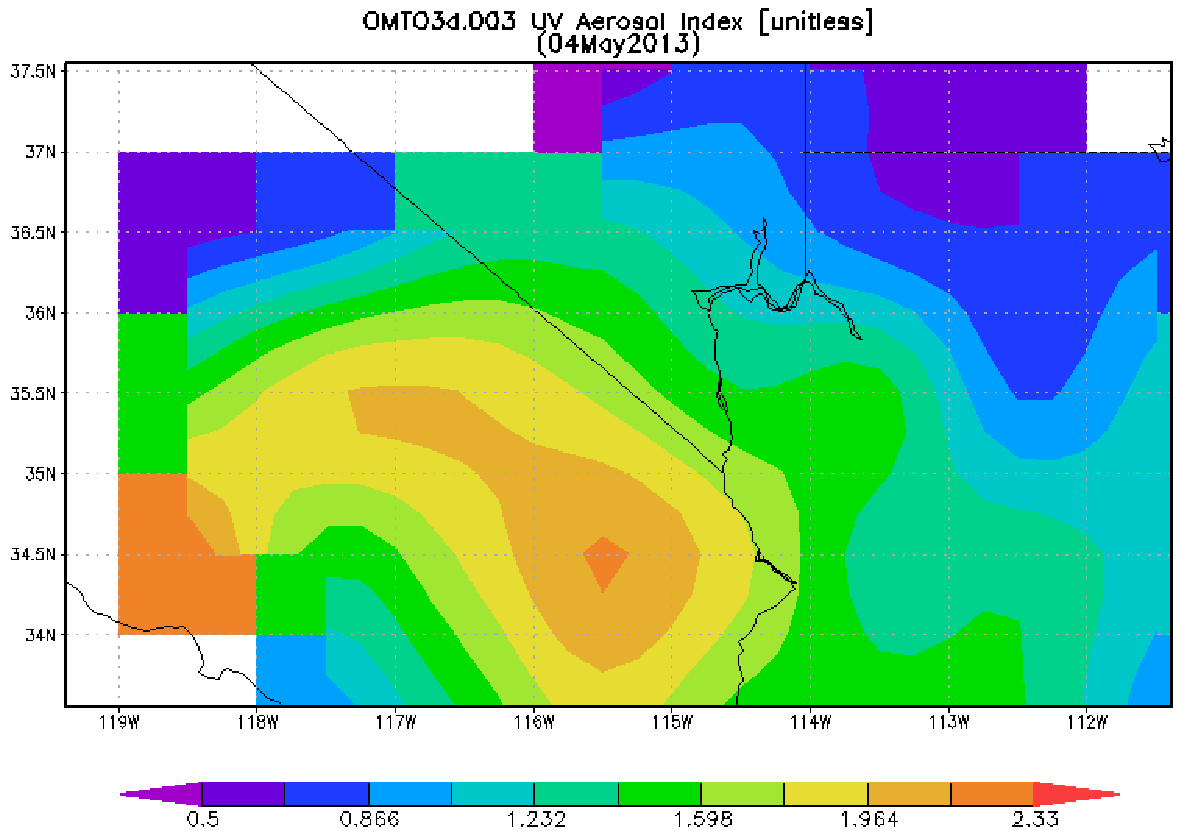


Figure 4-7. The UV Aerosol Index for May 4.

4.3.1.2 AERONET Data

The AErosol RObotic NETwork (AERONET) program is a federation of ground-based remote sensing aerosol networks established by the National Aeronautics and Space Administration and other institutions. AERONET data show the AOT for a daily or monthly time frame. The three AERONET sites in southern California and southern Nevada (Figure 4-8) were severely impacted by smoke plumes from the fire; the $PM_{2.5}$ concentrations at these three stations (Table Mountain, Frenchman Flat, and Railroad Valley) were some of the highest in the month of May.

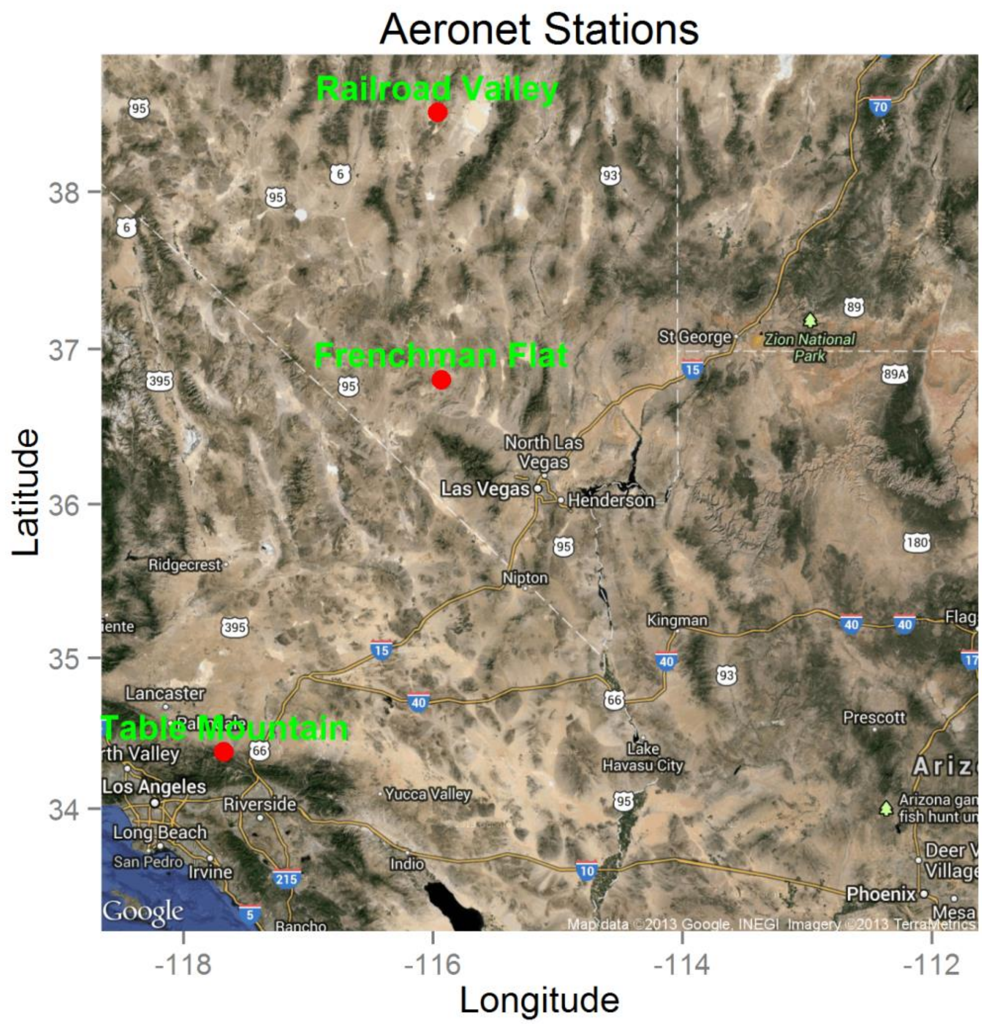


Figure 4-8. Aeronet Stations in Clark County.

Source: http://aeronet.gsfc.nasa.gov/

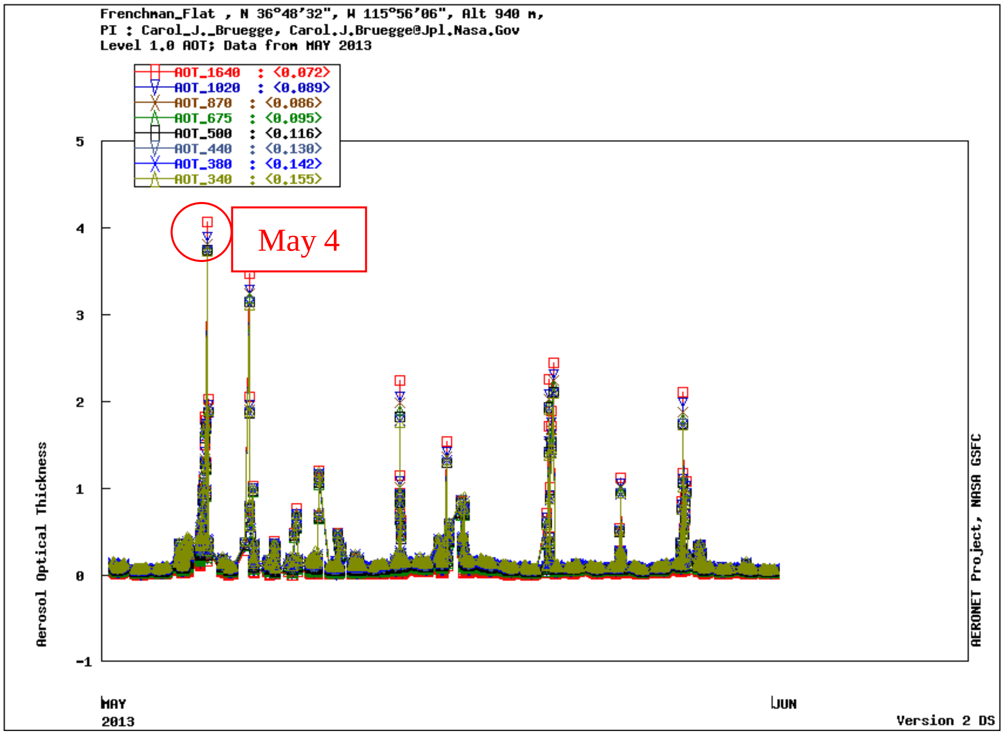


Figure 4-9. AOT for Frenchman Flat.

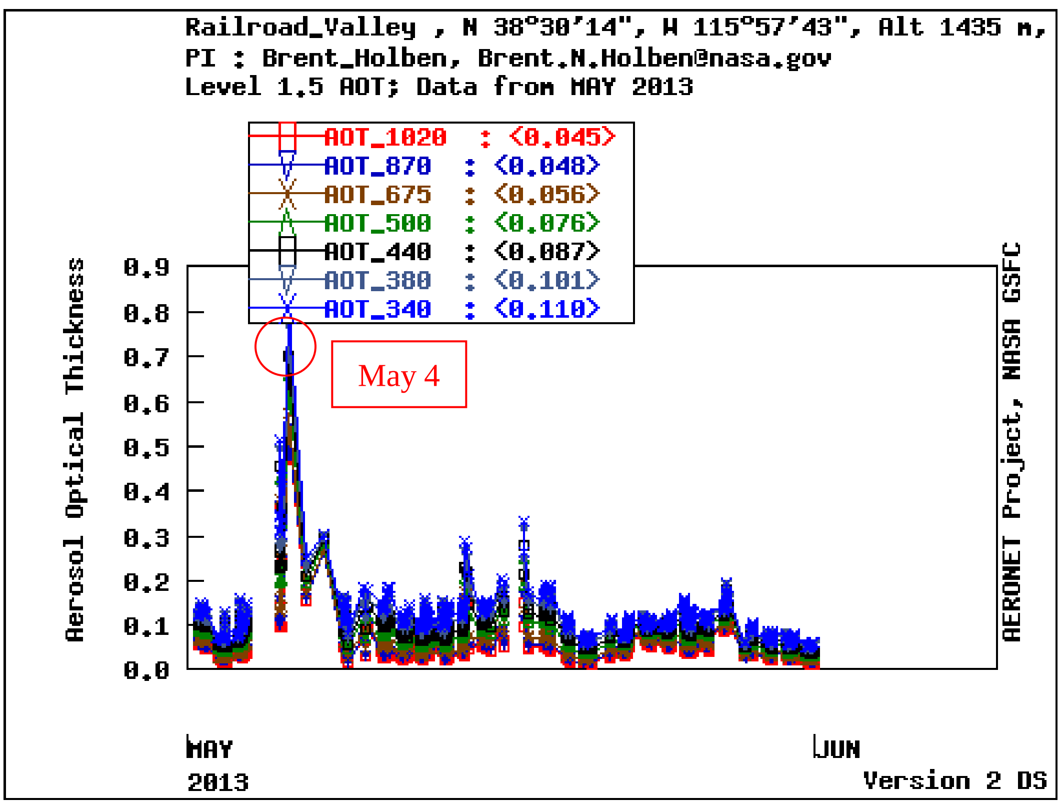


Figure 4-10. AOT for Railroad Valley.

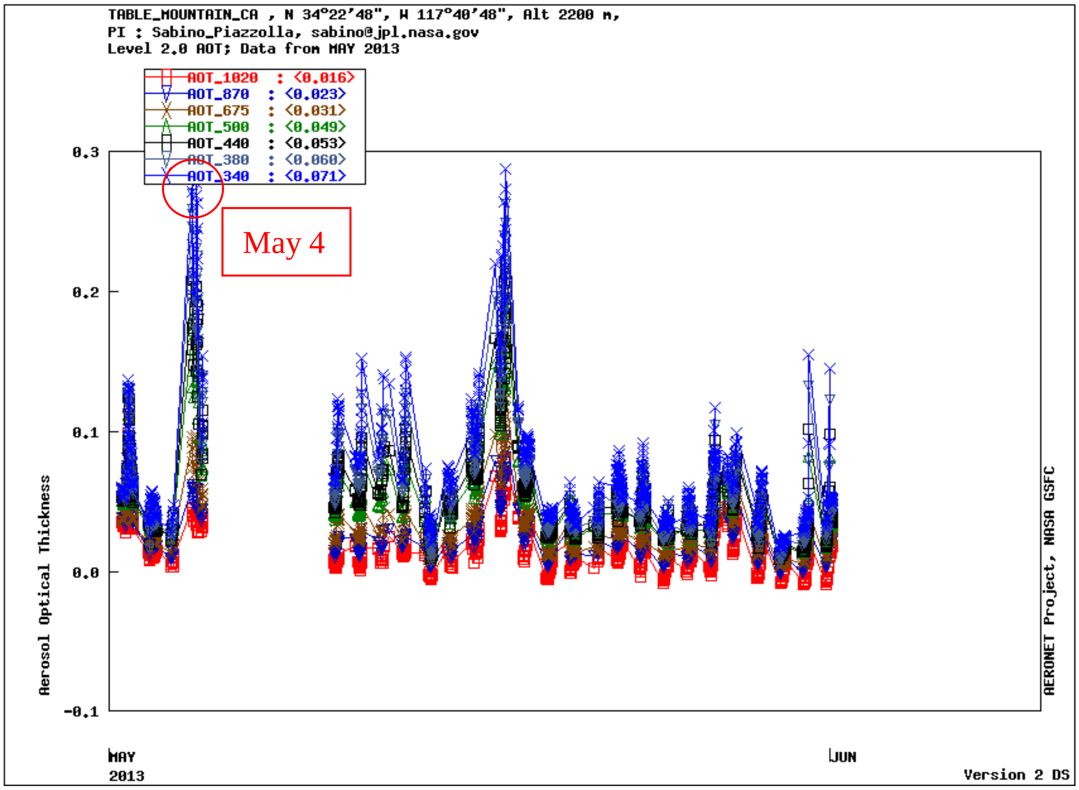


Figure 4-11. AOT for Table Mountain.

4.3.1.3 Site-Specific Time-Series and Correlations of AOD and Surface $PM_{2.5}$

The graphs in Figure 4-12 and 4-13 show AOD and $PM_{2.5}$ data from the Jean and J.D. Smith monitoring sites. The AOD/$PM_{2.5}$ mass concentration plot of site-specific Moderate Resolution Imaging Spectroradiometer (MODIS) and Geostationary Operational Environmental Satellite (GOES) Aerosol/Smoke Product (GASP) data details the temporal behavior of measurements made at a specific monitoring site location. Correlations between the MODIS/GASP AOD observations and $PM_{2.5}$ measurements can also be seen. The left vertical axis shows the mass concentration of $PM_{2.5}$ on a scale of 0–100; the right vertical axis shows the MODIS/GASP AOD on a scale of 0.0–1.6. Both graphs indicate a high concentration of $PM_{2.5}$ and a high AOD on May 4, proving that smoke was affecting the monitoring sites.

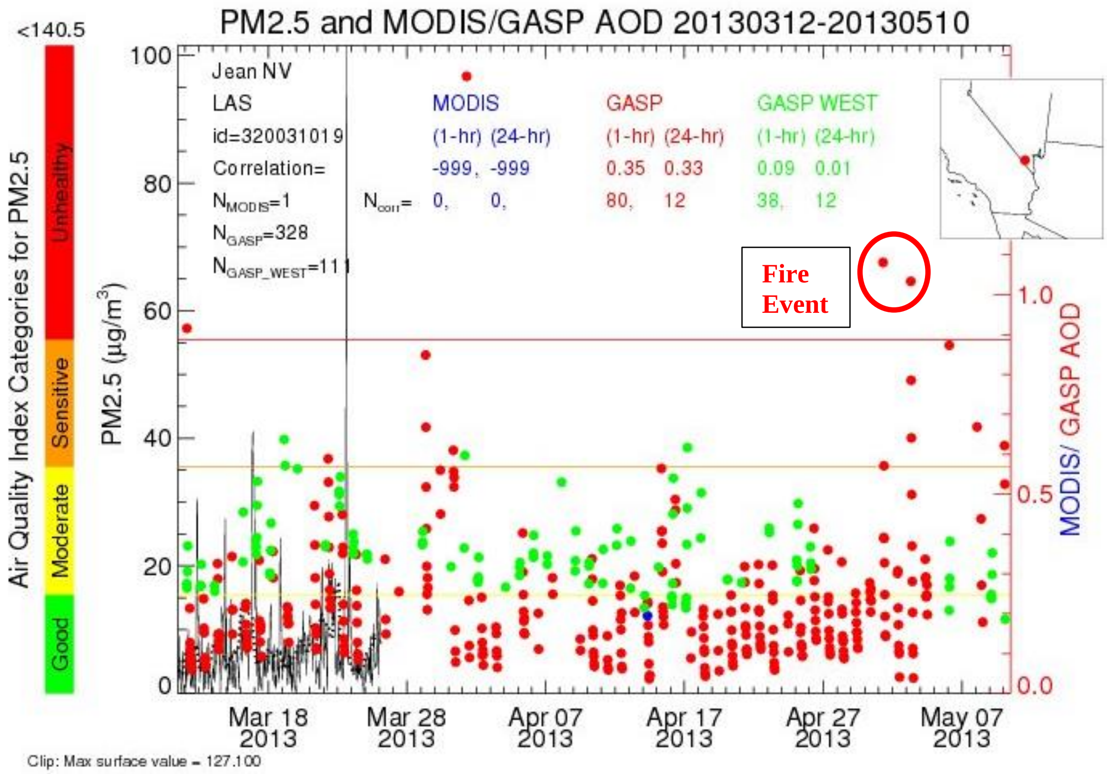


Figure 4-12. Data for Jean.

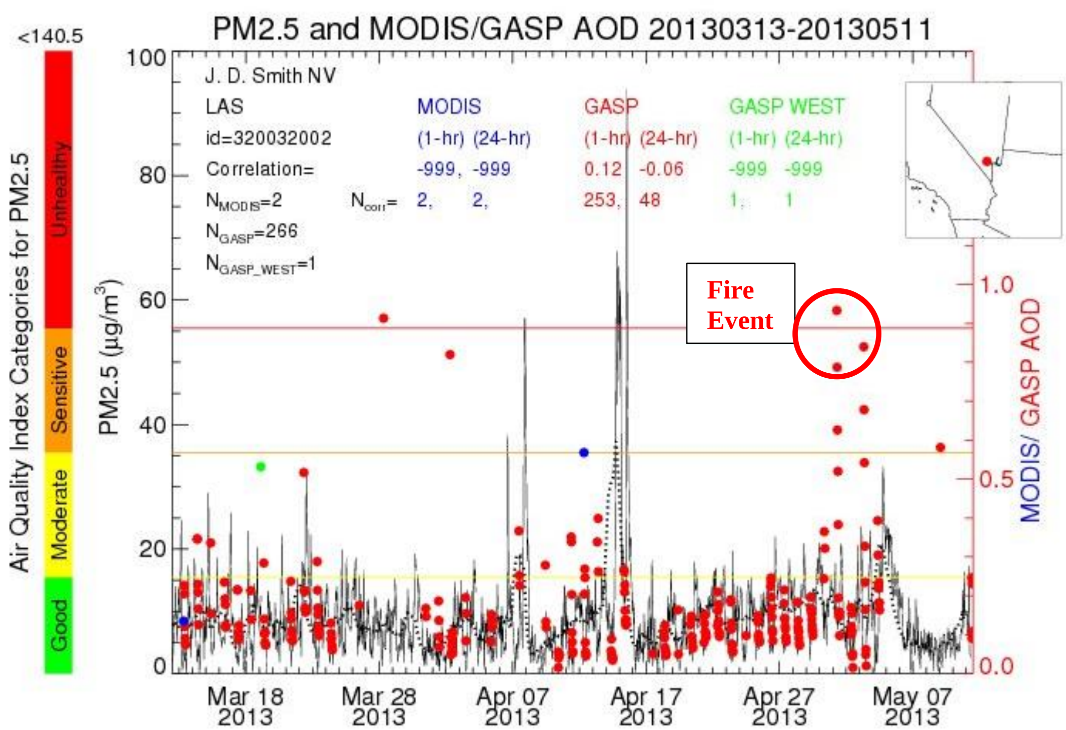


Figure 4-13. Data for J.D. Smith.

5.0 PUBLIC OUTREACH AND EDUCATION IN RESPONSE TO THE EXCEPTIONAL EVENT

DAQ has in place an education program to protect the public from adverse health problems associated with elevated pollutant levels. Its goals are to inform and educate the public on topics that include:

- How they can avoid exposure and minimize health impacts.
- How they can reduce their contributions to concentrations of the pollutant.
- What types of exceptional events may affect the area's air quality.
- When an exceptional event is imminent or occurring.

To meet these goals, DAQ conducts a comprehensive program that engages in local outreach events to provide information to the public. These include:

- Media press releases issued to the community as needed.
- School and youth outreach programs with classroom and youth group presentations, teacher training, and air quality information packets.
- Participation in community events (e.g., local fairs).
- Training in air quality reporting for local weather anchors.
- Activities with city, county, and local environmental/health professionals to improve methods for reaching and educating the community.

DAQ has also developed a notification system to contact at-risk populations. Avenues include:

- The Clark County School District.
- The Southern Nevada Health District.
- The Clark County Parks and Recreation Department.
- Local municipalities, comprising the cities of Henderson, Mesquite, Las Vegas, North Las Vegas, and Boulder City.
- Local media (i.e., newspapers, radio, and television stations).
- Sensitive individuals (through a notification service).

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6.0 CONCLUSIONS AND RECOMMENDATION

This demonstration makes a clear and compelling case, by weight of evidence, that the ozone exceedance on May 4, 2013, was due to the influence of the Springs Fire in southern California. It meets the EER requirements, allowing EPA to exclude that day's ozone data for regulatory purposes.

The tables and figures in this report depict the relationships between O_3, $PM_{2.5}$, and CO on May 4, as well as on the days before and after the event. Figure 4-1 demonstrates that temperature, humidity, and wind speeds had little influence on the ambient levels of O_3, $PM_{2.5}$, and CO during the subject period. Figures 3-4 through 3-13 show the variation in diurnal patterns between the non-fire days and the fire day. Section 3.3 describes historical fluctuations in ozone levels over four previous years, and demonstrates that ozone concentrations were very high in the beginning of May 2013 compared to previous years.

Figures 3-16 through 3-18 depict a clear causal relationship between the ambient levels of O_3**,** $PM_{2.5}$, and levoglucosan during the event. A strong correlation between O_3, $PM_{2.5}$, and levoglucosan proves that the smoke plume reached ground level and significantly affected ozone concentrations.

In addition, this demonstration analyzed the AQI values for O_3, $PM_{2.5}$, and CO (Figure 3-19). The high AQI values for all three pollutants tracked nearly identically, and were elevated proportionately on the wildfire smoke intrusion days. Back trajectories and wind data show that the smoke plume impacted Clark County. Satellite imagery also shows that high levels of smoke and dust impacted Clark County on May 4.

Section 5 outlines the steps Clark County took to protect public health through release of a public advisory and cooperation with local media.

Based on the information contained in this demonstration, EPA should exclude the ozone data for May 4, 2013, as being caused by an exceptional event in accordance with the EER.

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7.0 REFERENCE

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APPENDIX A: AIR ADVISORIES AND NEWS ARTICLES

DAQ air quality advisory for ozone.

News Release

Office of Public Communications • (702) 455-3546 • FAX (702) 455-3558 • www.accessclarkcounty.com

Contact: Stacey Welling
Sr. Public Information Officer

Phone: (702) 455-3201
Cell: (702) 249-3823
E-mail: stac@co.clark.nv.us

For Immediate Release **Monday April 1, 2013**

Air Quality Advisory Issued for Ozone from April 1 through Sept. 30

Clark County Department of Air Quality officials are advising residents that weather conditions and levels of pollutants may trigger a build-up of ground-level ozone in Southern Nevada from April through September.

At this time, unhealthy levels of ozone pollution are not occurring. Air Quality officials will continue to monitor conditions and will post an alert on the forecast page of the department's website if unhealthy levels actually occur. A link to the forecast page is located at http://redrock.clarkcountynv.gov/forecast/.

Ozone is a gas that occurs naturally in the upper atmosphere and protects the earth from the sun's harmful ultraviolet rays. At ground level, ozone is a key ingredient of urban smog during the hottest months of the year in Clark County. Ground-level ozone can build up during the afternoon hours due to a combination of several factors, including strong sunlight, hot temperatures, and pollutants from automobiles and other sources such as transport and wildfires from Southern California and other areas. Unhealthy doses of ground-level ozone can reduce lung function and worsen respiratory illnesses such as asthma or bronchitis. Exposure to ozone also can induce coughing, wheezing and shortness of breath even in healthy people. When ozone levels are elevated, everyone should limit strenuous outdoor activity, especially people with respiratory diseases. Officials suggest these tips to help reduce the formation of ground-level ozone:

- Fill up your gas tank after sunset.
- Plan errands so they can be done in one trip
- Try not to spill gasoline when filling up, and don't top off your gas tank.
- Keep your car well maintained.
- Use mass transit or carpool.
- Don't idle your car engine unnecessarily.
- Walk or ride your bike whenever practical and safe.
- Drive an electric or hybrid vehicle, or low-emission scooter or motorcycle.
- Consider low-maintenance landscaping that uses less water and doesn't require the use of gas-powered lawn tools to maintain.
- Turn off lights and electronics when not in use. Less fuel burned at power plants means cleaner air.

Detailed air quality conditions are posted in the monitoring section of the Department of Air Quality's website. You can receive free text and e-mail advisories and air quality forecasts through the U.S. Environmental Protection Agency's EnviroFlash service at www.enviroflash.org.

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Springs Fire information from the CalFire Web site.

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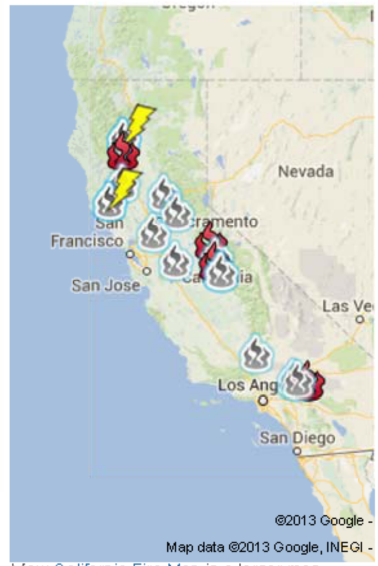
Incident Information

Last modified on May 11, 2013

SPRINGS FIRE

Springs Fire Incident Information:		
Last Updated:	May 11, 2013 6:30 am	FINAL
Date/Time Started:	May 2, 2013 7:01 am	
Administrative Unit:	Ventura County Fire/CAL FIRE	
County:	Ventura County	
Location:	Southbound Highway 101 at Camarillo Springs Road, Camarillo	
Acres Burned - Containment:	24,251 acres	
Estimated Containment	24,251 acres - 100% contained	
Structures Destroyed:	10 outbuildings have been destroyed 6 damaged commerical properties, and 6 damaged outbuildings.	
Evacuations:	All evacuations have been lifted.	
Injuries:	10	
Cause:	Under Investigation	
Cooperating Agencies:	Ventura County Fire Department, CAL FIRE, USFS, Ventura County Sheriff, National Park Service, California State Parks, CHP, Ventura County Animal Control, CalEMA, Department of Corrections and Rehabilitation, California Conservation Corps, Southern California Edison and Red Cross.	
Total Fire Personnel:	121 Firefighters	
Total Fire Engines:	5 Engines	
Total Fire crews:	6 Fire Crews	
Conditions:	Acreage has been reduced based upon more accurate mapping. Continue to mop up in areas very visible to public. Continue demobilization, fire damage inspections, and suppression repair.	

California Statewide Fire Map



View California Fire Map in a larger map

SPRINGS FIRE MORE INFO

- Springs Fire Information
- Incident Maps
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Figure 7-1. Smoke Plume near the Springs Fire.