SUPPORTING MATERIALS FOR THE STATE OF MISSOURI'S PETITION FOR RECONSIDERATION OF EPA'S NOVEMBER 5, 2024, "FINDING OF FAILURE TO ATTAIN AND RECLASSIFICATION OF THE MISSOURI PORTION OF THE ST. LOUIS NONATTAINMENT AREA AS SERIOUS FOR THE AIR QUALITY NATIONAL AMBIENT AIR QUALITY STANDARDS"

Prepared by:
Alpine Geophysics, LLC
387 Pollard Mine Road
Burnsville, NC 28714

July 21, 2025

Background

In the summer of 2023, Canada experienced its most severe wildfire season on record. Smoke from these fires was transported across the Upper Midwest region of the United States, leading to widespread increases in surface-level ozone concentrations, as observed by the U.S. AQS monitoring network. These events were particularly significant because they occurred early in the fire season (May 15–June 30) and resulted in the highest regional-scale surface ozone levels ever recorded across the northern U.S.[1]

Figure 1 below shows statistics extracted from the Canadian National Fire Database[2], and shows the extreme acres burned in Canada in 2023 compared to the past five decades.

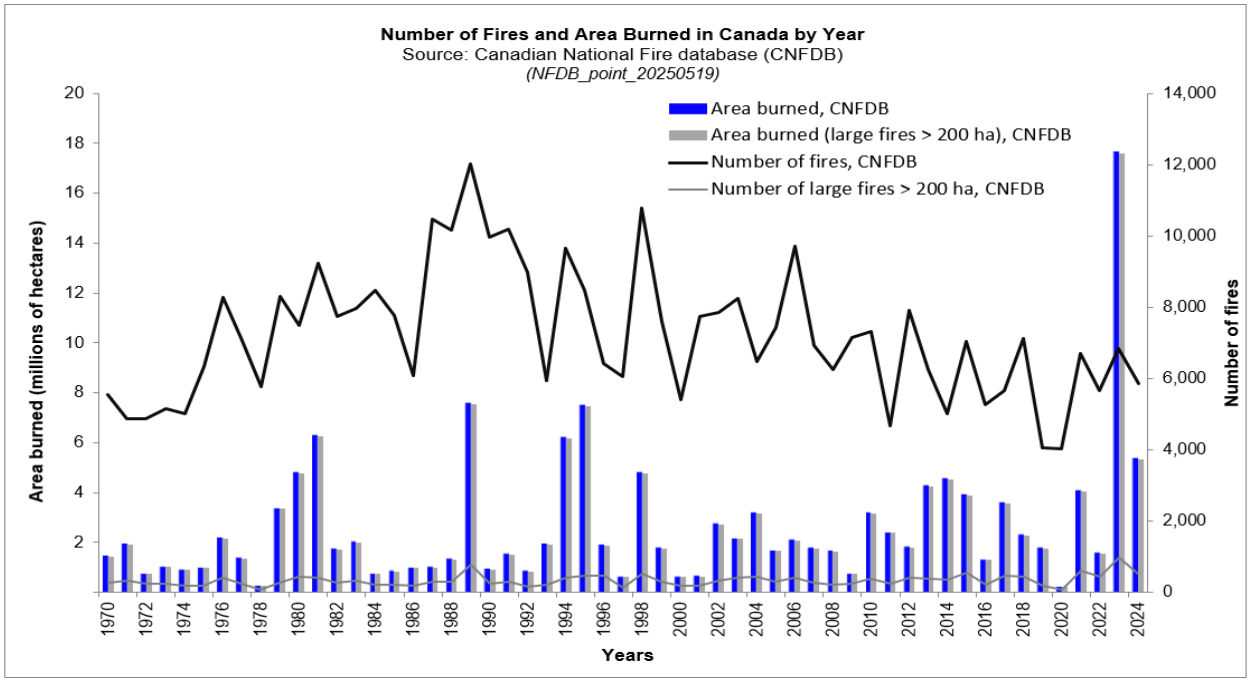


Figure 1. Number of fires and area burned in Canada by year, 1970-2024.

Additional studies[3] show that significant amounts of Canadian wildfire emissions were emitted into the atmosphere during the 2023 calendar year. Table 1 presents an accounting of those emissions as estimated using the U.S. Forest Service's BlueSky modeling framework. Much of those emissions eventually made their way into the northern and eastern regions of the U.S. This resulted in observable smoke coverage on most of the days during calendar year 2023 and for most of the eastern states, with a significant spike in May and June 2023 due to unprecedented levels of wildfire activity.

[1] https://doi.org/10.1029/2024GL111481
[2] https://cwfis.cfs.nrcan.gc.ca/ha/nfdb
[3] https://doi.org/10.1016/j.dib.2024.111208

Table 1. Monthly 2023 Canada wildland fire emissions (short tons)

Month	CO (tons)	CO2 (tons)	NOx (tons)	PM2.5 (tons)	VOC (tons)
Jan	174,640	2,943,797	2,509	24,299	54,063
Feb	26,430	466,961	426	3,716	8,673
Mar	33,191	597,026	564	4,765	11,244
Apr	29,440	569,269	601	4,228	10,448
May	4,530,476	76,361,970	65,021	607,398	1,346,389
Jun	8,572,781	138,754,014	112,729	1,134,010	2,442,094
Jul	6,592,839	112,494,448	101,312	883,722	2,046,350
Aug	5,765,409	98,807,492	89,586	780,091	1,809,509
Sep	3,871,245	65,528,376	56,429	527,038	1,177,193
Oct	327,395	5,690,758	5,044	45,253	102,992
Total	**29,923,847**	**502,214,113**	**434,222**	**4,014,519**	**9,008,956**

Cumulative smoke data annual statistics are derived by aggregating daily Hazard Mapping System (HMS) smoke polygons into a grid and counting the number of days when individual cells were covered by either light, medium or heavy smoke during the year. Contour lines and labels depicting the number of observed smoke days are used to help with data interpretation. The smoke contour map for 2023 is presented in Figure 2 and indicates that much of the eastern U.S. was covered in observed smoke for up to 55% (~ 200 days) of the year.

During the spring and summer of 2023, the St. Louis metro area experienced some of its worst recorded air quality as smoke and unhealthy haze from Canada's wildfires spread southward, as far as Missouri and Kentucky, as reported by multiple sources at the time.[4,5,6,7]

[4] https://www.ksdk.com/article/weather/wildfire-smoke-forecast-st-louis/63-86ae55ef-c633-49c2-a11d-f964688f8c47

[5] https://fox2now.com/news/missouri/canadian-wildfire-smoke-causes-hazy-skies-in-st-louis/

[6] https://www.stltoday.com/news/local/metro/canadian-wildfire-smoke-hits-st-louis-ahead-of-triple-digit-heat/article_913926e4-1525-11ee-bfc9-93e01281b6e6.html

[7] https://www.pbs.org/newshour/nation/air-quality-plummets-in-parts-of-the-u-s-again-due-to-wildfire-smoke-from-canada

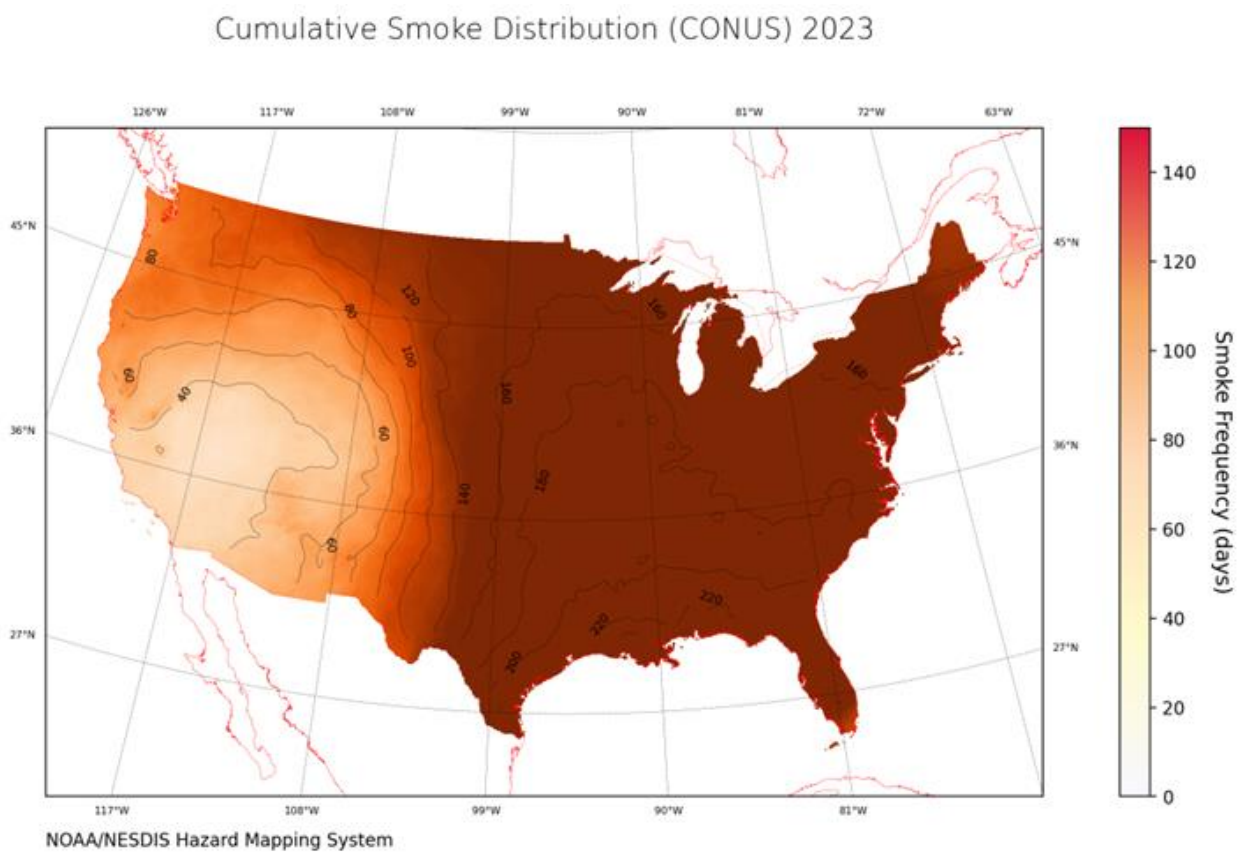


Figure 2. Cumulative smoke distribution observed across the continental U.S. in 2023.

Purpose and Presentation

This document is intended to provide objective, technical, supporting information related to wildfire smoke influence on ozone concentrations observed in the St. Louis ozone nonattainment area (NAA) in support of EPA's reconsideration of the NAA reclassification to "Serious" (e.g., "bump up").

Using protocols established in EPA's "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations,"[8] presented here is supporting information consistent with Tier 1 and Tier 2 approaches to addressing the clear causal relationship element within a wildfire/ozone demonstration.

And while not a formal exceptional events demonstration, information in this document provides the following key findings and evidence supporting the need for and likely result of such a demonstration:

1. Ozone concentrations in the spring and summer of 2023 at multiple St. Louis area monitors were above the 99th percentile of the 5-year distribution of ozone monitoring data at the site, were among the highest ozone concentrations for the year, and were among the highest observations in the most recent 5-year period.
2. Considerable ozone was created upstream of St. Louis due to the presence of wildfire smoke generated during Canada's largest recorded wildfire year, which was then transported into the region during the late spring and summer seasons.
3. Satellite images captured visual smoke plumes that were transported into the St. Louis region on days when the ozone concentrations were highest.
4. Analysis of the National Oceanic and Atmospheric Administration's (NOAA) Hazard Mapping System (HMS) smoke product and Ozone Air Quality Index (AQI) shows an enhanced ozone concentration impact at monitors along the wildfire smoke transport path that eventually culminates with excess ozone observations in St. Louis.
5. Regional upwind measurements identify multiple monitors with unusually high ozone concentrations during the dates when the transported smoke plume passes through the region.
6. Fine particulate matter (PM2.5) was also elevated during the event, consistent with a wildfire smoke plume.
7. PM2.5 speciated data (organic carbon and potassium ion) showed elevated wildfire attributable concentrations.

Several analytical methods were used to develop evidence that many of the 8-hour ozone concentrations above 70 parts per billion (ppb) recorded during the 2023 calendar year meet the rules for data exclusion as an Exceptional Event. In summary, satellite images and data, screening tools, and speciated PM2.5 data were used to assess whether conditions were favorable for transport of smoke from the Canadian wildfires to monitors that showed 8-hour ozone concentrations above 70 ppb. The data also showed that the transported smoke enhanced ozone concentrations and degraded air quality in the St. Louis nonattainment area, as well as in many regional areas in the Midwestern U.S.

[8] https://www.epa.gov/system/files/documents/2023-12/guidance-on-the-preparation-of-ee-wf-ozone.pdf

Data presented here are related to ozone monitors in the Missouri portion of the St. Louis ozone nonattainment area. Comparable information is available for Illinois-sited nonattainment and other regionally located Missouri monitors.

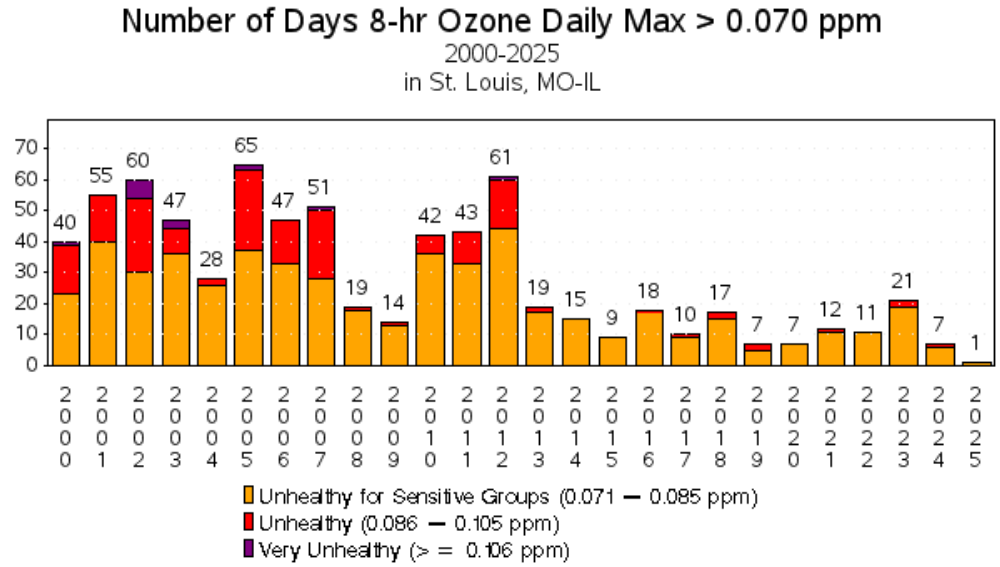
Information in this document is presented for the monitors shown in Table 2.

Table 2. Missouri located ozone monitors in the St. Louis nonattainment area.

			Ozone 3-Year Design Value (ppb)				
Monitor ID	**Local Name**	**County**	**2018-2020**	**2019-2021**	**2020-2022**	**2021-2023**	**2022-2024**
290990019	Arnold West	Jefferson	67	68	68	72	68
291831002	West Alton	Saint Charles	71	-	69	72	73
291831004	Orchard Farm	Saint Charles	68	66	65	68	69
291890005	Pacific	Saint Louis	66	64	63	67	67
291890014	Maryland Heights	Saint Louis	71	69	68	71	71
295100085	Blair Street	St. Louis City	68	65	67	71	70

Ozone Trends and 2023 Conditions in St. Louis

Ozone has significantly decreased in the St. Louis area over the past 25 years due to sizeable and sustained reductions in ozone precursor emissions. This is evident in Figure 3 below, showing the number of monitor-days in each year since 2000 where monitors in the St. Louis core based statistical area (CBSA) have exceeded the 70 ppb NAAQS for ozone on certain dates. As is demonstrated in this Figure, 2023 was exceptional in the recent historical record as more than approximately twice the number of NAAQS monitor-day exceedances occurred in 2023 (21 occurrences) compared to complete years of reporting from 2019 through 2024 (7 to 12 occurrences)[9].



Note: Based on ALL sites
Source: U.S. EPA AirData <https://www.epa.gov/air-data>

Figure 3. Number of days where St. Louis CBSA monitors exceeded the level of the current ozone NAAQS.

However, at each of the regulatory monitors on the Missouri side of the NAA, exceptionally high 4th high observations of maximum daily 8-hour averaged (MDA8) ozone in 2023, associated with the wildfire enhancements to ozone concentrations, resulted in estimated 3-year design values trending away from the decreases observed over the last decade. And while all these monitors had an estimated 3-year DV of below the 70 ppb NAAQS in both 2021 and 2022, these elevated 4th high values in 2023 produced design values at 4 of the 6 monitors that exceeded the 70 ppb standard. These 3-year design value trends can be seen in Figure 4. Note that future design values inclusive of the 4th high values from 2023 (through 2025) will be influenced by the excessively high observations that have been enhanced by the Canadian wildfire smoke in the spring and summer of 2023. This can already be seen in the following

[9] The number of exceedances in Figure 3 represent unique dates across all monitors, not necessarily the number of exceedances at any one monitor.

figure and the 2024 three-year design values presented, even though 2024 4th high observations were significantly lower than those in 2023.

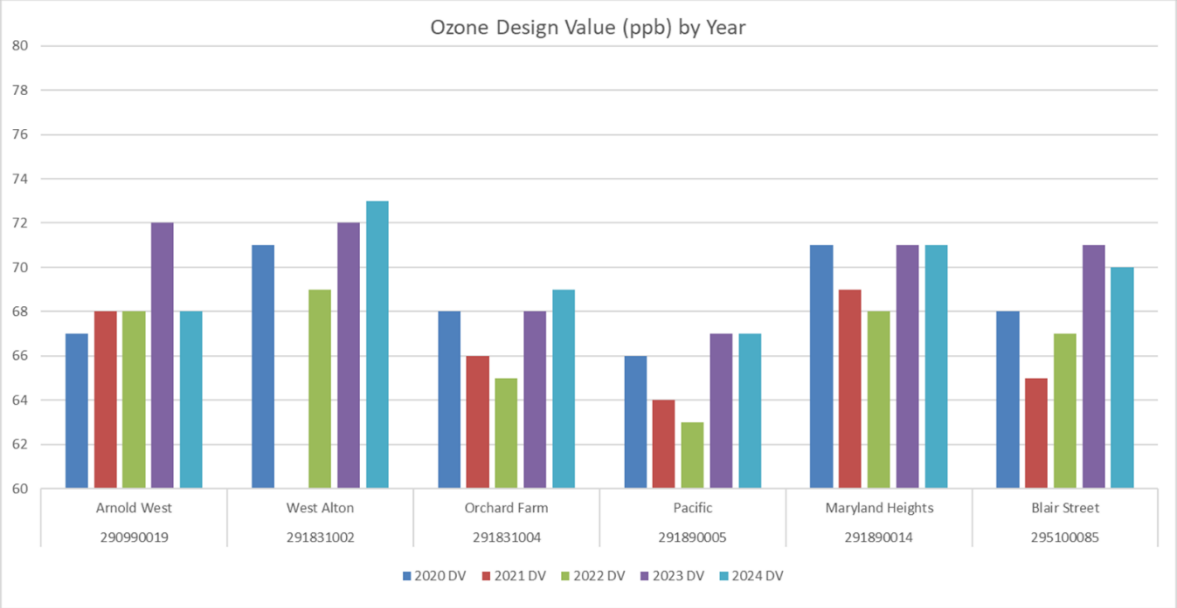


Figure 4. 3-year ozone design value trends at Missouri monitors in the St. Louis NAA.

In 2023, St. Louis' ozone air quality index (AQI), the measurement EPA uses to communicate outdoor air quality and health, was above both the 5-year average (2019-2023) as well as exceeding levels of the 24-year high (2000-2023). Figure 5 presents these values as generated from EPA's AirData website[10].

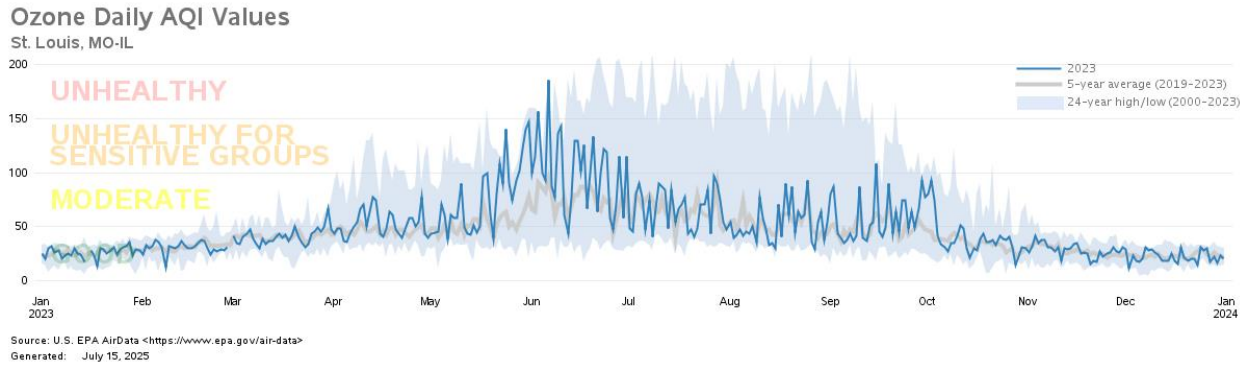


Figure 5. St. Louis CBSA ozone daily AQI values; 2023 compared to 5-year averages (2019-2023) and the 24-year (2000-2023) high/low values.

[10] https://www.epa.gov/outdoor-air-quality-data

Similarly, in 2023, St. Louis experienced an exceptionally high number of days where the AQI exceeded 100, a measure indicating that air quality is unhealthy, at first for certain sensitive groups of people, then for everyone as AQI values get higher. The cumulative number of high (> 100) AQI days in 2023 is presented in Figure 6 and is seen as greater than the 5-year average and comparable through July to high values in the 24-year period from 2000-2023.

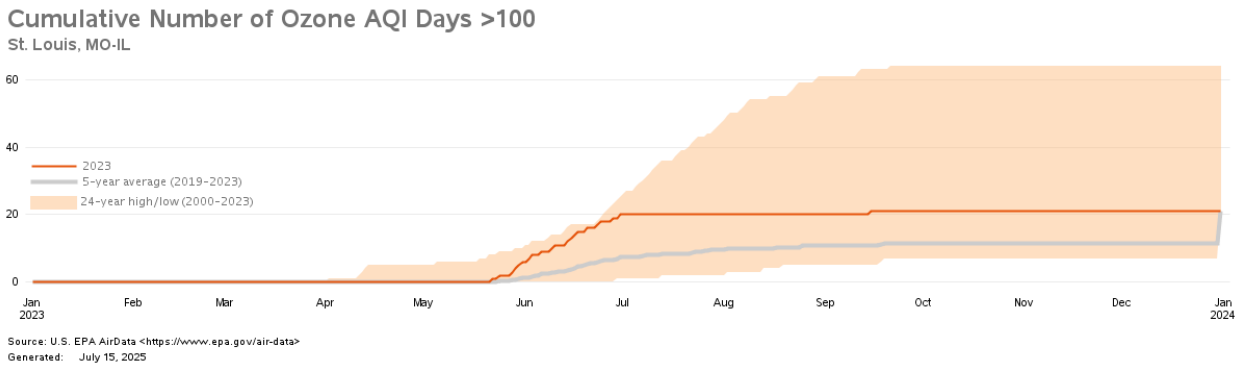


Figure 6. Cumulative number of ozone AQI days > 100 in the St. Louis CBSA; 2023 compared to 5-year averages (2019-2023) and the 24-year (2000-2023) high/low values.

The significantly exceptional ozone episodes in 2023 are easily seen when daily AQI values are plotted for St. Louis during the years 2020-2024. In the 2023 row presented in Figure 7, May, June, and July are shown to have many more "Unhealthy for Sensitive Group" and "Unhealthy" AQI days than any other months in the five-year period. These high AQI values will be shown to correlate with dates when Canadian wildfire smoke was present in and around the St. Louis region, enhancing the observed concentrations at multiple monitors.

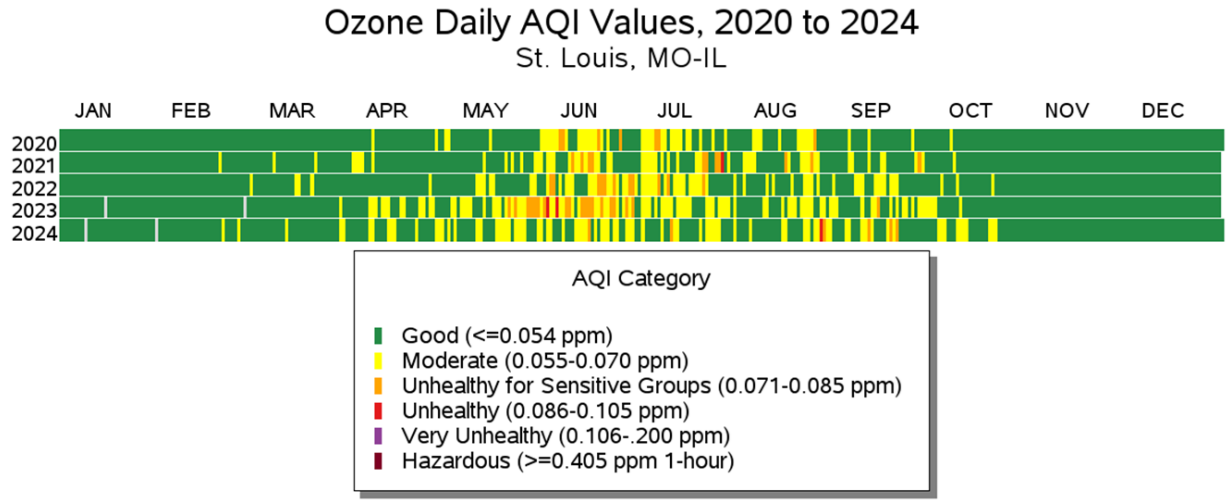


Figure 7. Ozone daily AQI values for St. Louis CBSA, 2020-2024.

On a monitor-by-monitor basis, it can also be seen that ozone concentrations from multiple dates across the spring and summer of 2023 were influenced by the Canadian wildfire smoke as it entered the St. Louis airshed.

Figure 8 through Figure 13 below present the MDA8 observations at the Missouri monitors located in the St. Louis ozone nonattainment area for the May through September period of the past five years (2020-2024). Each daily value is color coded to represent historical thresholds, exceedances of NAAQS levels, and the 99th or higher percentile of the five-year distribution of ozone monitoring data. This is an easy way to compare dates and to find trends and episodes that may be significantly different than historical averages.

In each figure, green cells represent MDA8 values below 70 ppb, yellow cells indicate MDA8 values greater than 70 ppb, red cells indicate MDA8 values above 75 ppb, and blue cells indicate MDA8 values greater than the 99th percentile of the five-year distribution of ozone monitoring data at that monitor.

What is initially noticeable is the fact that each of these monitors has multiple dates and observations that exceed the 99th percentile values of the past five years (blue cells). It is also notable that these 99th percentile dates are mainly from the May and June 2023 episode of Canadian wildfire smoke intrusion.

monitor	290990019															74 <-- 99th %ile of 2020-2024 observations															
Sum of value	Column L																													
Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2024																														
5	48	44	48	45	41	38	45	35	47	41	50	49	38	33	46	35	44	46	45	45	48	40	38	47	51	46	45	48	48	52	49
6	34	53	41	39	41	48	53	34	44	37	50	47	40	61	72	43	41	31	47	54	46	35	50	54	42	48	68	44	42	40	
7	45	52	33	39	43	48	45	46	30	40	42	40	39	25	27	43	42	42	53	56	47	63	48	45	60	48	28	30	26	33	43
8	45	44	42	48	35	42	33	42	29	32	41	26	37	31	38	46	42	33	44	40	42	48	57	39	51	44	54	50	53	43	38
9	40	40	42	48	38	41	36	43	42	53	58	45	24	31	33	41	46	61	46	49	43	38	25	14	41	47	30	27	29	34	
2023																														
5	46	46	48	56	52	38	49	48	53	55	42	39	34	48	45	41	69	66	50	40	53	62	59	**78**	64	62	65	66	74	**77**	68
6	59	71	**88**	69	68	**99**	59	60	**75**	**76**	48	47	52	**76**	72	71	72	53	70	**79**	55	70	**77**	52	57	51	60	66	53	66	
7	46	44	56	57	57	51	55	39	60	56	52	46	48	47	49	50	49	35	32	48	43	50	46	50	46	41	51	45	51	56	42
8	52	37	43	48	37	46	45	39	31	46	35	44	33	34	30	47	40	51	47	40	49	52	41	41	65	34	20	55	51	40	46
9	54	51	39	36	34	40	47	39	42	66	35	39	54	55	73	47	42	47	54	31	49	45	59	47	52	47	48	48	52	57	
2022																														
5	48	31	28	33	23	33	51	50	38	33	46	58	56	48	52	52		48	39	38	28	36	46	40	26	33	26	42	49	49	32
6	41	46	60	70	64	38	59	42	58	50	36	30	27	31	22	30	58	58	63	55	50	54	65	71	53	42	52	61	67	57	
7	52	38	52	40	40	59	51	46	37	64	43	46	55	58	53	62	33	60	62	62	52	73	50	46	43	32	37	42	43	36	30
8	40	48	37	43	40	28	28	35	26	54	64	42	47	32	41	43	50	53	43	42	36	52	51	49	50	48	47	30	29	43	50
9	46	32	41	24	26	27	43	58	50	49	26	41	46	56	49	48	46	32	40	45	46	31	22	46	37	35	38	29	37	38	
2021																														
5	47	36	43	19	50	42	51	34	36	44	40	41	47	54	43	46	40	39	44	48	50	41	53	45	40	62	33	28	42	56	61
6	41	34	59	50	44	33	35	35	49	56	65	51	66	68	65	**76**	59	47	52	42	33	56	58	37	30	22	21	21	23	41	
7	43	42	68	51	53	51	45	43	49	35	41	34	35	37	26	41	54	47	46	55	66	73	59	33	40	65	74	62	40	51	36
8	44	49	49	51	51	45	47	32	20	25	31	33	44	54	47	54	**77**	53	46	36	44	59	37	37	49	48	44	37	28	26	43
9	47	49	40	29	44	42	46	44	41	46	45	42	37	36	47	49	50	37	30	30	21	31	37	42	42	50	55	69	48	34	
2020																														
5	50	59	51	45	39	44	45	40	47	40	40	38	26	40	50	36	36	26	28	27	29	43	51	38	37	40	33	38	44	41	58
6	53	39	42	60	42	68	71	56	38	31	48	54	67	56	62	60	57	65	51	40	45	36	47	46	48	35	22	29	25	25	
7	33	56	53	59	59	62	57	41	37	48	44	58	48	57	35	64	54	25	34	46	29	43	45	46	41	22	31	46	32	30	28
8	26	34	25	30	46	46	48	45	42		46	39	37	44	42	36	32	40	39	47	62	37	37	43	50	23	18	25	31	38	31
9	26	24	31	45	33	30	31	32	40	41	44	19	29	39	35	49	34	35	39	41	43	42	41	45	43	34	38	25	26	40	

Figure 8. Calendar view of MDA8 ozone observations from 2020-2024 from the Arnold West (29-099-0019) monitor.

monitor 291831002 — 76 <-- 99th %ile of 2020-2024 observations

Sum of value / Row Labels	Column L 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2024																															
5	50	54	50	55	44	49	49	45	53	45	55	59	46	38	48	48	59	66	60	57	54	45	57	56	52	56	49	49	44	59	57
6	41	52	56	51	44	50	52	45	46	42	63	63	56	62	**78**	52	53	38	56	64	59	43	52	68	47	49	58	56	46	41	
7	50	66	45	47	46	47	51	56	38	42	58	67	52	35	39	47	43	39	47	49	50	53	61	45	49	53	39	39	39	45	53
8	46	46	38	42	52	44	35	41	29	33	51	32	44	41	51	50	39	35	45	40	45	54	64	49	66	63	76	65	58	53	38
9	41	39	43	55	52	42	38	46	53	58	59	55	30	38	38	47	56	74	63	60	48	43	25	24	38	47	35	32	32	34	
2023																															
5	45	46	48	61	56	42	52	55	56	63	52	47	46	55	45	48	61	70	55	41	60	68	65	**82**	60	61	68	68	76	**80**	**77**
6	69	75	**84**	67	66	**79**	62	60	75	**80**	55	47	61	73	74	54	76	57	68	74	59	62	71	76	55	46	55	70	45	58	
7	48	43	51	60	57	44	59	40	53	61	64	63	45	63	46	53	52	63	45	39	39	49	50	50	62	45	59	60	54	41	43
8	56	41	43	49	39	50	41	46	34	46	50	42	35	34	27	56	39	56	51	60		51	55	52	56	34	24	51	47	38	45
9	55	66	45	43	36	36	37	37	43	53	42	39	47	54	64	45	44	53	63	40	56	48	59	57	47	57	51	54	56	62	
2022																															
5	48	37	31	41	28	38	52	49	43	45	51	67	60	63	52	54	62	44	47	41	35	39		44		37	27	50	53	55	37
6	38	47	53	71	74	46	50	44	59	60	59	39	34	41	30	47	59	53	68	**78**	62	51	56	70	68	39	49	64	76	71	
7	57	42	55	53	43	44	50	59	41	53	69	39	43	61	49	53	36	46	61	45	46	61	54	46	37	32	42	35	34	38	44
8	47	49	40	50	44	35	37	32	24	47	42	39	61	27	38	43	47	47	50	49	32	42	50	51	53	42	52	36	38	39	35
9	52	41	41	25	23	31	40	51	58	50	24	37	38	58	53	60	53	42	50	56	54	33	22	46	36	34	35	26	36	36	
2021																															
5	50	42	46	25	42	42	50	34	37	46	39	41	46	56	48	51	43	40	42	48	56	45		49	45	48	37	30	43	55	65
6	48	44	57	62	52	38	44	40	40	50	60	49	58	66	58	54	74	57	56	48	33	54	64	37	37	26	27	27	36	34	
7	40	38	48	56	61	64	53	33	49	40	53	40	36	53	32	31	44	43	44	45	54	73	67	34	38	54	56	53	38	35	27
8	34	39	42	48	57	53	57	38	29	32	33	38	33	38	40	40	46	56	49	42	33	39	48	54	60	52	53	41	36	38	37
9	42	48	40	29	37	48	53	38	35	49	50	50	45	35	40	50	51	44	30	34	23	32	33	46	39	50	61	70	54	38	
2020																															
5	54	62	49	45	35	44	51	41	48	40	43	39	31	44	56	44	44	31	29	30	30	45	54	47	40	42	33	51	45	39	51
6	58	52		54	54	70	72	61	37	33	46	57	62	54	61	62	62	74	67	47	55	52	47	43	66	47	28	36	33	32	
7	28	48	57		53	67	72	60	53	41	50	53	46	60		47	49	31	34	41	44	35	39	51	48	28	31	52	53	36	34
8	30	36	22	26	36	46	55	52	49	42	44	47	44	51	36	31	44	38	38	52	52	66	46	58	71	43	29	27	36	44	33
9	35	32	42	32	52	37	39	38	43	29	51	21	29	38	40	40	38	35	42	46	49	45	34	51	48	41	35	24	23	38	

Figure 9. Calendar view of MDA8 ozone observations from 2020-2024 from the West Alton (29-183-1002) monitor.

monitor	29183100			70 <-- 99th %ile of 2020-2024 observations																											
Sum of value	Column L																														
Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2024																															
5	50	51	48	53	43	46	45	43	53	45	53	56	45	42	47	47	56	57	51	51	51	43	62	53	53	55	48	50	44	60	57
6	38	51	50	49	46	50	54	44	48	40	61	56	56	61	**78**	52	49	36	49	67	56	44	54	62	46	47		53	46	37	
7	49	62	44	46	46	48	45	46	37	44	57	64	53	32	37	46	41	36	46	46	47	48	49	46	44	50	36	37	35	40	48
8	45	46	40	44	46	41	36	41	29	33	44	28	42	38	49	47	36	32	40	36	42	51	67	43	54	57	65	63	58	45	37
9	38	36	40	54	48	41	36	42	55	59	64	53	26	38	38	48	55	70	53	55	44	39	21	24	38	47	35	30	30	33	
2023																															
5	44	45	45	59	54	40	53	52	51	62	50	46	44	50	41	45	57	67	48	37	55	64	60	**73**	54	54	59	62	68	**80**	**71**
6	65	65	**78**	57	59	**74**	56	56	**71**	**73**	53	45	55	70	**72**	45	64	51	62	64	47	54	61	53	52	46	50	62	40	51	
7	43	42	48	55	53	44	52	38	47	57	56	53	42	52	50	52	51	57	42	43	38	47	46	49	58	45	58	61	49	38	41
8	52	41	40	47	40	44	44	43	30	46	48	42	30	33	28	51	39	54	58	55	34	57	44	45	52	33	21	45	44	34	41
9	55	57	42	40	37	32	40	32	40	47	36	36	46	50	56	42	40	52	59	37	50	47	59	57	48	50	50	50	63	62	
2022																															
5	46	36	29	40	28	38	50	50	41	45	53	64	66	61	48	51	57	44	46	36	34	38	44	43	30	35	29	50	51	49	34
6	36	50	54	65	68	48	47	46	57	53	48	39	36	40	27	40	57	51	**71**	65	54	51	54	67	56	42	47	65	69	65	
7	55	37	52	43	41	41	51	52	37	48	52	39	44	55	47	54	40	43	60	53	45	60	50	45	33	28	39	31	33	35	39
8	45	46	36	44	42	28	32	30	22	42	40	35	47	28	34	42	41	44	48	47	31	39	44	48	45	37	51	29	38	38	32
9	48	39	39	22	21	26	37	47	59	50	27	36	38	66	56	51	47		44	49	50	31	21	43	36	34	34	26	33	36	
2021																															
5	47	40	42	24	41	42	48	34	36	43	38	39	46	55	47	50	43	39	42	49	51	42	58	48	42	44	36	29	43	54	64
6	48	46	58	59	49	33	39	38	37	41	56	54	55	65	56	49	64	53	53	51	34	47	58	39	34	26	33	24	30	30	
7	39	39	50			59	55	41	56	41	51	40	37	42	32	36	44	44	45	46	56	**76**	69	40	44	49	54	49	43	35	27
8	42	39	41	47	54	53	52	36	31	28	33	37	39	39	41	41	53	61	50	48	40	46	48	49	54	51	51	43	34	34	38
9	42	50	42	30	39	48	51	41	36	53	49	49	43	34	42	52	55	45	32	33	27	33	35	43	41	44	57	65	58	37	
2020																															
5	54	62	47	44	34	45	48	40	46	40	42	37	29	40	54	44	41	29	27	30	31	46	50	39	39	41	36	47	43	37	50
6	57	49		50	46	68	69	63	38	31	45	55	60	51	58	63	65	70	57	46	54	48	46	44	61	41	27	37	27	28	
7	31	46	50	57	52	64	57	52	41	45	48	53	43	61	38	41	54	32	37	41	39	40	32	50	50	28	29	45	39	32	33
8	30	36	19	24	36	44	58	43	45	37	35	46	37	46	41	31	40	35	34	47	52	54	42	55	60	38	23	24	36	42	30
9	32	29	39	35	48	31	37	35	36	26	51	20	29	35	40	44	35	34	41	44	51	47	35	50	54	38	33	24	24	39	

Figure 10. Calendar view of MDA8 ozone observations from 2020-2024 from the Orchard Farm (29-183-1004) monitor.

monitor	291890005									71 <-- 99th %ile of 2020-2024 observations																					
Sum of value	Column L																														
Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2024																															
5	50	48	48	45	43	40	45	38	51	44	54	50	40	44	45	38	49	49	42	43	50	41	44	44	53	47	46	52	45	54	50
6	36	54	42	39	44	52	53	35	42	38	50	45	40	59	**73**	45	37	33	39	49	46	36	53	50	46	46	65	42	40	36	
7	48	43	34	38	45	49	41	40	35	43	40	41	45	23	28	38	40	42	52	46	45	49	46	42	42	48	29	29	24	30	41
8	45	44	38	43	36	39	34	41	29	33	35	25	38	31	38	44	43	36	43	41	48	52	59	39	49	46	53	56	42	41	38
9	42	42	48	57	42	43	35	46	49	55	62	51	24	35	32	44	52	64	47	51	43	37	23	15	37	48	33	30	31	37	
2023																															
5	46	46	50	55	53	38	52	48	57	56	44	34	31	41	48	41	50	62	47	38	54	62	62	**77**	67	62	66	71	69	**73**	63
6	62	**75**	**88**	64	66	**92**	53	56	69	**73**	49	44	53	**72**	69	68	68	51	66	**80**	57	63	**72**	47	55	51	58	66	57	61	
7	39	44	53	53	54	48	59	38	53	50	50	44	42	42	51	48	46	31	31	47	40	49	43	49	41	39	52	46	49	50	43
8	42	39	42	39	37	45	42	39	28	41	34	44	32	34	31	43	39	53	39	38	45	46	42	37	52	32	20	49	47	38	56
9	63	45	32	37	35	37	44	36	40	54	29	38	49	55	62	47	41	46	52	37	43	41	54	47	48	48	44	50	57	57	
2022																															
5	48	32	25	33	25	33	50	48	37	30	44	52	58	44	47	51	45	46	37	33	30	34	47	37	27	28	25	35	47	44	28
6	34	44	56	57	61	33	46	40	53	40	37	29	21	29	19	30	50	61	71	44	47	48	59	57	47	38	49	59	57	54	
7	48	35	42	34	35	51	54	47	33	56	46	46	48	55	48	61	31	49	53	60	50	61	50	47	40	26	37	39	38	41	30
8	44	48	34	41	39	27	29	30	24	43	54	52	40	30	38	38	52	49	40	43	34	44	54	55	47	43	48	27	30	40	40
9	50	29	39	26	24	25	41	60	51	46	26	40	41	55	49	46	46	29	39	47	44	29	20	43	38	34	37	30	37	40	
2021																															
5	47	39	43	21	46	42	50	34	33	42	38	40	48	53	38	42	41	32	38	44	42	41	51	42	40	52	30	24	37	52	56
6	39	31	51	49	42	28	29	35	41	48	65	48	58	61	59	68	44	48	44	45	31	52	56	34	27	21	19	17	22	31	
7	34	38	50	39	44	42	41	38	50	30	42	35	31	33	25	35	44	47	53	48	62	53	51	33	38	71	**78**	40	40	56	35
8	41	50	47	57	44	40	42	29	20	22	25	29	41	47	45	51	47	43	45	32	41	61	29	31	45	34	35	30	25	22	38
9	44	48	36	24	38	41	45	42	35	38	41	39	34	34	45	48	53	36	31	28	21	28	32	39	36	44	53	65	49	28	
2020																															
5	50	57	49	43	44	44	43	41	45	39	40	38	25	33	46	33	33	27	29	24	28	40	48	34	30	37	34	37	43	39	49
6	45	41	42	45	36	65	70	58	37	30	45	47	65	59	65	61	57	51	44	38	46	31	45	45	46	33	21	28	18	19	
7	32	62	43	59	58	58	52	39	33	48	45	56	51	54	33	58	39	25	37	41	30		50	48	38	23	25	44	27	33	33
8	30	34	24	28	49	49	60	39	37	30	41	43	39	54	42	35	36	38	45	56	66	38	40	48	48	23	16	27	30	41	27
9	31	22	34	40	33	29	31	32	45	51	44	19	29	45	38	37	36	37	42	44	49	41	31	36	36	31	33	24	24	39	

Figure 11. Calendar view of MDA8 ozone observations from 2020-2024 from the Pacific (29-189-0005) monitor.

monitor	291890014														75 <-- 99th %ile of 2020-2024 observations																
Sum of value	Column L																														
Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2024																															
5	49	48	43	46	44	40	48	39	51	44	52	52	42	38	45	40	55	57	46	47	49	40	50	49	55	50	47	51	44	58	54
6	34	55	45	42	46	50	55	39	47	39	56	49	45	59	**77**	46	45	35	44	61	49	37	55	57	50	44	61	49	43	37	
7	51	58	38	42	45	49	47	42	33	42	53	51	49	30	36	43	41	39	49	52	51	51	51	39	57	57	36	34	32	41	53
8	44	46	42	45	44	43	35	41	29	33	41	28	49	39	43	49	40	33	42	39	46	57	65	42	53	50	66	68	57	47	40
9	40	40	43	57	52	41	37	44	50	55	63	55	25	38	36	48	57	71	49	55	41	39	22	24	39	46	33	29	28	31	
2023																															
5	46	46	47	57	53	40	51	49	56	60	47	41	38	50	44	43	60	66	50	39	58	66	64	**78**	61	60	66	69	74	**82**	71
6	64	73	**85**	58	63	**86**	59	58	**81**	75	50	44	55	73	75	58	**78**	53	66	75	57	65	71	54	54	49	54	69	51	72	
7	43	43	51	60	54	48	62	40	53	55	62	50	45	47	51	47	53	48	40	45	41	50	49	49	51	42	55	54	49	44	51
8	50	43	46	51	39	47	45	46	30	45	40	43	34	36	30	48	41	67	53	57	38	58	50	45	59	34	20	48	52	36	49
9	64	52	41	38	34	37	42	34	40	52	35	36	49	52	60	44	41	51	57	35	49	46	62	52	48	52	49	60	57	63	
2022																															
5	48	34	26	38	25	35	50	50	39	37	50	60	66	55	50	52	52	46			31	35	46	43	28	33	27	46	51	49	32
6	37	48	58	63	63	42	48	47	56	48	48	34	26	33	23	40	55	57	66	59	65	52	56	63	53	42	49	67	70	61	
7	56	38	56	42	48	47	59	49	38	53	68	42	50	59	55	58	37	49	65	59	50	**81**	52	48	34	29	38	41	35	40	36
8	49	51	35	47	48	30	42	33	25	46	48	47	47	30	37	43	48	54	43	50	33	43	54	58	46	41	52	31	34	41	38
9	48	38	43	23	19	27	39	54	57	61	28	41	43	63	52	49	46	34	44	49	48	31	20	43	38	35	35	26	37	37	
2021																															
5	47	39	42	23	46	43	52	35	35	44	39	41	48	55	46	48	42	37	42	49	50	46	57	44	43	54	34	30	40	57	62
6	46	38	59	53	46	34	35	40	41	53	64	54	58	66	59	60	59	52	52	44	36	54	59	39	33	24	24	22	34	37	
7	35	37	57	45	52	53	49	42	56	39	50	39	32	37	30	37	45	45	50	46	63	74	58	35	41	63	68	51	41	53	29
8	43	46	44	52	51	46	51	32	25	28	29	33	41	41	43	44	61	54	53	41	44	50	39	42	48	49	47	39	33	37	45
9	43	54	40	25	40	49	48	42	36	47	45	44	40	35	42	54	54	46	32	31	26	31	35	42	40	49	56	69	54	35	
2020																															
5	53	63	50	46	38	46	48	41	48	42	44	40	28	42	52	41	41	30	28	28	29	45	51	39	38	42	35	44	45	39	56
6	55	46	50	57	45	**76**	**77**	66	40	32	49	54	66	59	68	67	61	70	54	43	56	46	49	48	66	39	25	35	28	24	
7	35	60	58	64	55	74	**78**	57	41	49	52	57	58	64	39	57	56	28	38	58	40	45	51	58	47	28	29	63	40	34	34
8	30	36	22	27	43	58	59	45	45	37	43	51	49	56	49	34	43	39	42	61	64	47	45	57	63	33	22	29	36	53	38
9	32	33	40	38	48	35	37	34	49	35	55	19	31	43	44	51	37	37	44	49	50	45	35	46	52	36	34	27	26	40	

Figure 12. Calendar view of MDA8 ozone observations from 2020-2024 from the Maryland Heights (29-189-0014) monitor.

monitor	295100085			71 <-- 99th %ile of 2020-2024 observations																											
Sum of value	Column L																														
Row Labels	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2024																															
5	41	46	46	49	42	41	44	33	51	44	53	53	39	33	34	41	47	57	52	50	49	42	44	49	52	51	48	51	44	53	47
6	38	56	47	42	46	51	56	42	48	38	59	56	46	59	**74**	46	42	33	53	57	54	39	55	59	45	46	62	48	50	37	
7	45	57	48	45	48	50	49	48	37	46	59	54	47	32	35	39	43	39	48	54	50	66	53	62	53	49	32	33	33	44	47
8	53	47	47	50	54	49	31	41	30	35	42	27	39	32	45	52	44	34	42	36	40	48	58	44	58	54	**76**	71	52	55	42
9	43	36	37	45	45	41	35	43	45	49	55	43	24	32	32	45	50	65	51	60	46	41	17	20	38	41	32	29	29	31	
2023																															
5	46	46	47	56	51	39	50	50	48	56	42	41	36	48	39	45	66	62	53	39	54	59	55	**73**	56	55	63	64	**75**	**76**	67
6	59	67	**82**	60	61	**91**	60	61	**74**	**75**	50	45	57	**77**	**78**	57	**73**	55	66	71	50	64	**72**	65	55	49	55	65	43	65	
7	47	47	56	55	60	46	54	38	54	58	56	53	52	51	52	56	51	53	39	50	42	51	53	56	54	41	61	55	57	45	40
8	48	35	44	48	42	49	46	50	36	57	42	49	36	38	31	58	44	57	47	48	38	51	53	58	67	36	24	49	58	35	42
9	50	57	39	39	31	41	42	34	41	56	39	36	49	49	66	48	42	48	56	33	47	44	51	50	51	51	51	49	50	54	
2022																															
5	48	29	27	33	21	34	48	47	40	36	49	57	48	59	52	52	56		39	40	30	36	43	38	25	31	24	46	50	53	36
6	40	50	60	67	68	38	50	47	61	55	48	39	32	40	30	41	62	53	69	66	63	55	58	63	61	42	50	61	**74**	65	
7	63	35	53	48	48	57	49	64	38	55	58	43	50	69	52	66	37	49	57	64	62	67	58	49	31	26	42	50	38	37	37
8	55	48	37	49	43	32	28	43	20	48	49	39	54	33	38	44	43	52	50	49	35	45	47	48	56	43	47	33	32	42	38
9	47	38	36	22	19	26	39	51	54	48	28	41	41	52	47	54	49		46	60	56	34	19	51	40	37	35	27	34	35	
2021																															
5	48	36	44	21	42	42	51	31	36	43	32	37	42	52	43	43	39	35	36	44	50	46	59	47	43	53	34	27	40	52	65
6	36	39	59	57	50	34	37	35	43	51	70	57	61	68	64	57	65	56	51	46	35	54	62	35	30	26	24	24	35	43	
7	38	39	59	66	61	55	58	46	49	40	55	42	40	47	30	37	49	43	42	49	61	66	59	46	43	60	61	**99**	50	42	29
8	47	42	41	49	56	54	55	39	25	29	32	40	48	48	41	41	59	62	46	41	45	57	47	48	58	49	51	38	36	34	36
9	39	46	40	26	43	50	51	43	36	45	47	47	42	39	38	47	44	36	27	29	23	30	35	43	42	48	55	**73**	44	35	
2020																															
5	50	62	48	37	35	44	48	38	48	41	42	36	23	35	52	36	37	28	25	24	22	40	49	39	36	37	26	42	45	39	52
6	54	47	52	53	60	69	70	53	34	32	50	59	64	53	58	58	55	65	60	45	54	44	50	48	60	45	26	34	28	20	
7	28	49	54	60	59	63	**73**	62	47	48	50	55	47	57	38	53	44	30	43	51	39	49	47	52	44	28	30	50	36	31	28
8	32	45	25	28	39	46	54	52	51	38	51	40	37	50	49	36	46	41	37	49	56	55	54	64	62	31	25	23	39	43	34
9	25	27	46	40	49	36	40	39	47	36	47	24	30	35	36	47	36	33	40	44	42	41	36	45	41	37	40	25	23	39	

Figure 13. Calendar view of MDA8 ozone observations from 2020-2024 from the Blair Street (29-510-0085) monitor.

Comparison of Fire-Influenced Ozone Exceedances with Historical Concentrations

U.S. EPA's Exceptional Events Guidance indicates that a clear causal demonstration should include a comparison of the event-related exceedance with historical concentrations measured at each monitor requested for data exclusion. Examples of supporting documentation include time-series plots overlaying five years of data and five-year percentiles. The Exceptional Events Guidance indicates that if the flagged data is above the 99th or higher percentile of the five-year distribution of ozone monitoring data, or is one of the four highest ozone concentrations within one year, these data can be considered outliers and provide strong evidence for the event.

Figure 14 shows the MDA8 ozone concentrations (solid blue line) from May and June 2023 at the West Alton monitor in Missouri portion of the St. Louis NAA where smoke enhancements are observed. Increased ozone above the 5-year 99th percentile (red dotted line) is evident on multiple dates in May and June, as indicated within grey columns. The grey columns indicate dates when smoke was observed to be present at the monitor location using NOAA's Hazardous Mapping System (HMS) Fire Detect and Smoke Plume Data overlay. Ozone concentrations were elevated at all sites on the Missouri side of the St. Louis NAA during these dates (Figure 15 through Figure 19), demonstrating that the region was impacted by an area-wide event.

All six of the Missouri monitors in the St. Louis NAA recorded MDA8 ozone concentrations above their 99th percentile values during May and June 2023, indicating a rare ozone episode. At all monitors, the observations from many of these days were in the top five days of the five-year period between 2020 and 2024, in many locations they were the single top value.

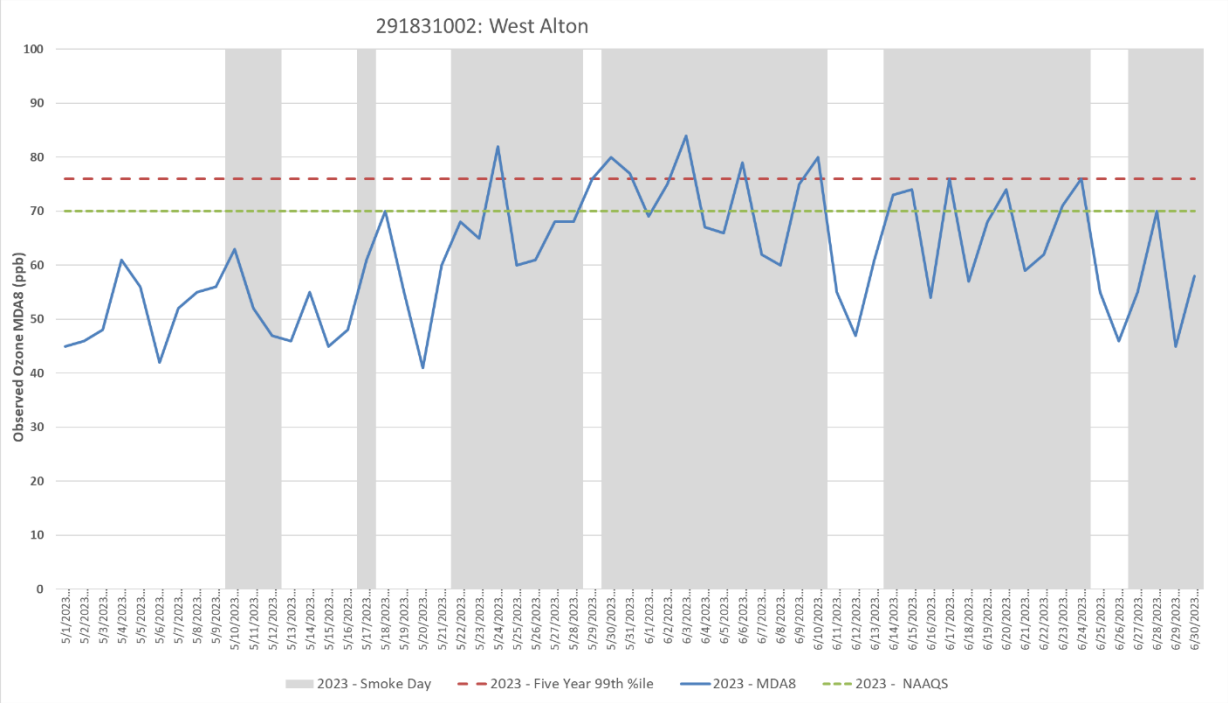


Figure 14. May-June 2023 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the West Alton (29-183-0002) monitor in St. Louis.

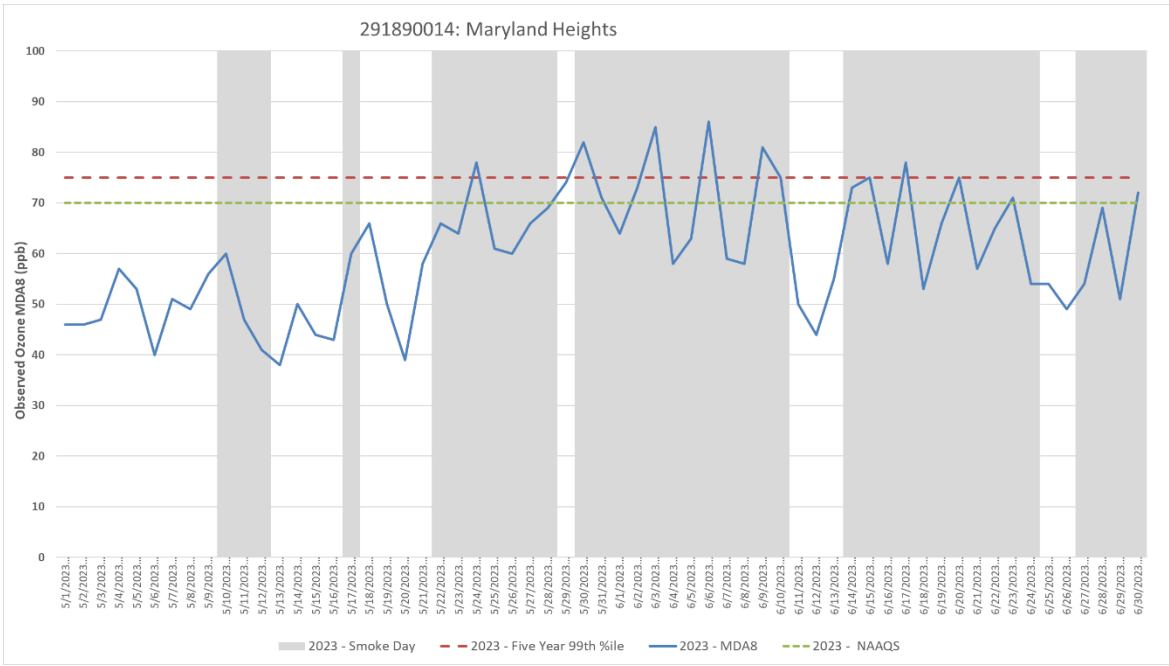


Figure 15. May-June 2023 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Maryland Heights (29-189-0004) monitor in St. Louis.

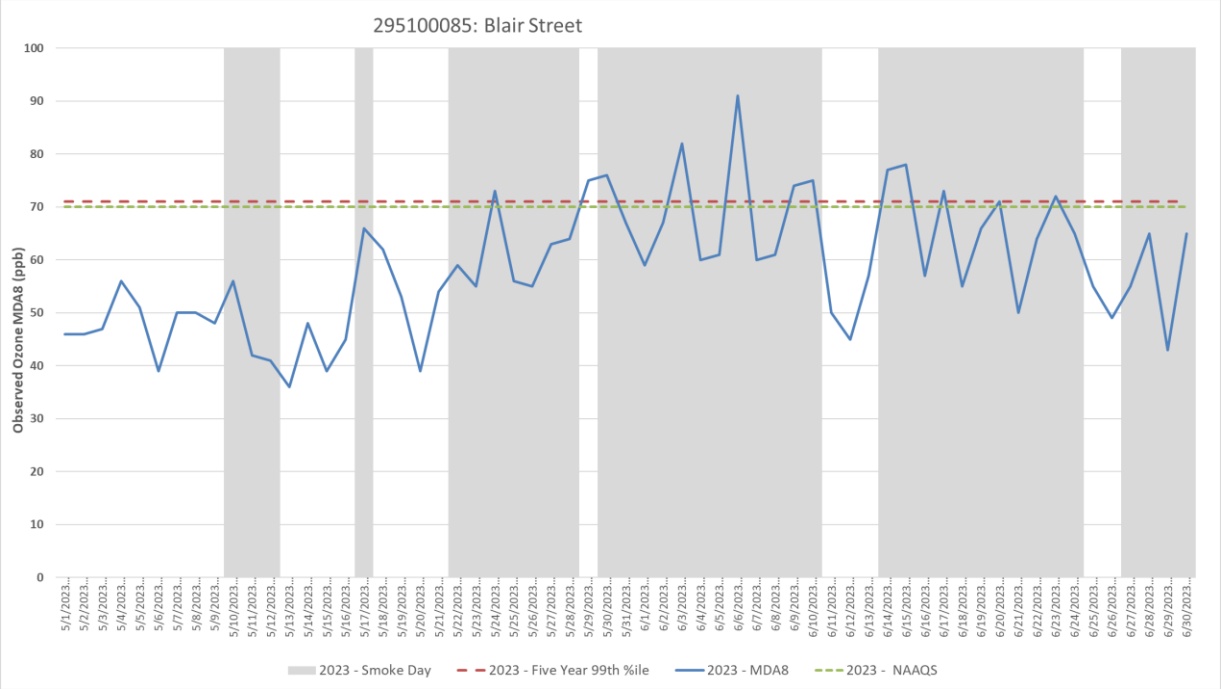


Figure 16. May-June 2023 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Blair Street (29-510-0085) monitor in St. Louis.

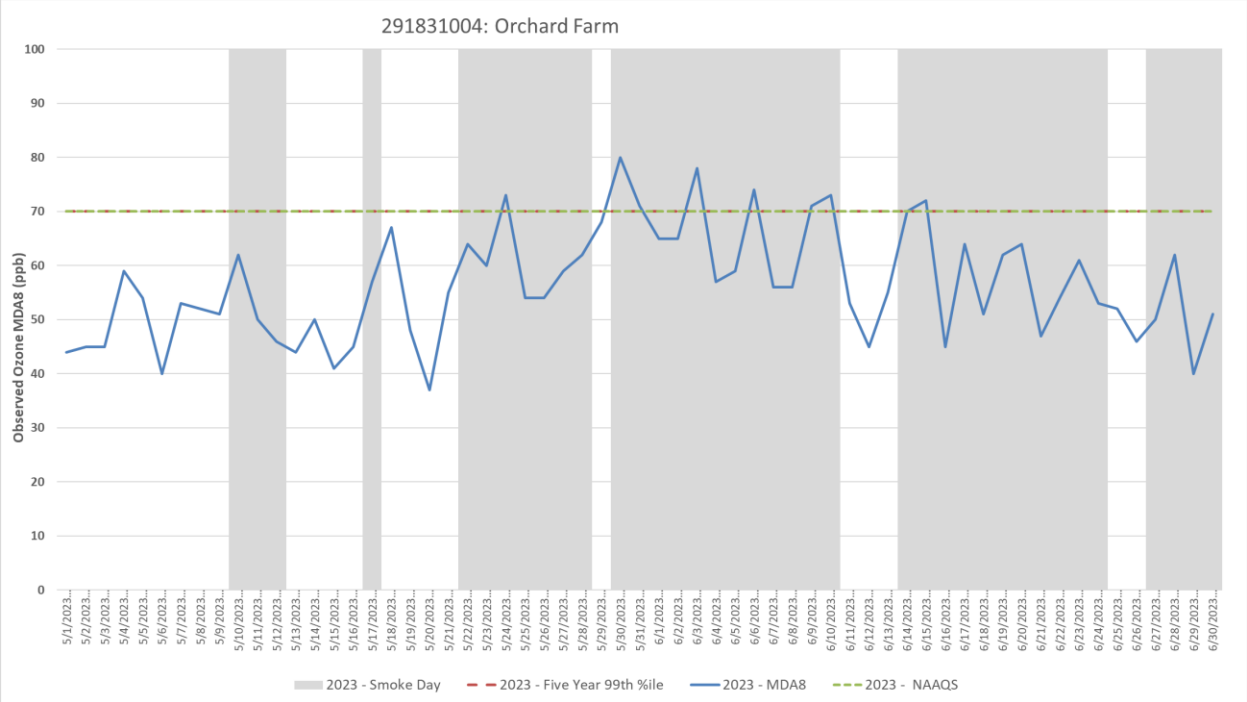


Figure 17. May-June 2023 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Orchard Farm (29-183-0004) monitor in St. Louis.

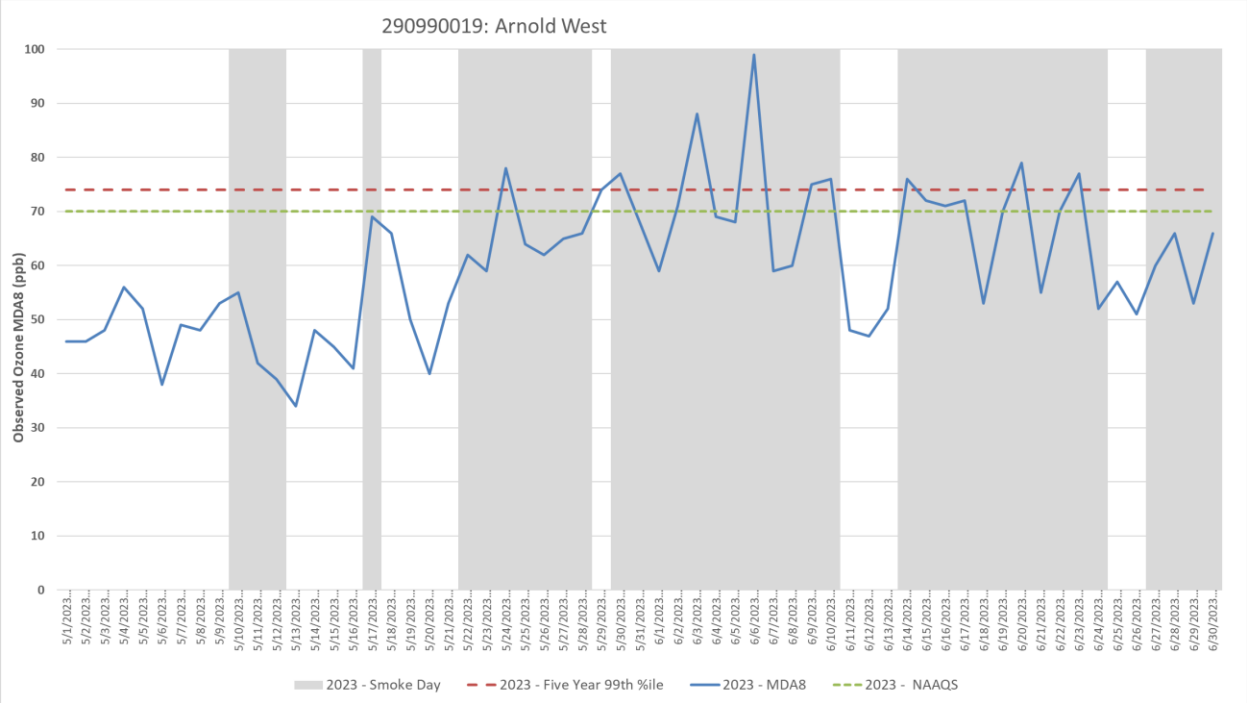


Figure 18. May-June 2023 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Arnold West (29-099-0019) monitor in St. Louis.

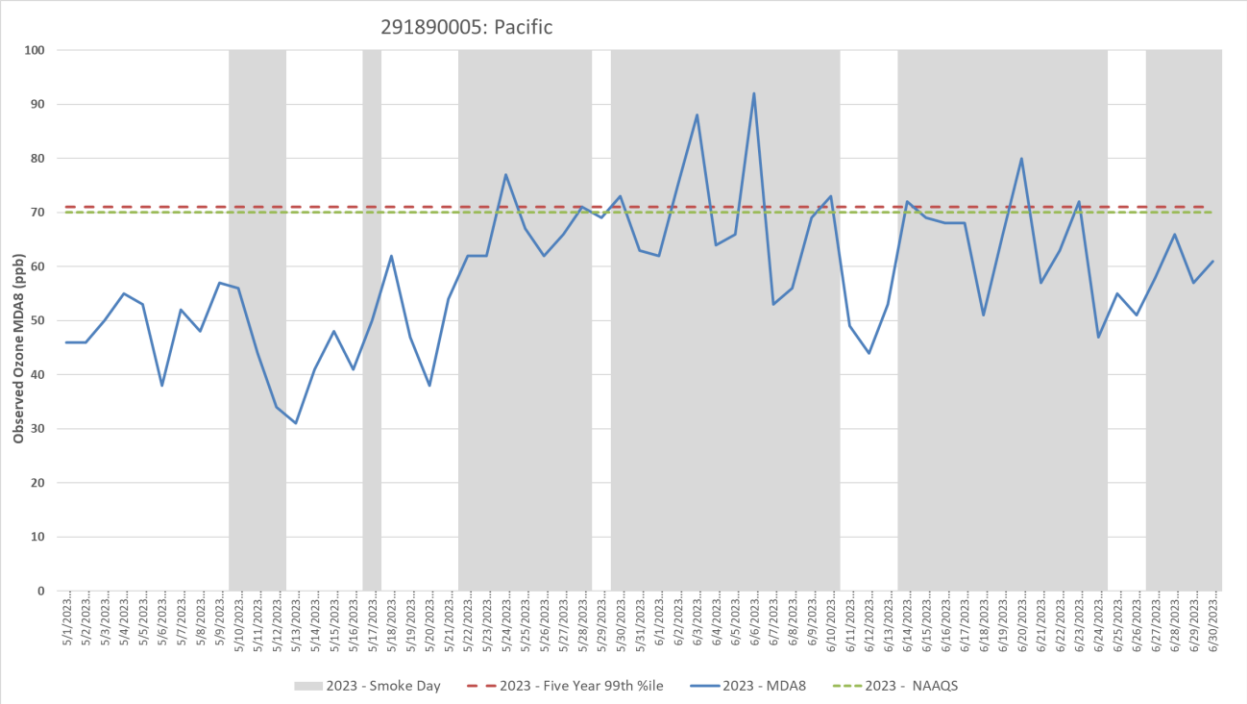


Figure 19. May-June 2023 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Pacific (29-189-0005) monitor in St. Louis.

The MDA8 ozone concentrations measured on June 3 (84 ppb), May 24 (82 ppb), May 30 (80 ppb), June 10 (80 ppb), and June 6 (79 ppb) in 2023 at the West Alton monitor were not only the top five observations for the year, but also the top five observations over the past five years (2020-2024). Figure 20 provides historical context of ozone concentrations at the Arnold West monitor (29-099-0019) and presents the MDA8 concentrations across the past five years with the May-June 2023 episode standing out in the figure. This period is among the observations that exceeded the 99th percentile threshold for the five-year period and are among the highest observations during the five years. Figure 21 through Figure 25 clearly demonstrates that May and June of 2023 included MDA8 observations that were unusually high across all the Missouri St. Louis NAA monitors.

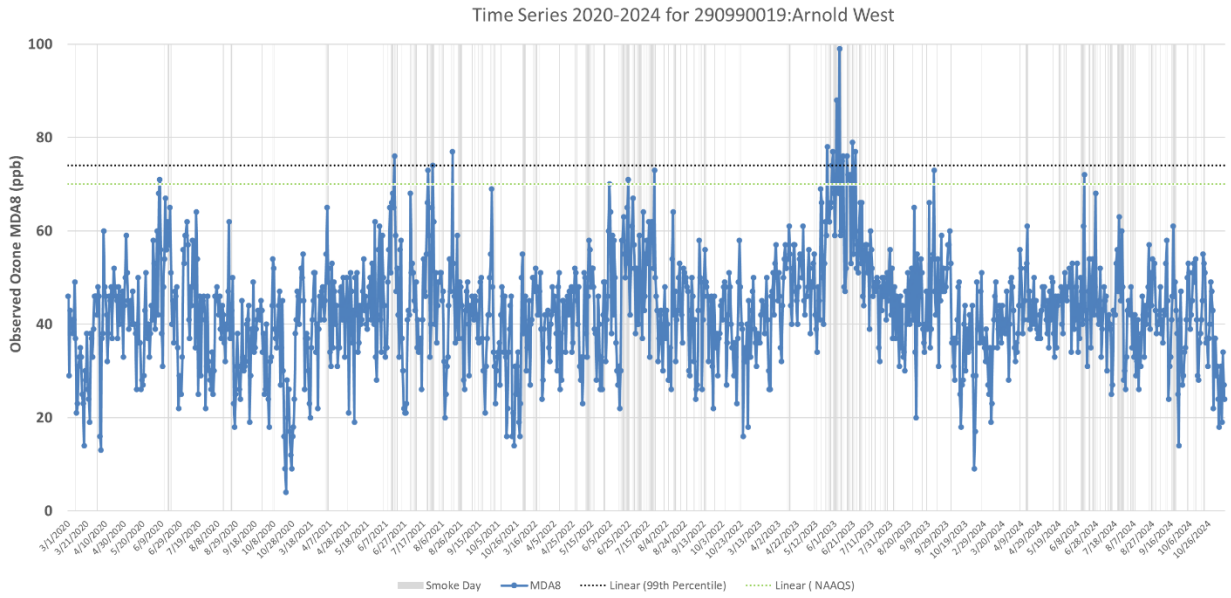


Figure 20. 2020-2024 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Arnold West (29-099-0019) monitor in St. Louis.

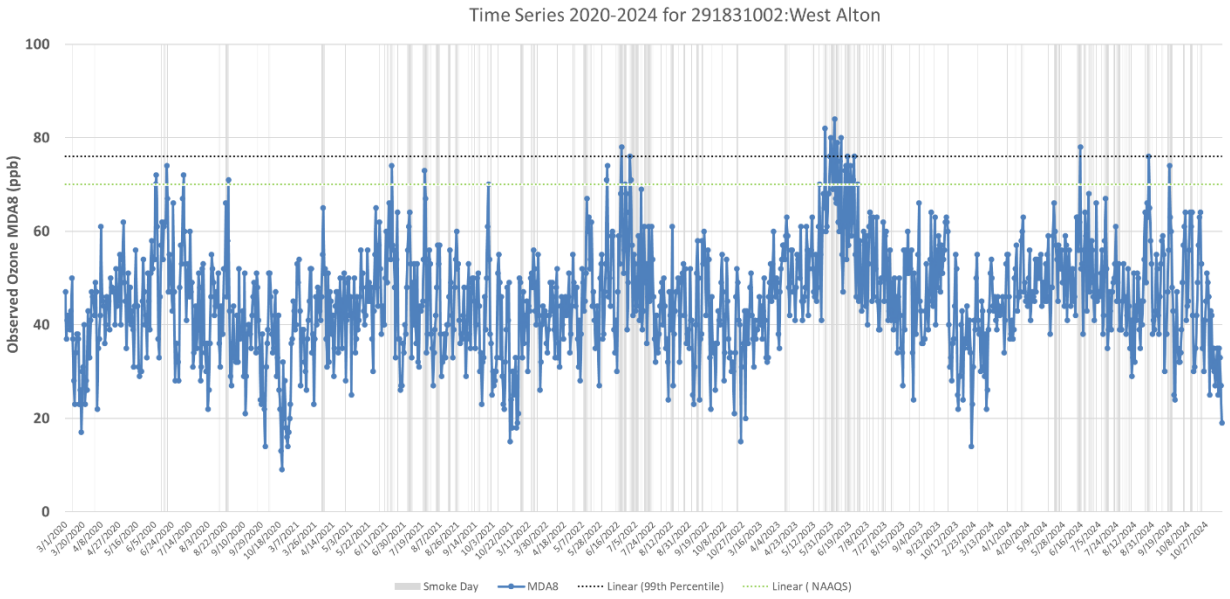


Figure 21. 2020-2024 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the West Alton (29-183-1002) monitor in St. Louis.

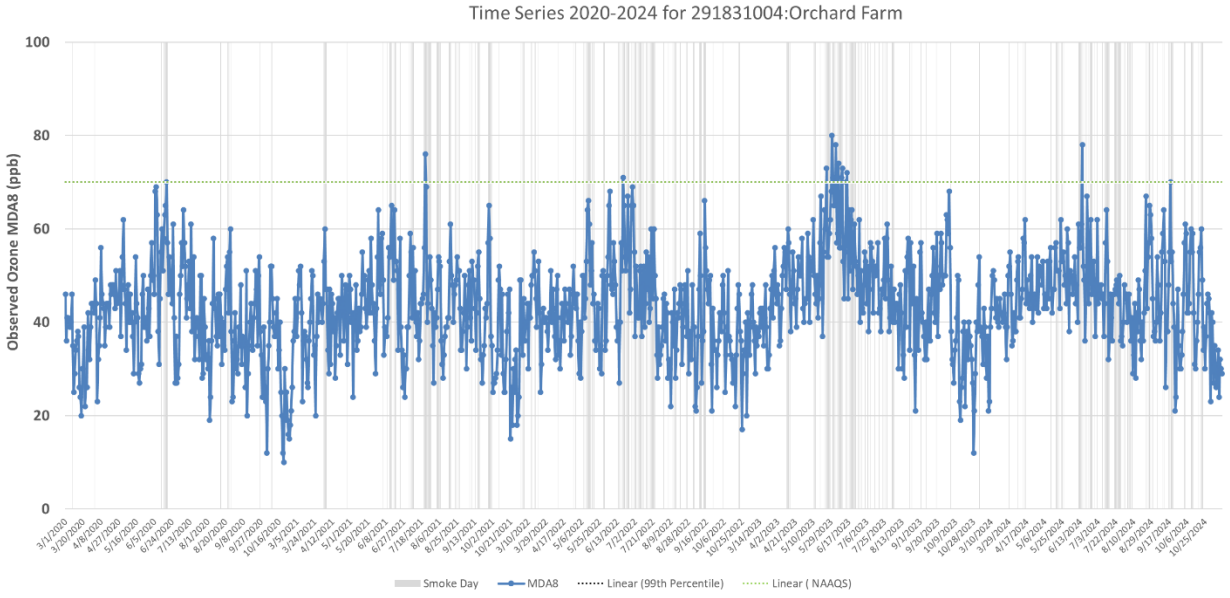


Figure 22. 2020-2024 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Orchard Farm (29-183-1004) monitor in St. Louis.

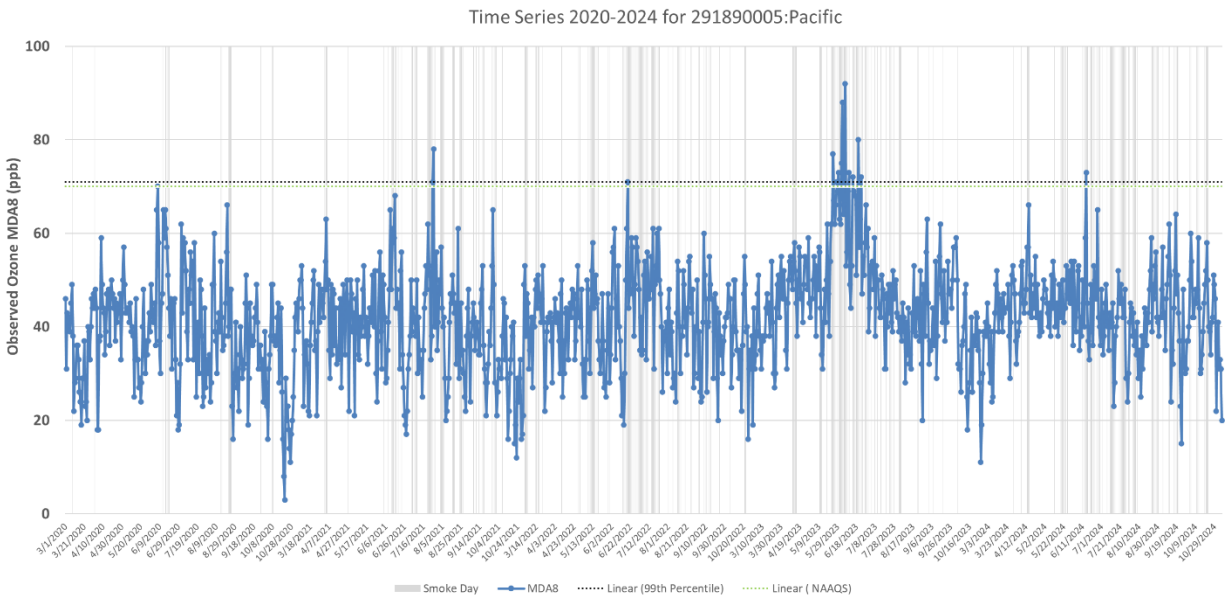


Figure 23. 2020-2024 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Pacific (29-189-0005) monitor in St. Louis.

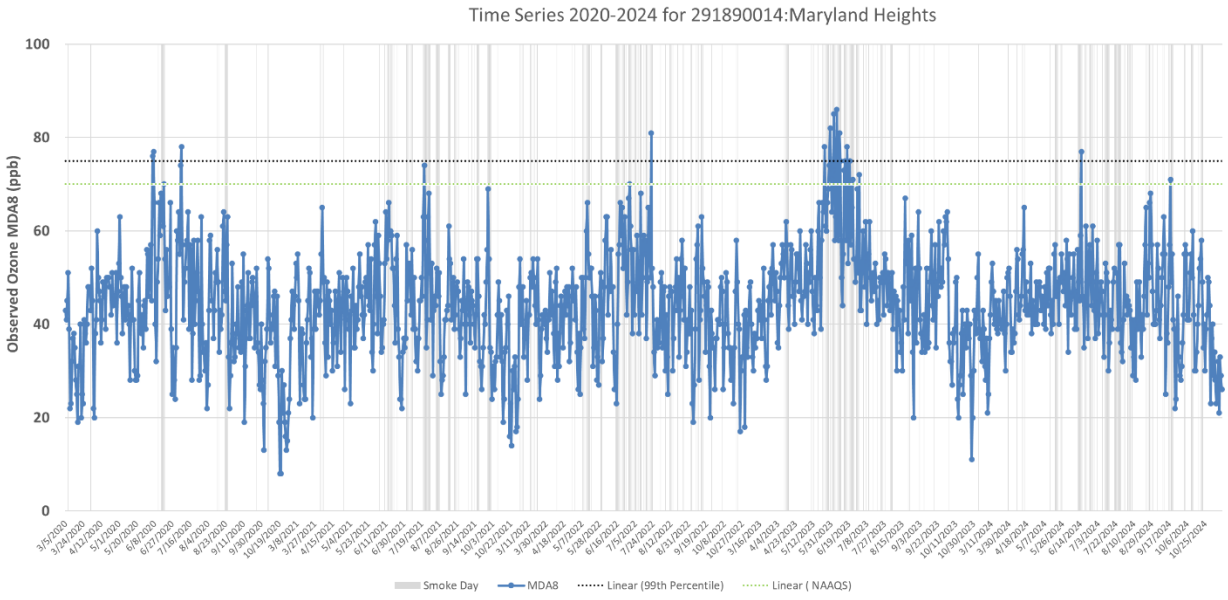


Figure 24. 2020-2024 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Maryland Heights (29-189-0014) monitor in St. Louis.

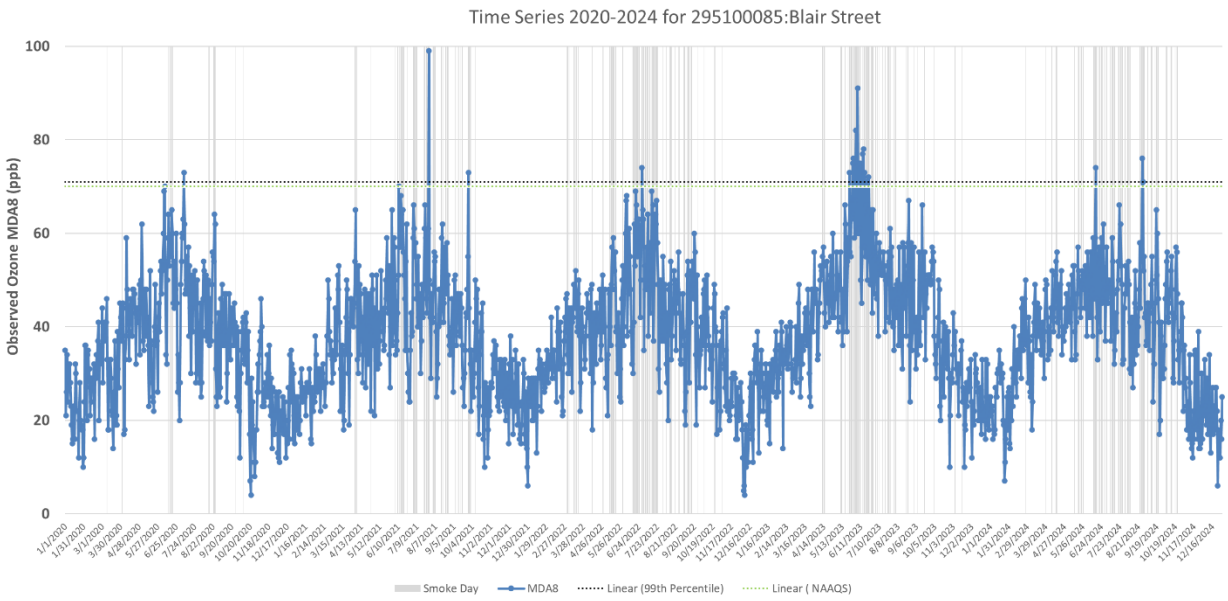


Figure 25. 2020-2024 time series of MDA8 ozone concentrations, 5-year 99th percentile values, and dates with NOAA HMS smoke indications at the Blair Street (29-510-0085) monitor in St. Louis.

Figure 26 through Figure 31 further demonstrate that many May and June 2023 MDA8 observations (blue line) were remarkably higher than the five-year May and June 2020-2024 average MDA8 concentrations (solid orange line) and were oftentimes more than two times the standard deviation (orange dotted lines) over this period. At some monitors on certain dates, the MDA8 observation was 30 to almost 50 ppb higher than the five-year average at that monitor for those months. In these figures, those dates and observations are highlighted with red bars.

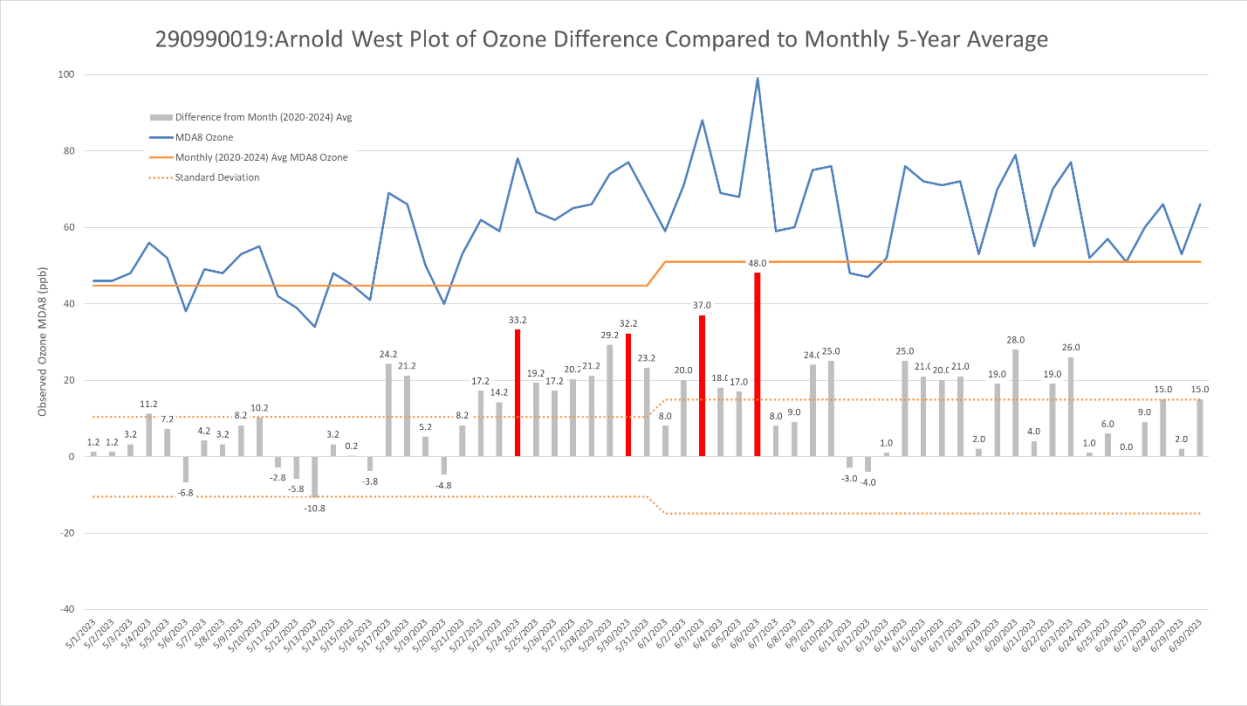


Figure 26. Arnold West May-June 2023 8-hr Ozone Comparison to May-June 2020-2024 Average 8-hr.

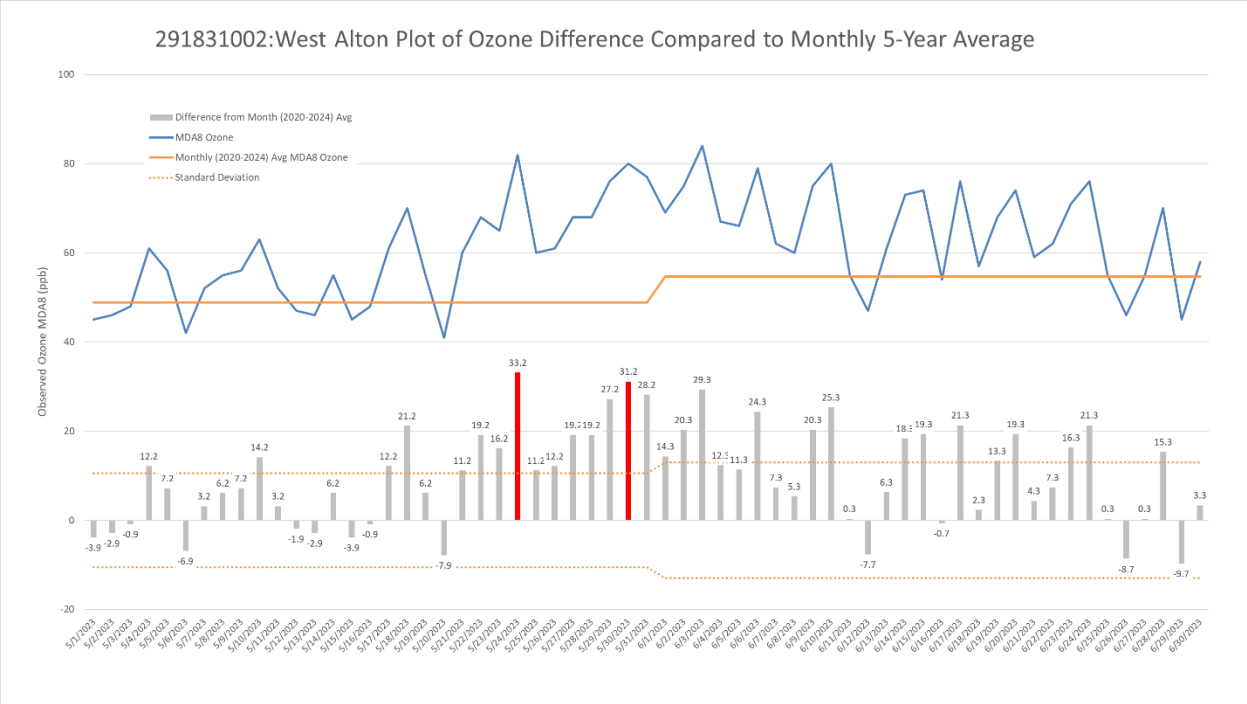


Figure 27. West Alton May-June 2023 8-hr Ozone Comparison to May-June 2020-2024 Average 8-hr.

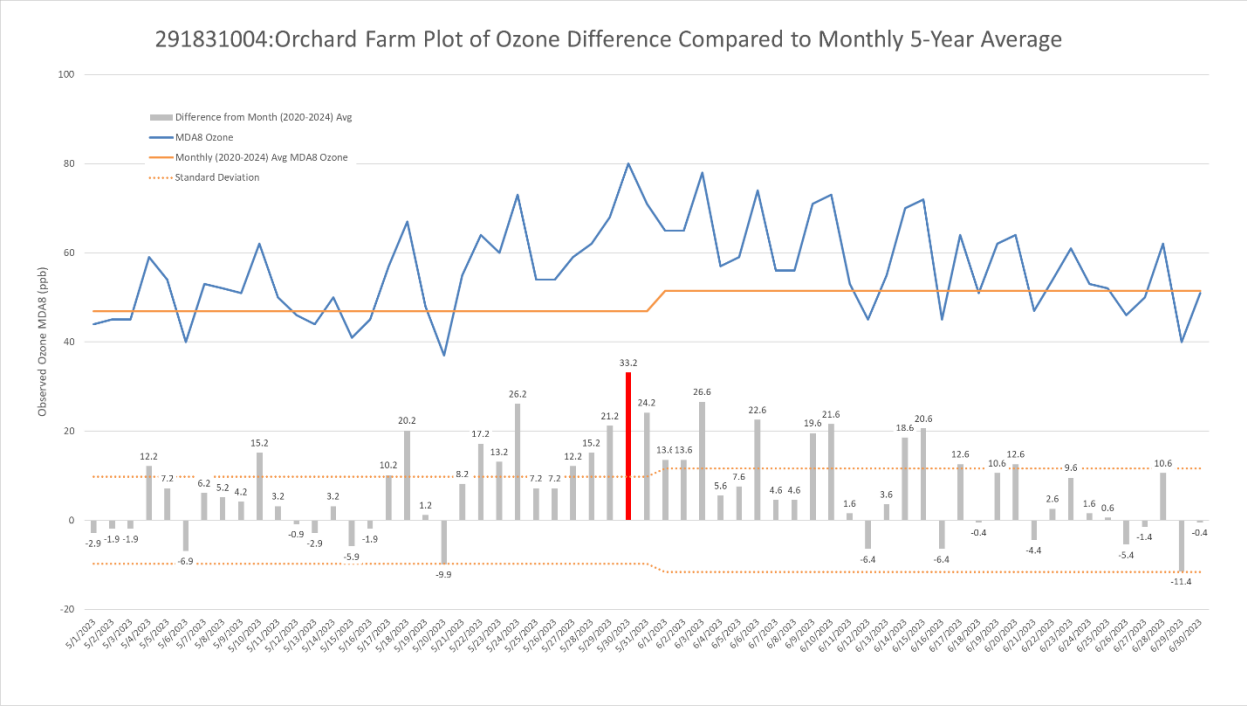


Figure 28. Orchard Farm May-June 2023 8-hr Ozone Comparison to May-June 2020-2024 Average 8-hr.

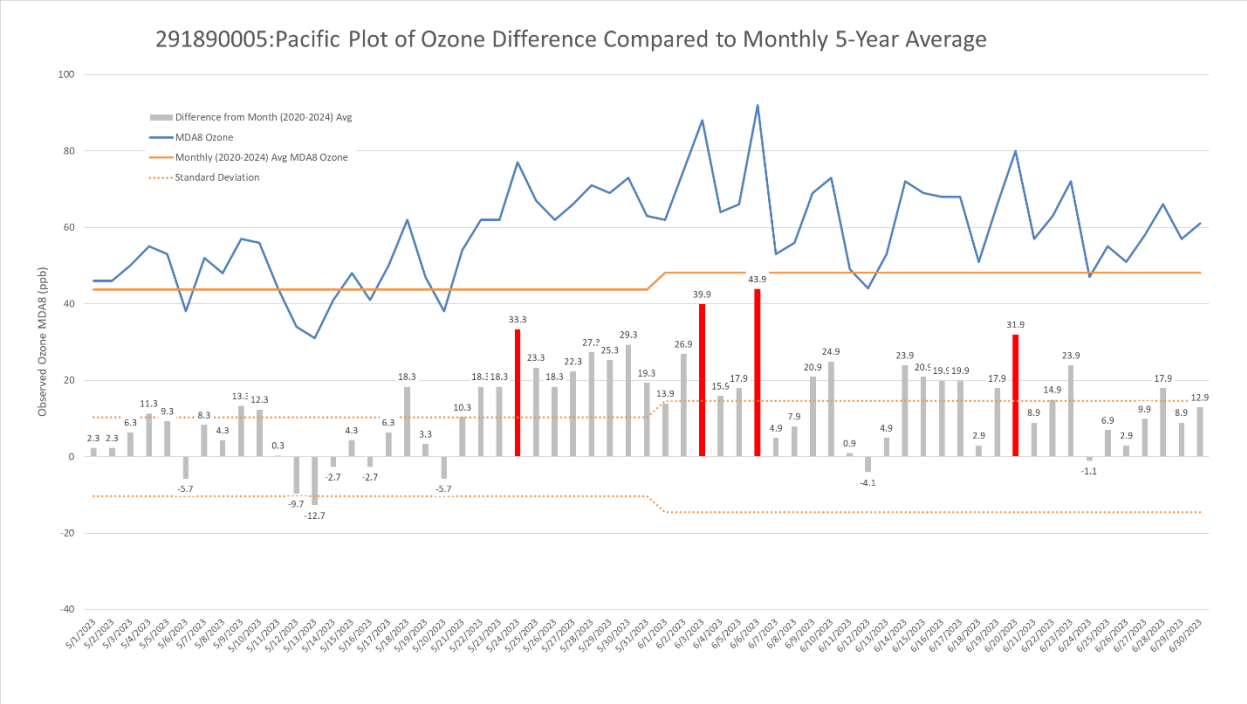


Figure 29. Pacific May-June 2023 8-hr Ozone Comparison to May-June 2020-2024 Average 8-hr.

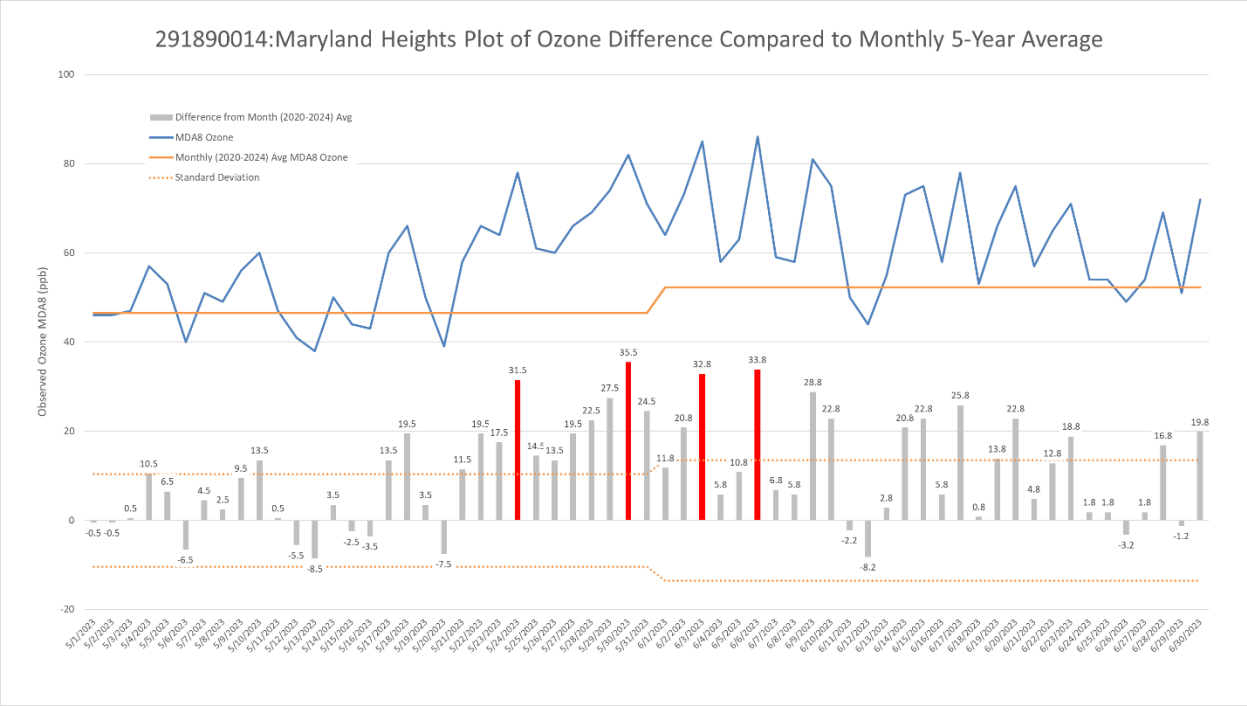


Figure 30. Maryland Heights May-June 2023 8-hr Ozone Comparison to May-June 2020-2024 Average 8-hr.

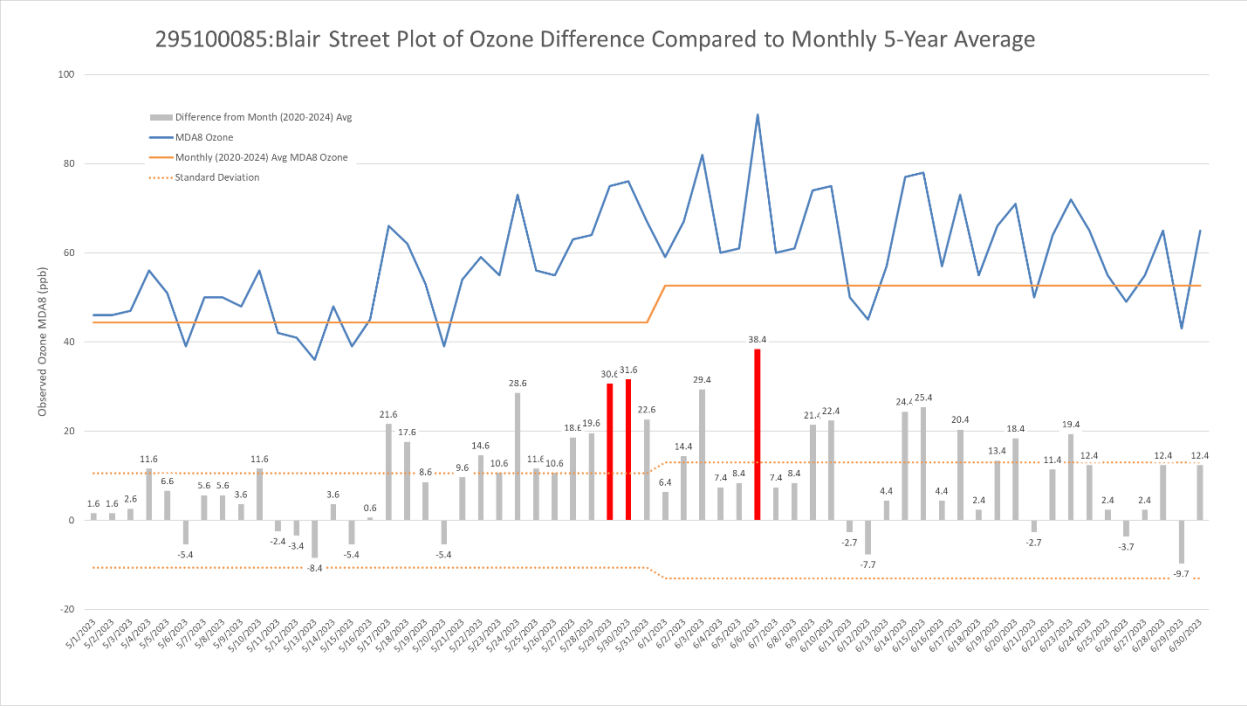


Figure 31. Blair Street May-June 2023 8-hr Ozone Comparison to May-June 2020-2024 Average 8-hr.

Multi-pollutant and alternate species corroboration

Missouri's monitoring network observes both total PM2.5 mass and speciated compounds such as ionic potassium (K+) and organic carbon (OC), as well as other pollutants such as carbon monoxide (CO) and elemental or black carbon (EC) which can act as tracers of wildfire emissions.

The daily PM2.5 concentrations at the Arnold West monitor (29-099-0019) and OC and K+ at the Blair Street monitor (29-510-0085) in the St. Louis area were examined.

Figure 32 provides daily PM2.5 concentrations during the summer of 2023 (May through September) and shows that enhanced PM2.5 concentrations correlate to dates when high ozone concentrations are also observed. It can also be seen that there is a buildup of PM2.5 as the Canadian wildfire smoke is present over the region for multiple days. In these instances, we see the gradual increase of PM2.5 concentrations, the longer the plumes reside over the region.

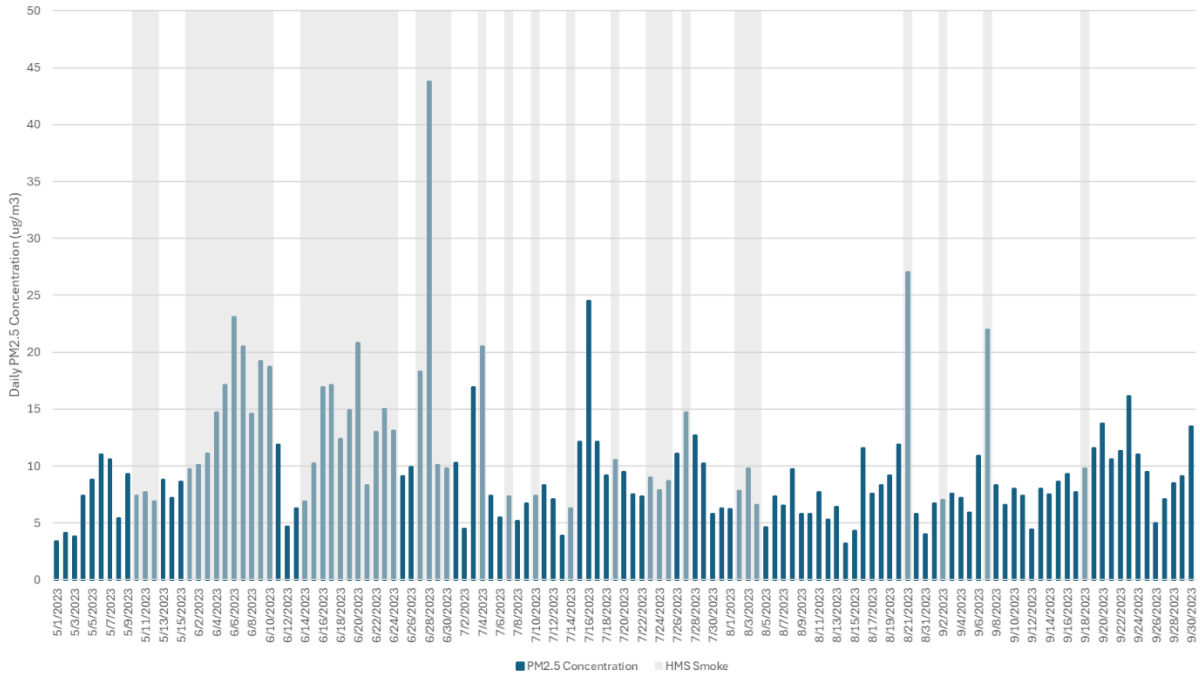


Figure 32. Daily PM2.5 concentrations at the Arnold West (29-099-0019) monitor; May through September 2023.

OC and K+ are the compounds most associated with wildfire emissions, so comparing these chemical compounds against the monitored 8-hour maximums for these months can provide evidence regarding the impact of such emissions. Speciated data (run every 3 or 6 days) retrieved from the Blair Street monitor (29-510-0085) showed increased concentrations of both species in May and June 2023, consistent with the track of the smoke plume analyzed by HMS and observed increases in the ozone

concentrations. K+ acts as a useful tracer of wildfire smoke because there are few anthropogenic sources, and concentrations above background levels are a signature of wildfire emissions.

Particularly in late May leading into early June 2023, the magnitudes of OC and K+ were largest at the monitor (except for July 5 observation associated with Independence Day fireworks), demonstrating influence by the wildfire smoke still present in the area. Since the K+ and OC are specific wood combustion markers, these speciated PM2.5 data provide conclusive evidence that the ozone affecting the airmass in St. Louis developed in areas under the heavy influence of smoke related emissions.

Figure 33 and Figure 34 show that OC, along with K+, increased around the time of the elevated ozone readings measures during the 2023 episodes at the Blair Street monitor, days in which smoke was visibly present over the location, providing further support that this was an event with a clear indicator of wildfire influence. What is also observed in these figures is the buildup of concentrations of these tracers as the Canadian wildfire smoke is persistent over the region for multiple days. In these instances, we see a gradual increase in these tracer species concentrations, the longer the plumes reside over the NAA.

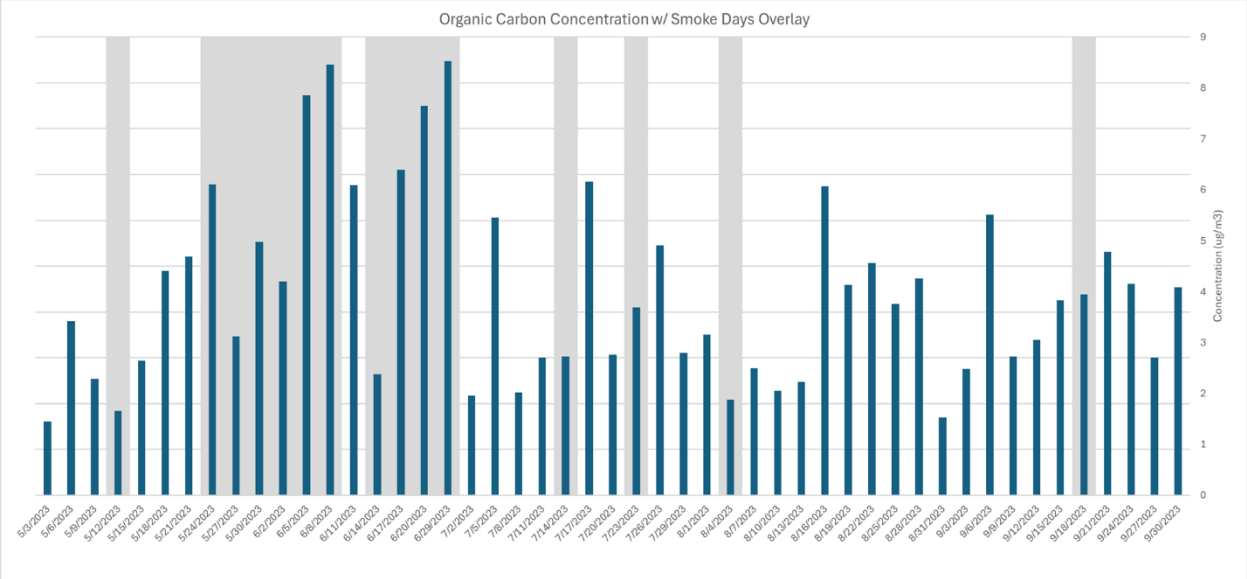


Figure 33. Organic carbon concentrations at Blair Street (29-510-0085) monitor; May through September 2023.

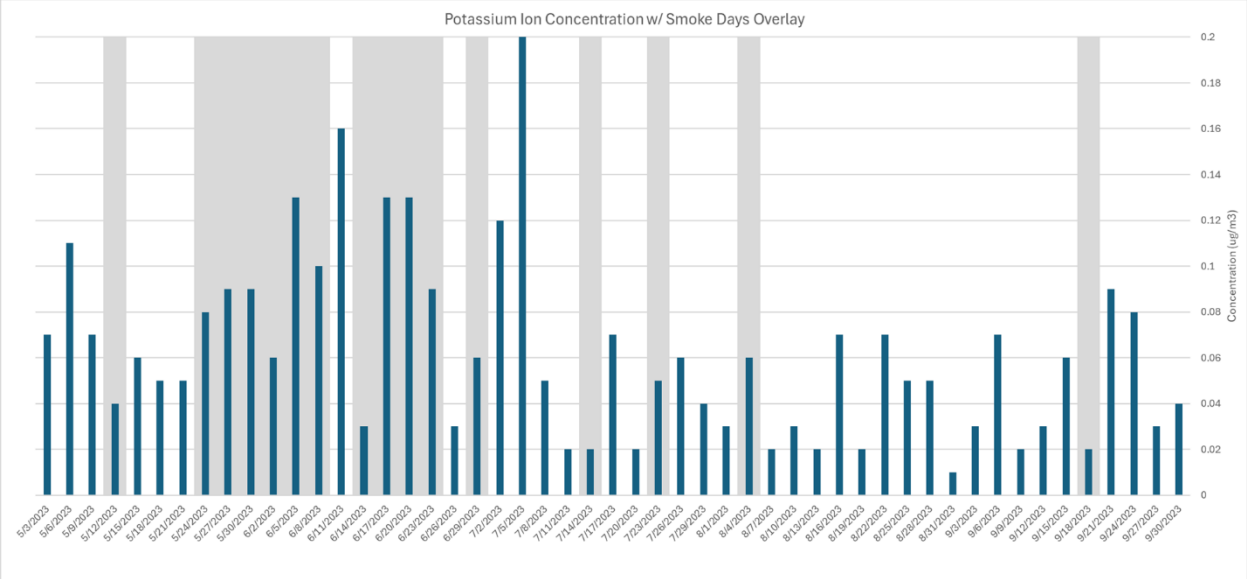


Figure 34. Potassium ion concentrations at Blair Street (29-510-0085) monitor; May through September 2023.

Evidence of Transport of Fire Emissions from the Fire to the Monitor

Visible Satellite Imagery

Visible satellite imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua and Terra satellites plainly shows transport of smoke from fires burning in Canada to the midwestern United States, including St. Louis, between May and June 2023, when ozone concentrations were at their highest. In the example episode below, June 4-6, 2023, the movement of a dense smoke plume south and southeast from Canada is particularly noteworthy as this plume eventually makes its way across the international border and into the Missouri region, enhancing ozone concentrations along its path.

The associated smoke text product produced by NOAA for June 6, 2023, and represented in Figure 37 notes the following:

"DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1550Z June 6, 2023

SMOKE:

Canada, Central United States and Eastern United States… Wildfire activity in northern British Columbia and the Northwest Territories continued to produce high-density smoke, contributing to a lengthy plume of moderate to high-density remnant smoke extending eastward over northern Canada and southward over Ontario and Quebec. Over southern Quebec, wildfire activity was producing a large area of high density smoke extending southwestward and southward, adding to the smoke from the western fires. This area of moderate to high density smoke was extending south and southwestward over much of the Eastern United States to as far south and west as portions of the Southeastern United States and Midwestern United States."

The movement of this smoke corresponds to the expansion of elevated ozone values along the pathway of transport to St. Louis, as demonstrated in following sections using ozone observations, NOAA HMS smoke products, and Ozone AQI maps.

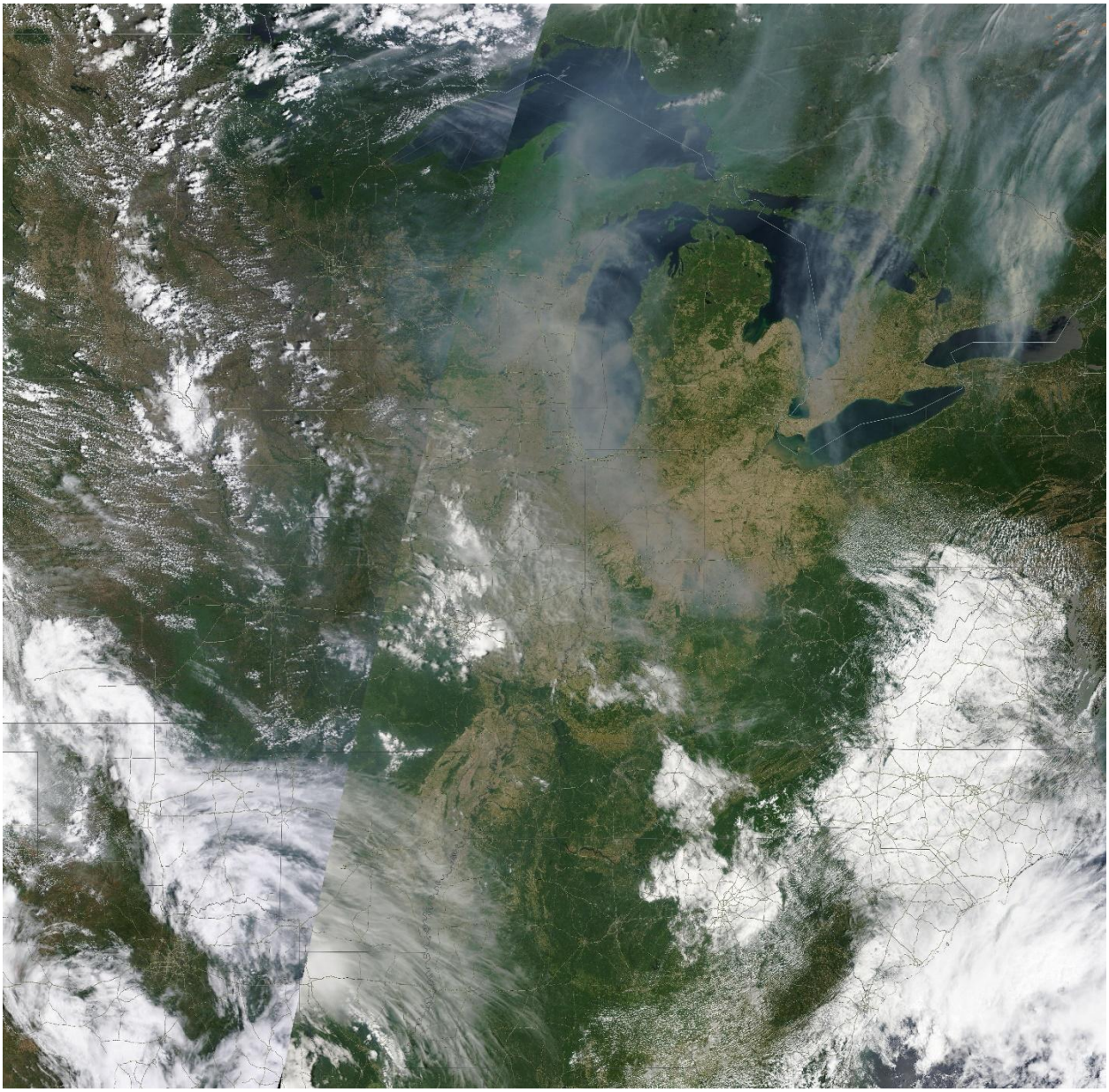


Figure 35. MODIS Terra true color satellite imagery from June 4, 2023, with smoke continuing to be present over Ontario, the Lake Michigan region, and the Mississippi Valley as it moves southwest into Missouri and the central states. Image source: NASA Worldview.

Figure 36. MODIS Terra true color satellite imagery from June 5, 2023, with smoke continuing to be present over Ontario, upper New York, the Lake Michigan region, the Mississippi Valley, the Mid-Atlantic region, and St. Louis as it moves southwest into the central states. Image source: NASA Worldview.

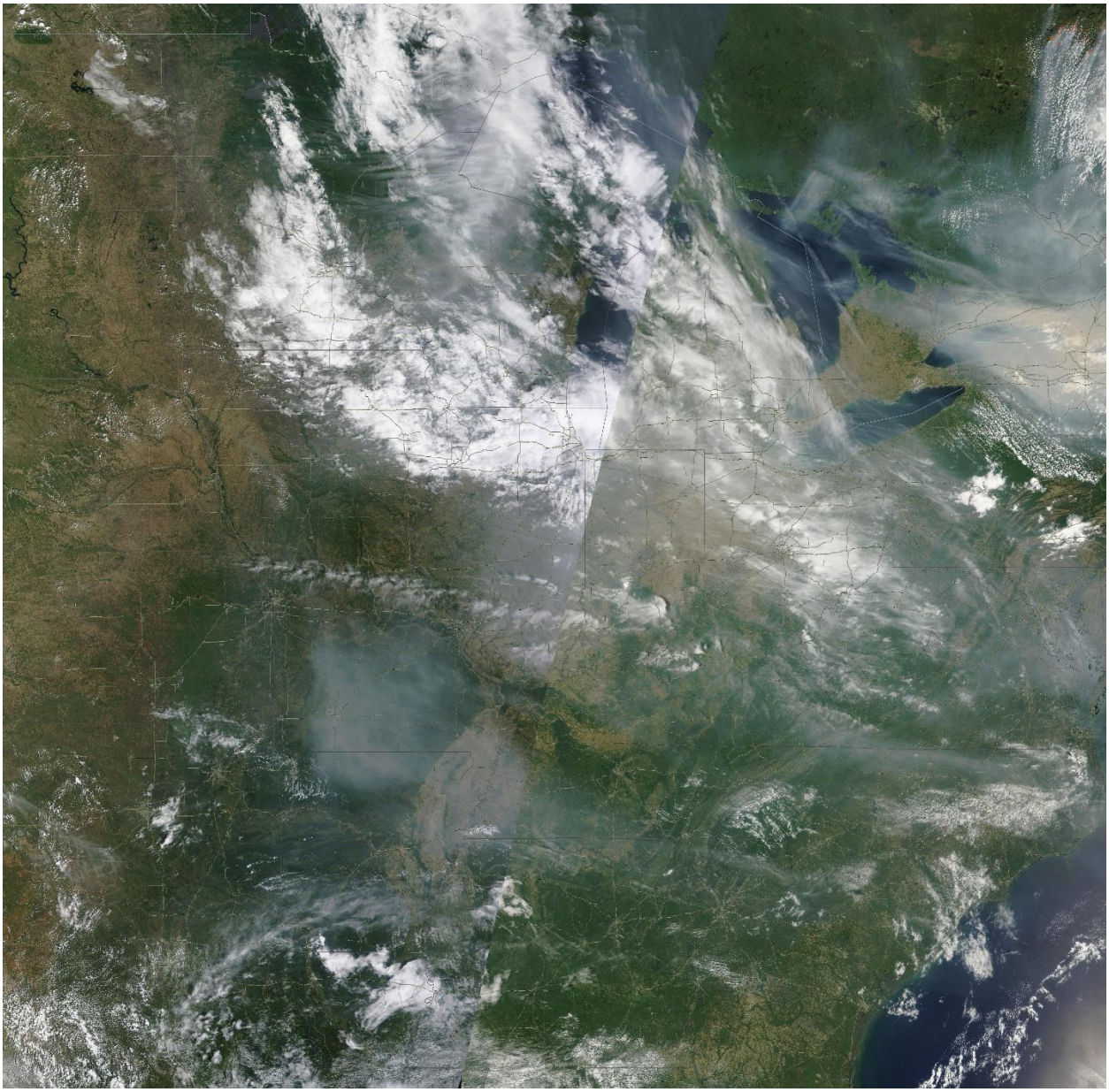


Figure 37. MODIS Terra true color satellite imagery from June 6, 2023, with smoke continuing to be present over Lake Michigan, the Mississippi Valley, the Mid-Atlantic region, and St. Louis as it moves southwest into the central states. Image source: NASA Worldview.

HMS Smoke Plume Data and Ozone AQI Maps

Based on the considerable collective size of the Canadian wildfire complexes, significant amounts of ozone and PM2.5 precursors were emitted in addition to other smoke components. As early as May 10, 2023, plumes from the Canadian wildfires began dispersing into the St. Louis region. Through all of June and into early July, with additional episodes in mid-July and mid-August, wildfire smoke was prevalent in the Midwestern U.S. and enhanced ozone concentrations in Missouri.

Figure 38 shows the progression of the smoke plumes over the Midwest during the example episode of June 4, 5, and 6, 2023, as analyzed by the HMS staff at NOAA, using satellite images and Ozone AQI. This series of maps shows the movement of the Canadian smoke plumes as a first plume tracks west and then south toward the Mississippi Valley eventually finding its way over St. Louis during the episode.

As shown in these figures, the Ozone AQI from June 4 and 5, 2023, showed an impact on monitors in St. Louis and the surrounding areas. Additionally, the Ozone AQI tracks well with the movement of the densest portion of the smoke plume with highest values coinciding with thickest smoke. Figure 38 corroborates the evidence of smoke over St. Louis demonstrated by the visual satellite images (Figure 35 through Figure 37) that enhanced the ozone concentrations during June 4-6, 2023.

Additional ozone AQI and HMS smoke plume plots for May and June 2023 can be found in Appendix A.

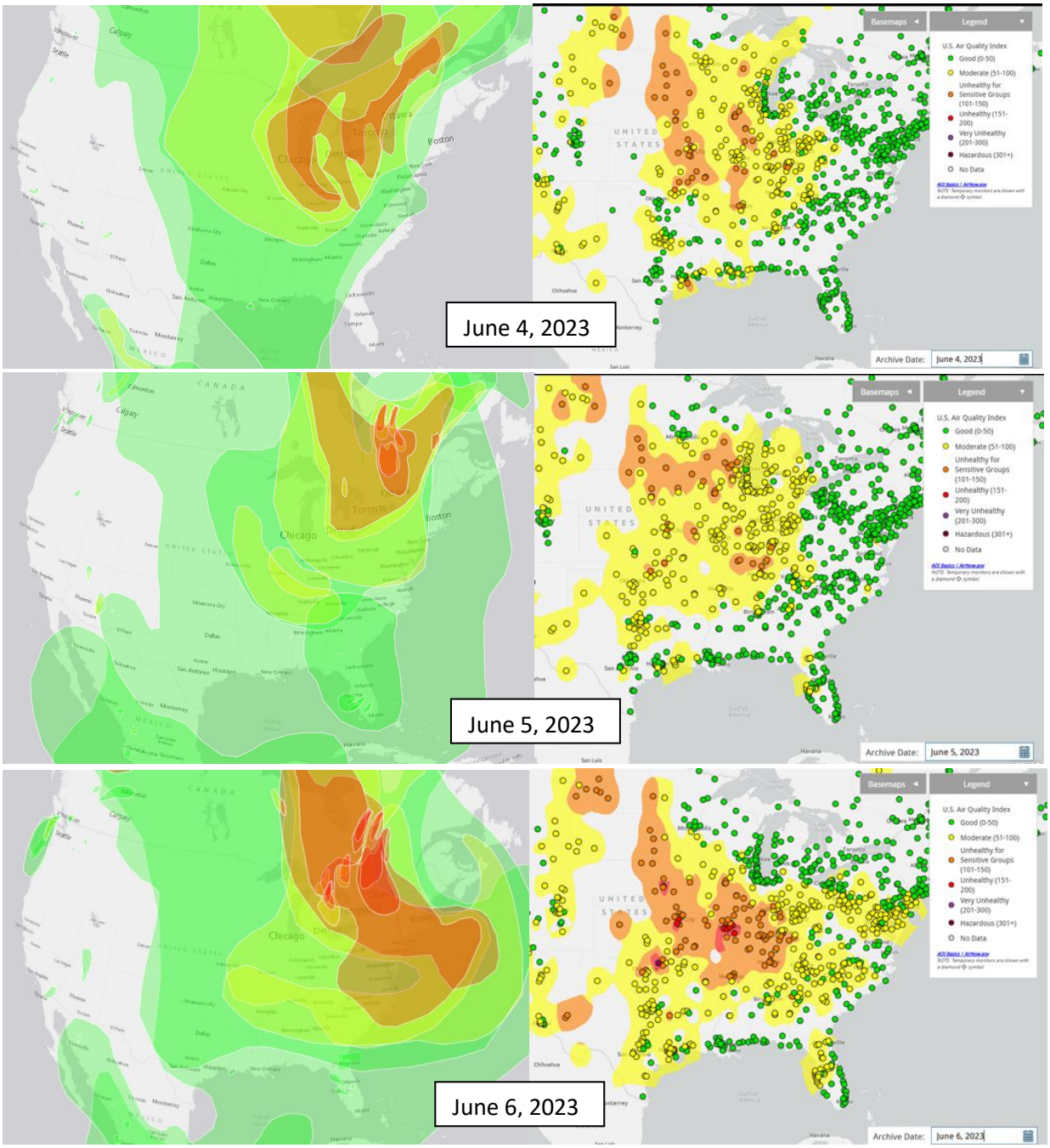


Figure 38. HMS Smoke Analysis (left) and Ozone AQI Maps (right) from June 4-6, 2023.

Regional Supporting Measurements

Additionally, the comparison of the HMS smoke plumes with MDA8 ozone concentrations shows that ozone concentrations increased at monitors along the paths of the smoke plumes between Canada, the northern and Midwestern states, and across all of Missouri. This impact is even clearer based on examination of the highest ozone concentrations at other Missouri sites. Ozone concentrations on most of the examined dates, as presented in Table 3, were associated with the ten highest annual concentrations at all other monitors within Missouri. While many of these sites may not have exceeded the level of the ozone NAAQS during this period, it is clearly seen that during the episode of the smoke transport, these sites had unusually high MDA8 ozone concentrations.

In fact, across all the monitors in Missouri and across all the top ten days at each of those monitors, only seven monitor-days observed did not occur within the May and June 2023 Canadian wildfire extended episode.

Table 3. Observed Top Ten MDA8 Ozone Concentrations (ppb) at Monitors in Missouri enhanced by the Canadian Wildfire Smoke during the Period May-June 2023 (episode days May-June 2023 highlighted in orange).

			MDA8 Ozone Observations (ppb)																			
State	County	Monitor ID	1st Max Value	1st Max Date	2nd Max Value	2nd Max Date	3rd Max Value	3rd Max Date	4th Max Value	4th Max Date	5th Max Value	5th Max Date	6th Max Value	6th Max Date	7th Max Value	7th Max Date	8th Max Value	8th Max Date	9th Max Value	9th Max Date	10th Max Value	10th Max Date
Missouri	Andrew	290030001	76	6/3/2023	75	6/6/2023	73	6/4/2023	72	6/20/2023	71	5/22/2023	71	5/25/2023	70	9/18/2023	69	6/16/2023	68	5/29/2023	68	6/7/2023
Missouri	Boone	290190011	83	6/3/2023	74	6/5/2023	74	6/20/2023	72	6/10/2023	71	6/6/2023	70	5/28/2023	69	6/14/2023	69	6/15/2023	67	5/23/2023	67	6/7/2023
Missouri	Callaway	290270002	80	6/3/2023	73	6/6/2023	73	6/20/2023	71	6/10/2023	71	6/15/2023	70	6/5/2023	70	6/14/2023	68	6/23/2023	67	5/28/2023	67	6/19/2023
Missouri	Cass	290370003	83	6/6/2023	75	6/4/2023	74	6/7/2023	73	5/25/2023	69	6/3/2023	69	6/20/2023	69	6/21/2023	68	6/15/2023	66	6/9/2023	64	5/17/2023
Missouri	Cedar	290390001	77	6/6/2023	74	6/4/2023	73	5/25/2023	72	6/7/2023	69	6/20/2023	67	6/21/2023	66	6/9/2023	66	8/3/2023	65	6/3/2023	62	6/1/2023
Missouri	Clay	290470003	75	6/6/2023	74	6/3/2023	71	5/25/2023	71	6/15/2023	70	7/10/2023	69	6/4/2023	69	6/5/2023	69	6/9/2023	69	6/14/2023	67	6/23/2023
Missouri	Clay	290470005	80	6/15/2023	76	6/6/2023	74	5/25/2023	74	6/3/2023	73	6/14/2023	71	6/4/2023	71	6/9/2023	69	6/5/2023	68	7/10/2023	67	6/7/2023
Missouri	Clay	290470006	77	6/15/2023	76	5/25/2023	75	6/6/2023	74	6/3/2023	74	6/14/2023	74	6/30/2023	72	6/4/2023	71	6/9/2023	70	5/29/2023	70	6/5/2023
Missouri	Clinton	290490001	78	6/6/2023	76	5/25/2023	76	6/3/2023	76	9/2/2023	73	6/4/2023	71	5/29/2023	71	6/5/2023	71	6/7/2023	70	6/9/2023	70	6/20/2023
Missouri	Greene	290770036	76	5/25/2023	73	6/6/2023	72	6/4/2023	71	6/7/2023	70	6/21/2023	68	6/20/2023	67	6/3/2023	65	6/5/2023	64	5/23/2023	62	5/29/2023
Missouri	Greene	290770042	77	5/25/2023	73	6/6/2023	72	6/4/2023	72	6/7/2023	70	6/21/2023	68	6/3/2023	68	6/5/2023	68	6/20/2023	65	6/23/2023	65	8/3/2023
Missouri	Jasper	290970004	75	6/6/2023	72	6/4/2023	72	6/7/2023	69	5/25/2023	67	6/20/2023	67	6/21/2023	65	5/23/2023	65	6/5/2023	65	9/7/2023	64	5/26/2023
Missouri	Jefferson	290990019	99	6/6/2023	88	6/3/2023	79	6/20/2023	78	5/24/2023	77	5/30/2023	77	6/23/2023	76	6/10/2023	76	6/14/2023	75	6/9/2023	74	5/29/2023
Missouri	Lincoln	291130004	82	6/3/2023	77	5/30/2023	76	6/6/2023	76	6/10/2023	75	5/24/2023	74	6/9/2023	74	6/17/2023	74	6/23/2023	73	5/22/2023	73	5/31/2023
Missouri	Monroe	291370001	76	6/3/2023	75	6/20/2023	71	6/23/2023	70	6/10/2023	70	6/14/2023	69	6/6/2023	68	6/15/2023	67	6/19/2023	66	5/29/2023	66	6/22/2023
Missouri	Perry	291570001	85	6/10/2023	84	6/3/2023	83	6/23/2023	80	6/6/2023	77	6/15/2023	76	5/29/2023	76	6/9/2023	75	5/24/2023	74	6/28/2023	71	6/4/2023
Missouri	Saint Charles	291831002	84	6/3/2023	82	5/24/2023	80	5/30/2023	80	6/10/2023	79	6/6/2023	77	5/31/2023	76	5/29/2023	76	6/17/2023	76	6/24/2023	75	6/2/2023
Missouri	Saint Charles	291831004	80	5/30/2023	78	6/3/2023	74	6/6/2023	73	5/24/2023	73	6/10/2023	72	6/15/2023	71	5/31/2023	71	6/9/2023	70	6/14/2023	68	5/29/2023
Missouri	Sainte Genevieve	291860005	84	6/6/2023	82	6/3/2023	82	6/9/2023	78	6/23/2023	77	6/4/2023	77	6/20/2023	76	6/17/2023	75	6/10/2023	74	6/16/2023	73	6/15/2023
Missouri	Saint Louis	291890005	92	6/6/2023	88	6/3/2023	80	6/20/2023	77	5/24/2023	75	6/2/2023	73	5/30/2023	73	6/10/2023	72	6/14/2023	72	6/23/2023	71	5/28/2023
Missouri	Saint Louis	291890014	86	6/6/2023	85	6/3/2023	82	5/30/2023	81	6/9/2023	78	5/24/2023	78	6/17/2023	75	6/10/2023	75	6/15/2023	75	6/20/2023	74	5/29/2023
Missouri	St. Louis City	295100085	91	6/6/2023	82	6/3/2023	78	6/15/2023	77	6/14/2023	76	5/30/2023	75	5/29/2023	75	6/10/2023	74	6/9/2023	73	5/24/2023	73	6/17/2023

Recommendations

Based on the results of this analysis and the widespread impact of Canadian wildfire smoke on Missouri monitors both within the St. Louis ozone nonattainment area and statewide, the following action is recommended.

1. Each date at each monitor within the Missouri portion of the St. Louis NAA identified to have been influenced by Canadian wildfire smoke during the May-June 2023 episode, and found to have enhanced ozone concentrations as a result, should be flagged as influenced by exceptional events, and the associated pollutant concentration values should be removed from the regulatory record used to determine design values and attainment designations.
    a. The "regulatory significant" nomenclature typically applied to concurring with exceptional events demonstrations should not be limited to the attainment / nonattainment determination and instead should include any date or concentration that was enhanced by wildfire smoke, regardless of the attainment outcome of the exceptions.
2. Consideration should be given to excluding dates and concentrations at other monitors outside of the Missouri portion of the St. Louis NAA, but in the same regional airshed, that would have also been impacted by Canadian wildfire smoke during the same May-June 2023 episode. This may include simply referencing other state exceptional events demonstrations when proximal monitors were impacted on the same dates and by the same wildfire plumes. An example application would be excluding dates and concentrations from Illinois monitors within the St. Louis ozone nonattainment area consistent with dates and monitors on the Missouri side of the nonattainment area.
3. Consideration should be given to states, including Missouri, to allow limited information necessary to support the clear causal relationship criterion for any wildfire date that fell within the 2023 Canadian wildfire episode. Ample evidence has been provided here and elsewhere to support the fact that smoke from Canadian wildfires in spring and summer of 2023 had significant impact on ozone and PM2.5 observations and enhanced concentrations beyond reasonable and typical conditions. As it is understood that MoDNR is preparing an exceptional events demonstration for monitors and dates affected during the Canadian wildfire episodes of 2023, it would be appropriate to allow for information in this document to be adopted to satisfy Tier 1 obligations in that demonstration.

ALPINE GEOPHYSICS

Appendix A

Ozone AQI and HMS Smoke Plots – May 15 – June 30, 2023

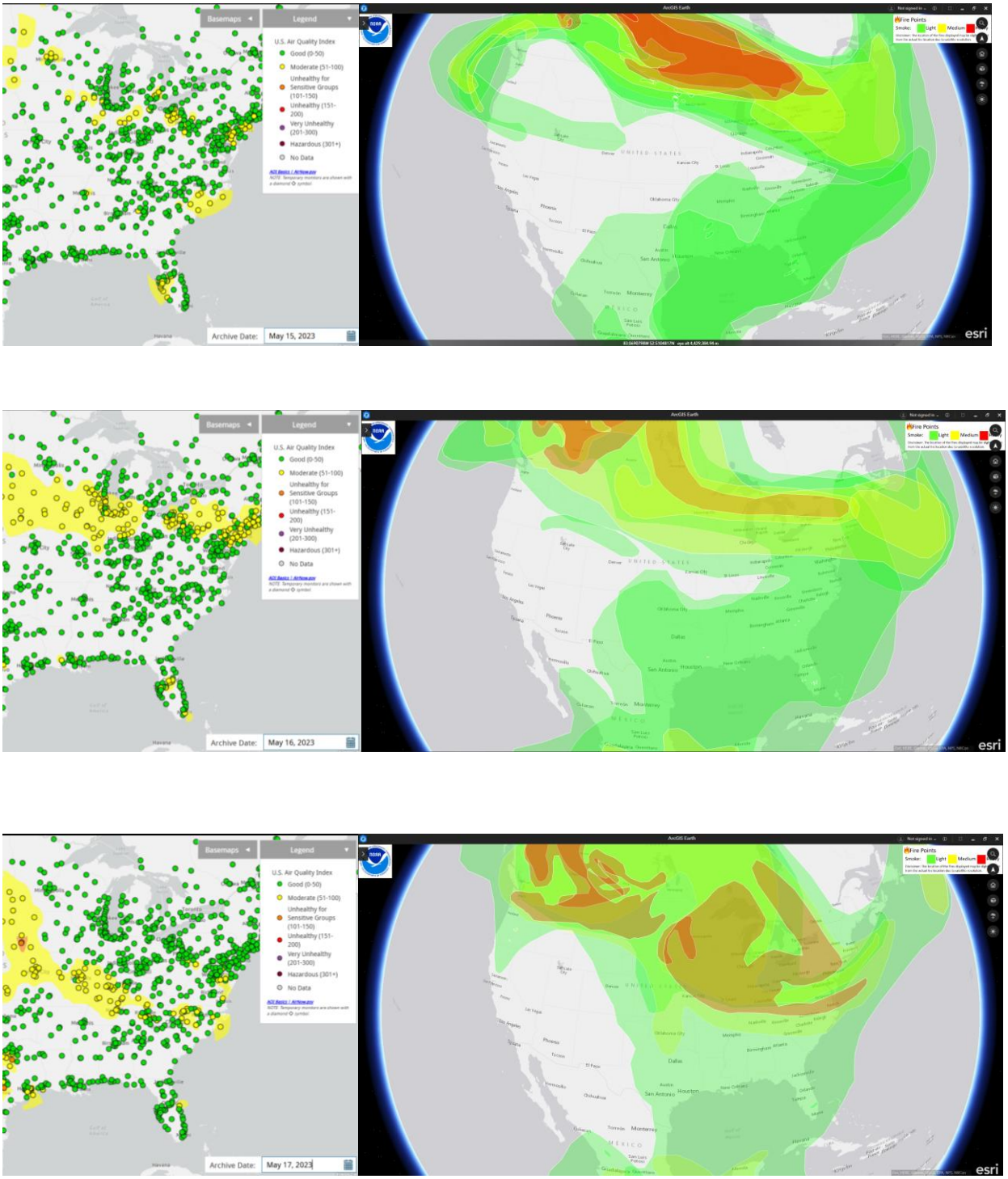


Figure A-1. Ozone AQI and HMS Smoke Plots, May 15 (top), May 16 (middle), and May 17 (bottom), 2023

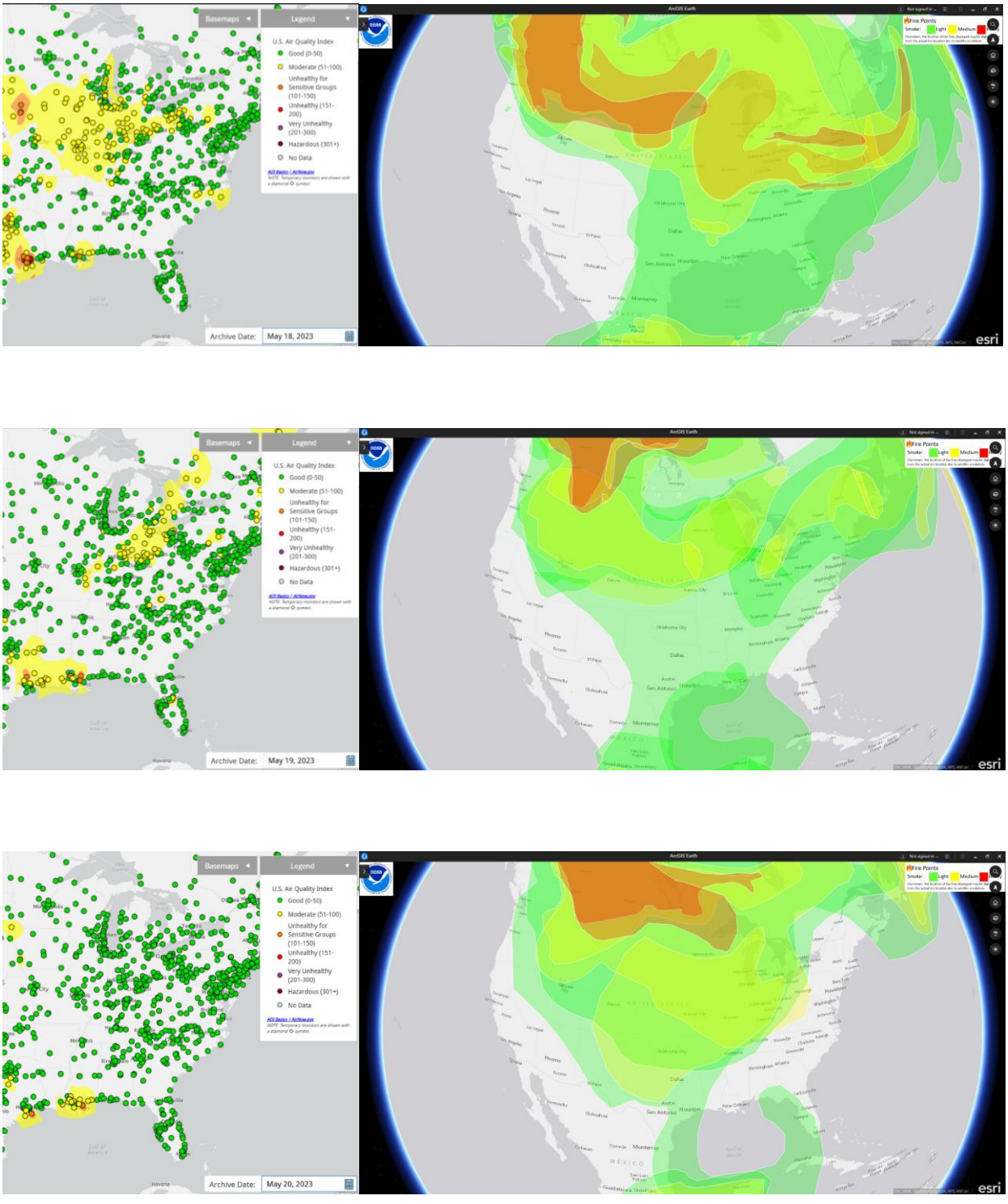


Figure A-2. Ozone AQI and HMS Smoke Plots, May 18 (top), May 19 (middle), and May 20 (bottom), 2023

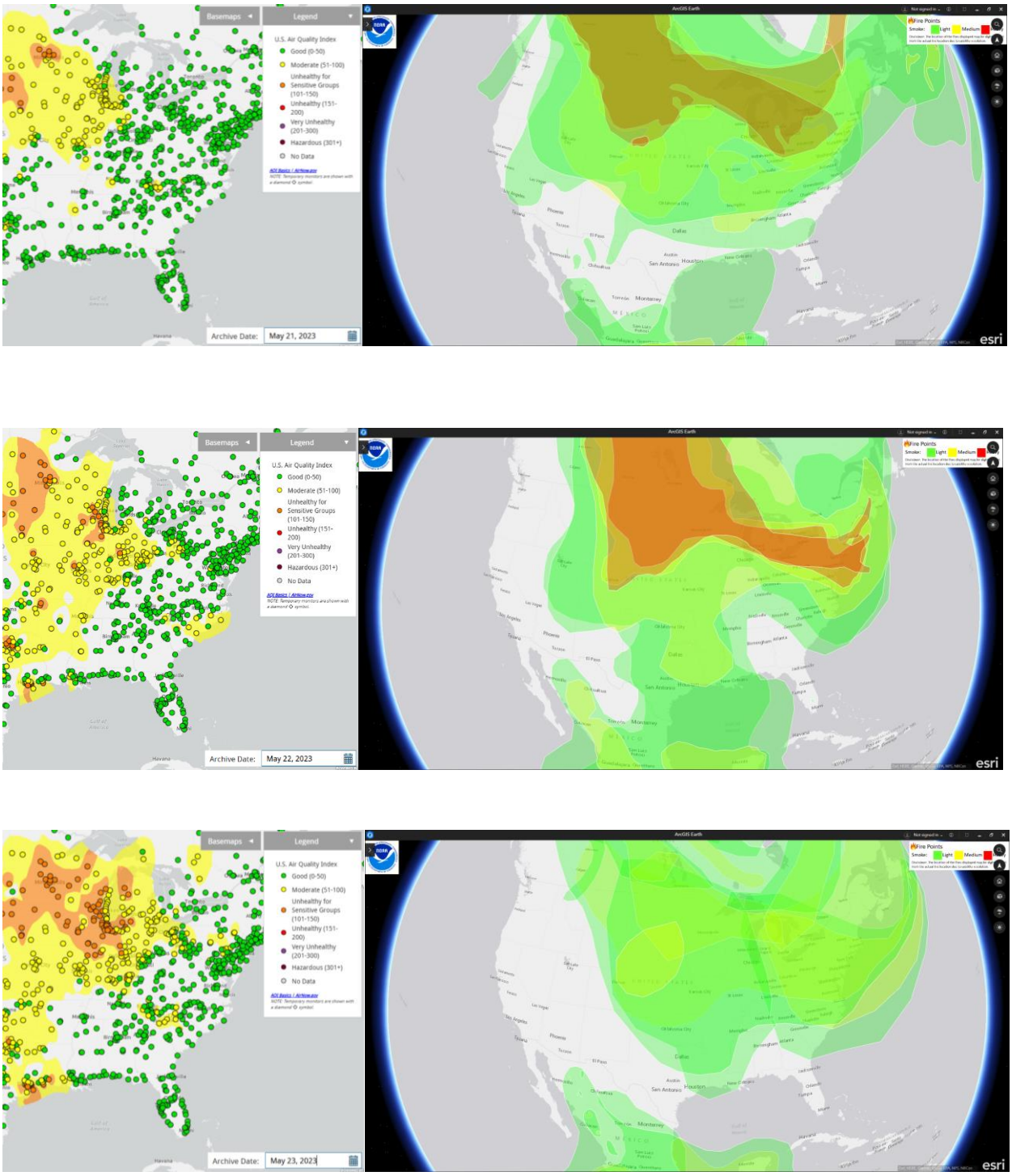


Figure A-3. Ozone AQI and HMS Smoke Plots, May 21 (top), May 22 (middle), and May 23 (bottom), 2023

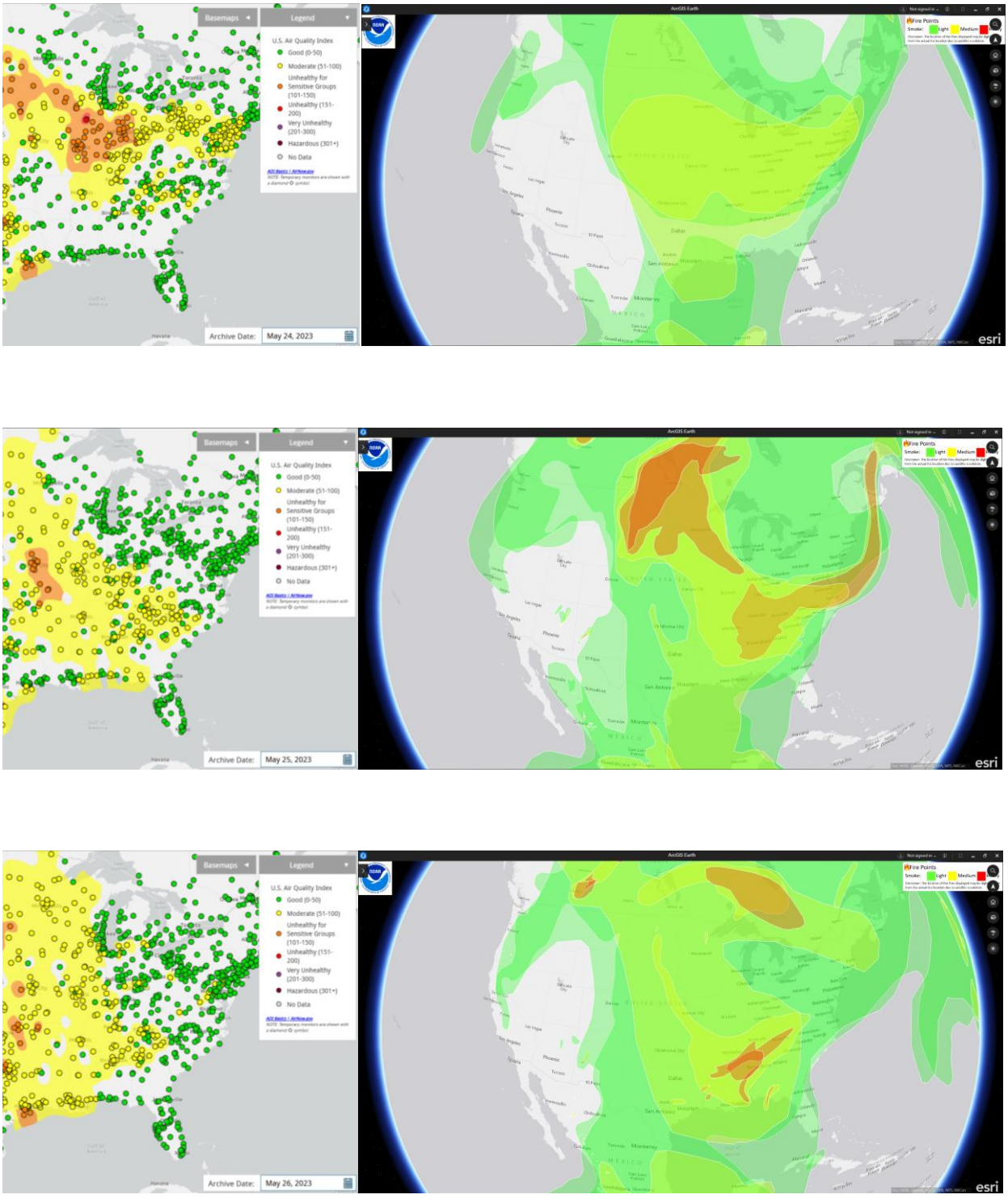


Figure A-4. Ozone AQI and HMS Smoke Plots, May 24 (top), May 25 (middle), and May 26 (bottom), 2023

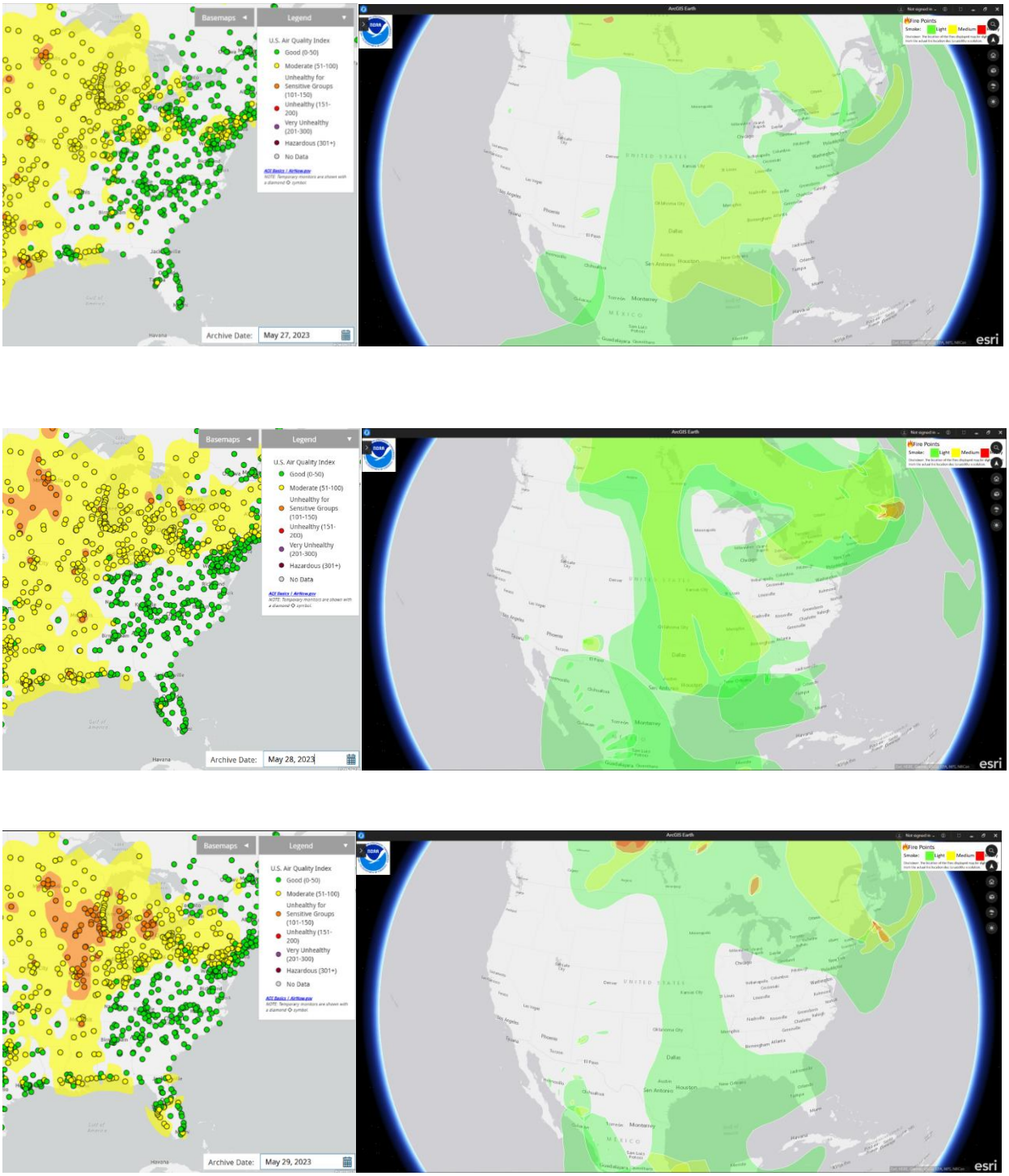


Figure A-5. Ozone AQI and HMS Smoke Plots, May 27 (top), May 28 (middle), and May 29 (bottom), 2023

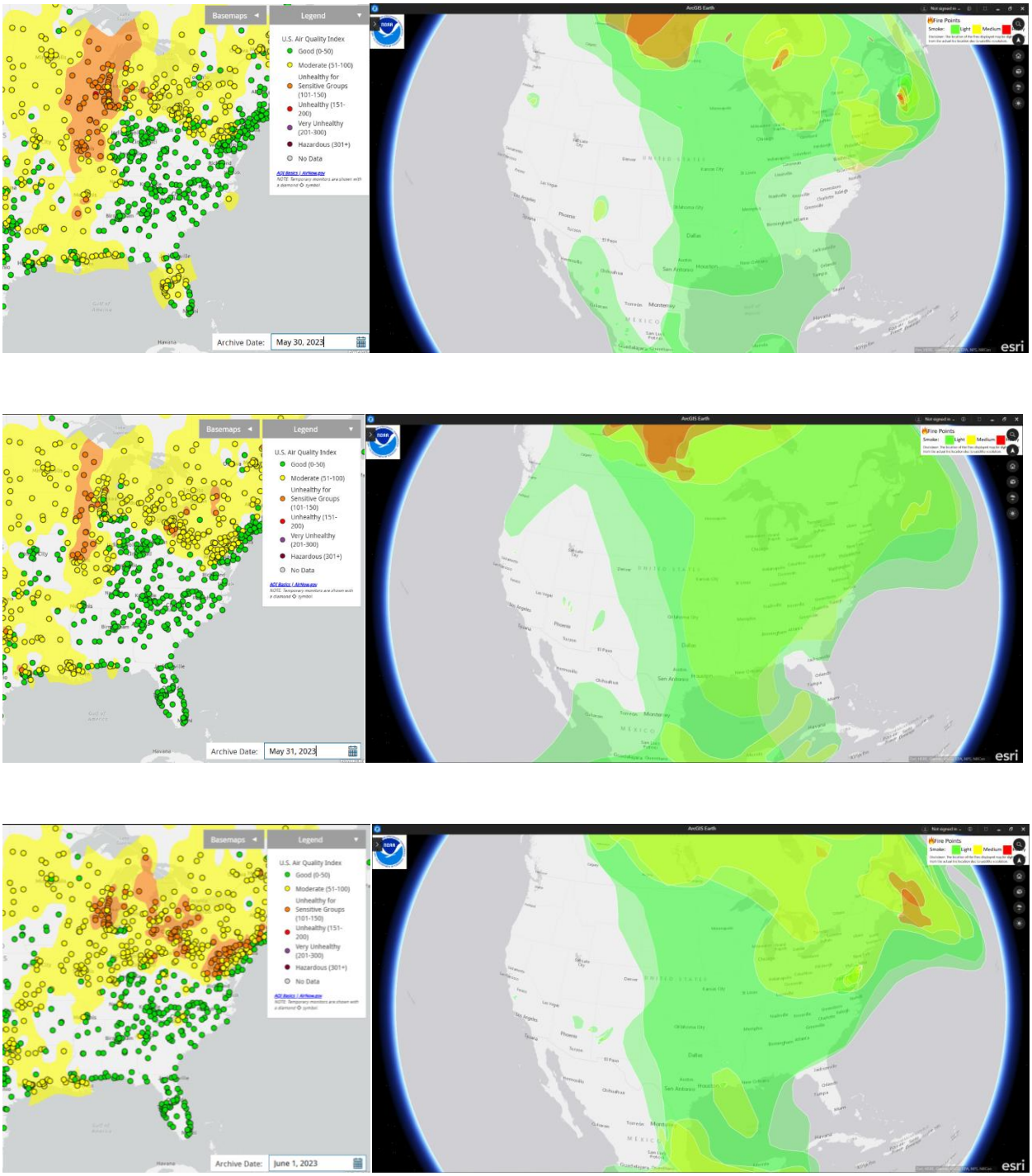


Figure A-6. Ozone AQI and HMS Smoke Plots, May 30 (top), May 31 (middle), and June 1 (bottom), 2023

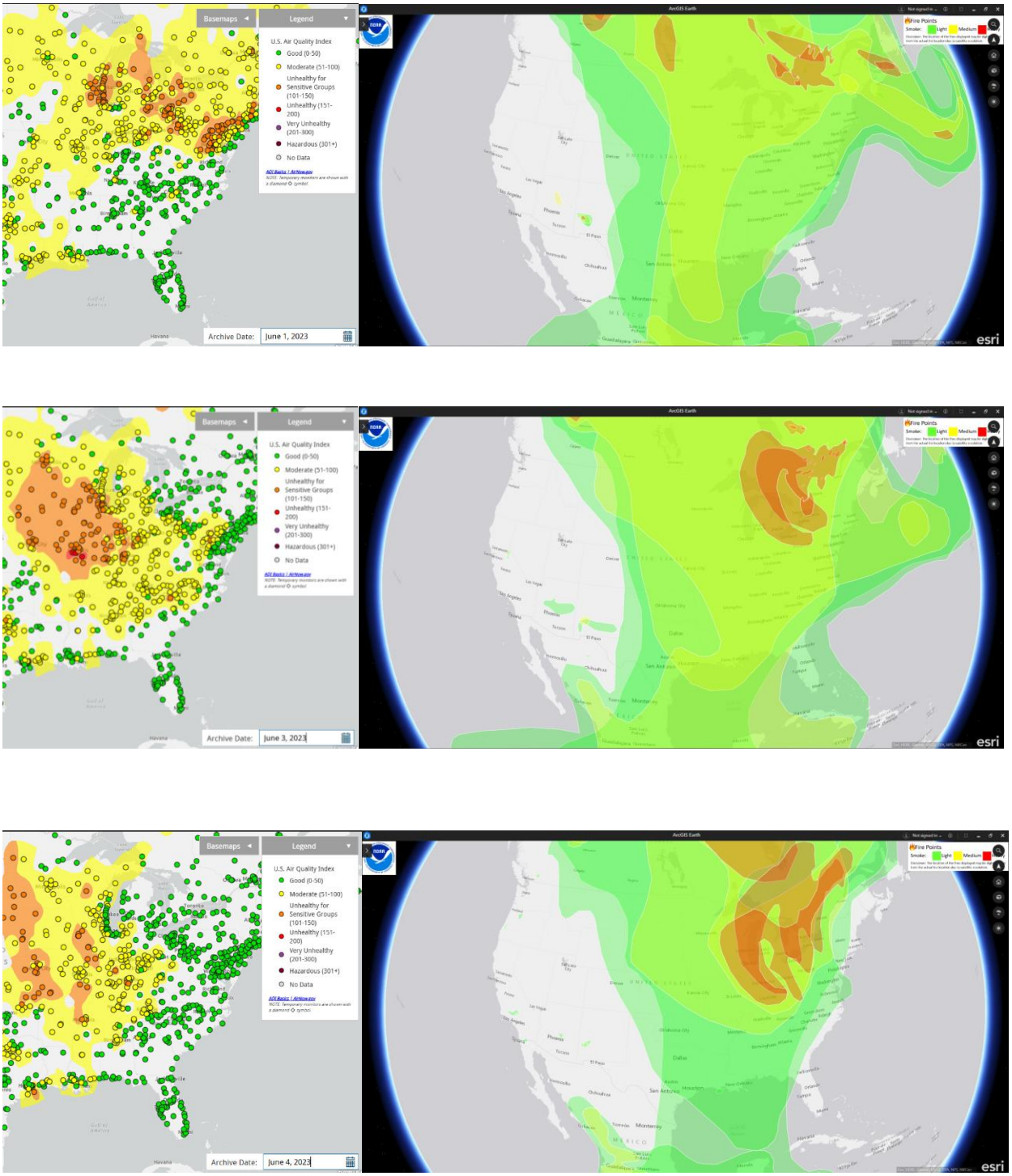


Figure A-7. Ozone AQI and HMS Smoke Plots, June 2 (top), June 3 (middle), and June 4 (bottom), 2023

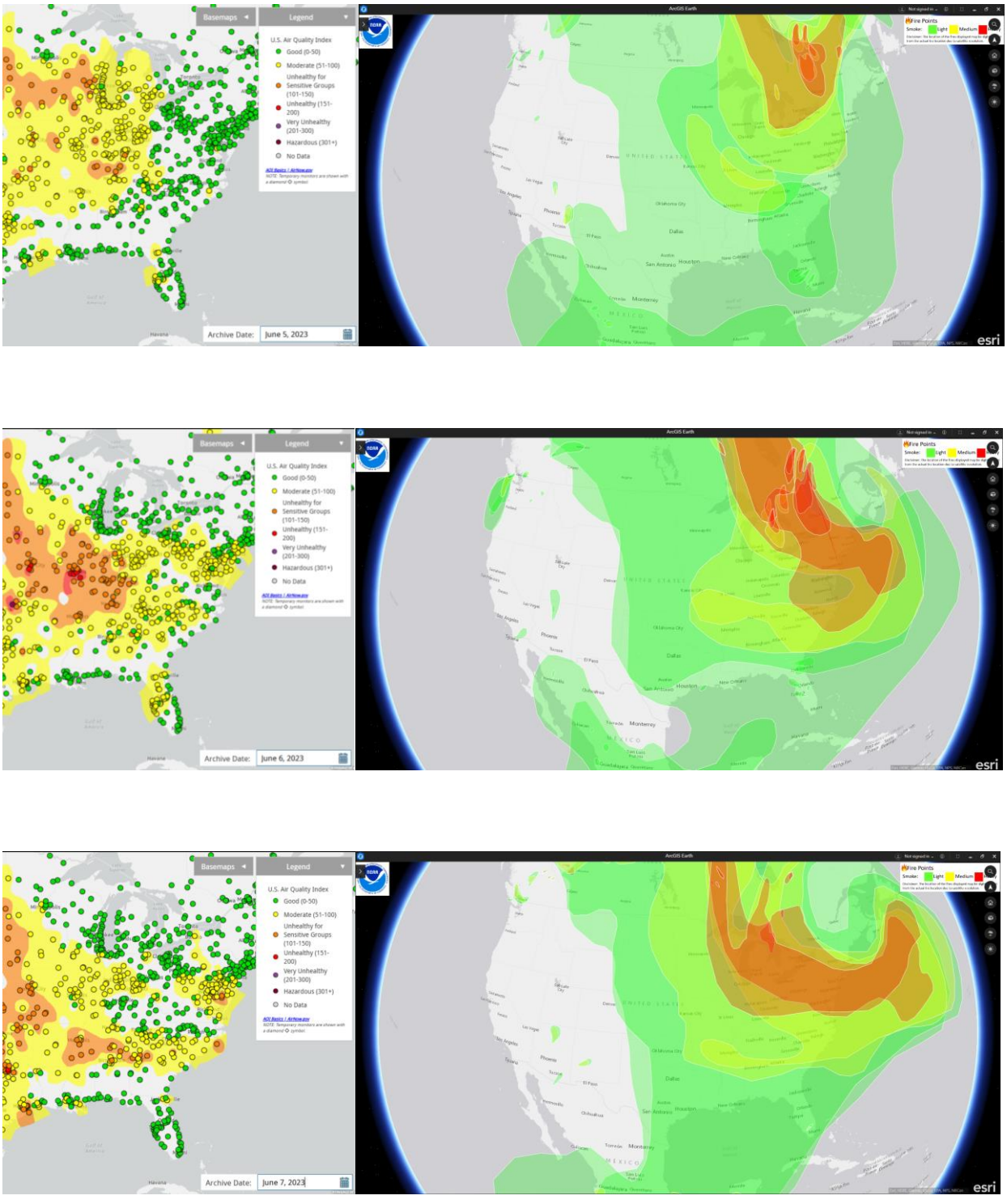


Figure A-8. Ozone AQI and HMS Smoke Plots, June 5 (top), June 6 (middle), and June 7 (bottom), 2023

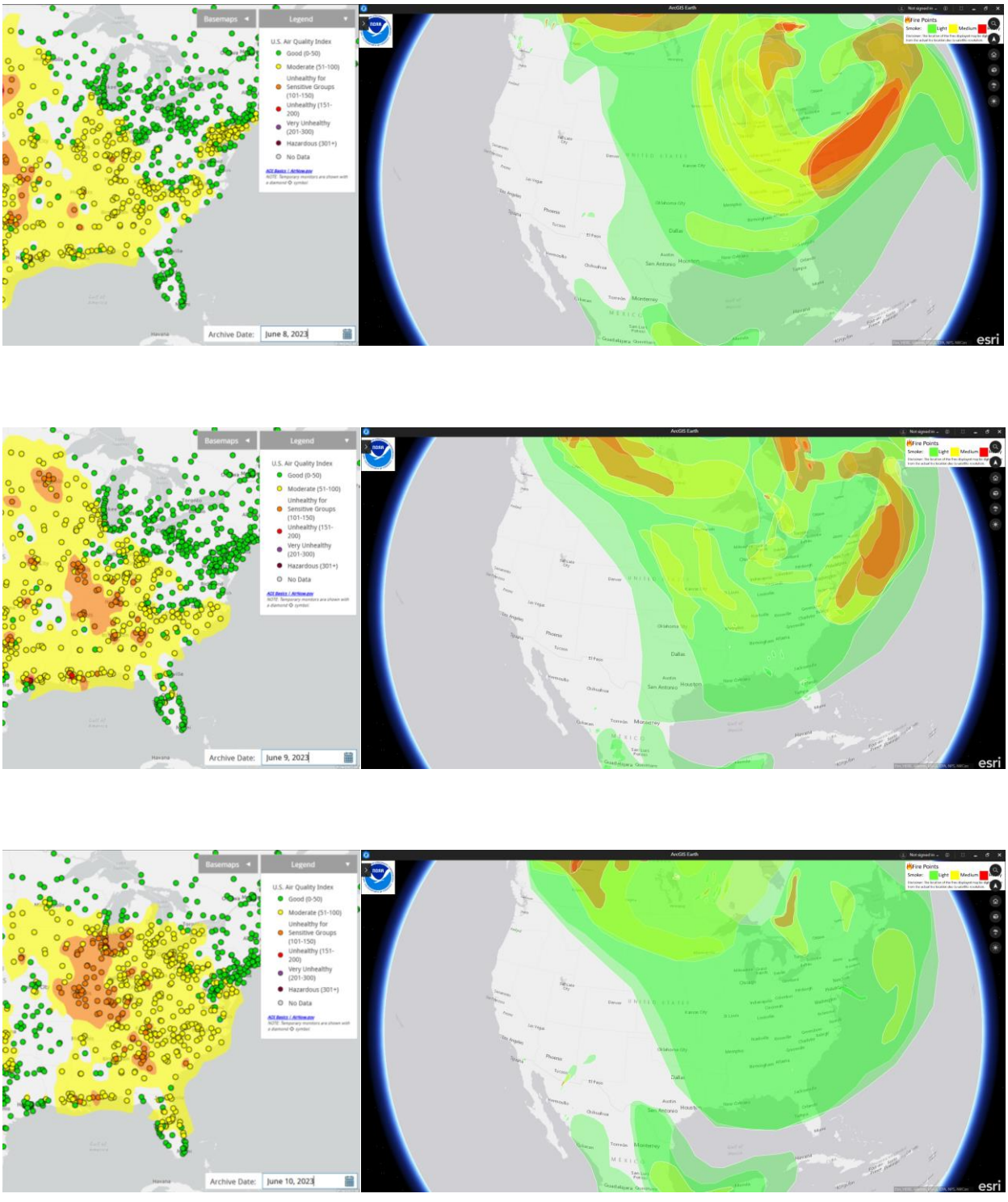


Figure A-9. Ozone AQI and HMS Smoke Plots, June 8 (top), June 9 (middle), and June 10 (bottom), 2023

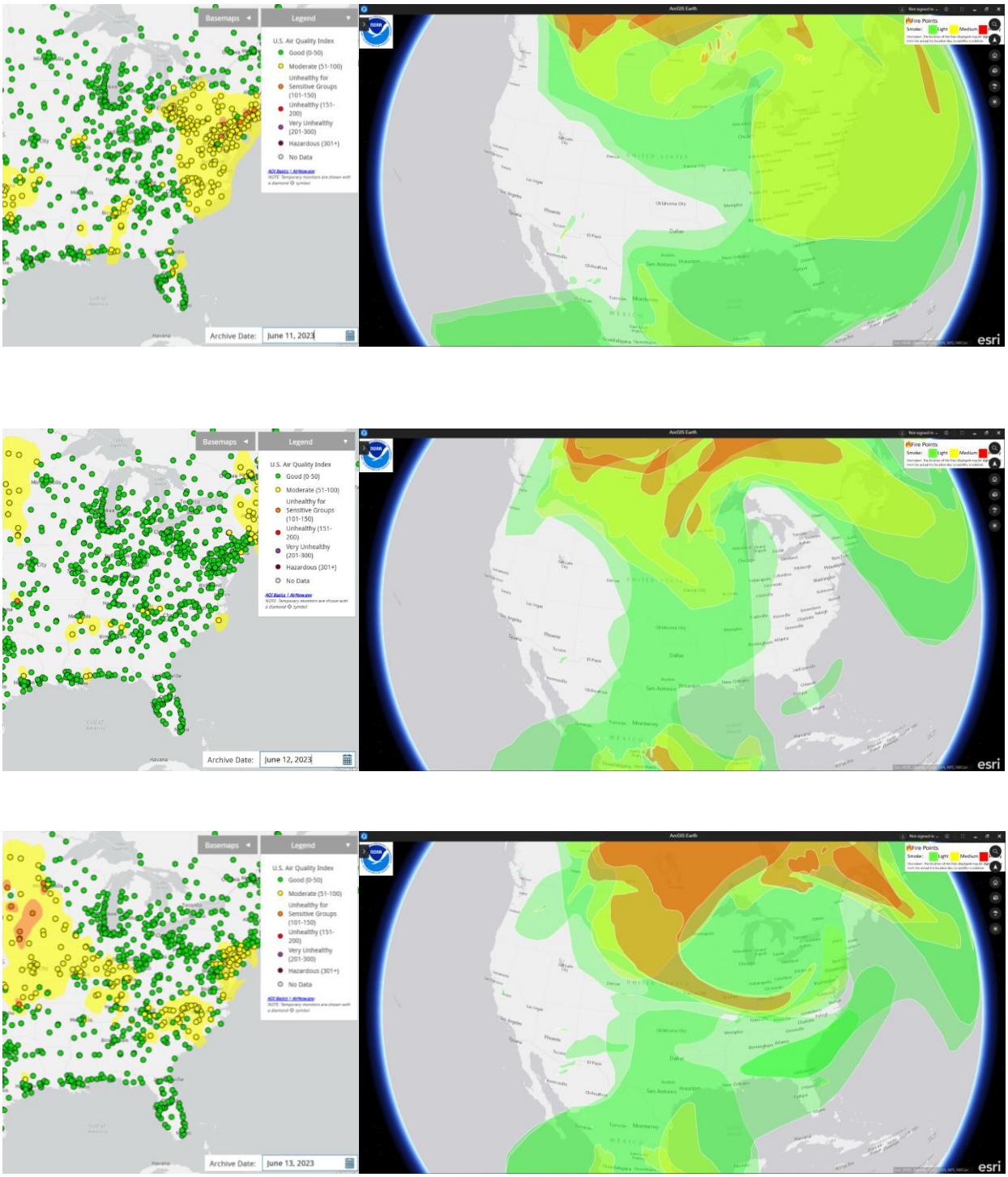


Figure A-10. Ozone AQI and HMS Smoke Plots, June 11 (top), June 12 (middle), and June 13 (bottom), 2023

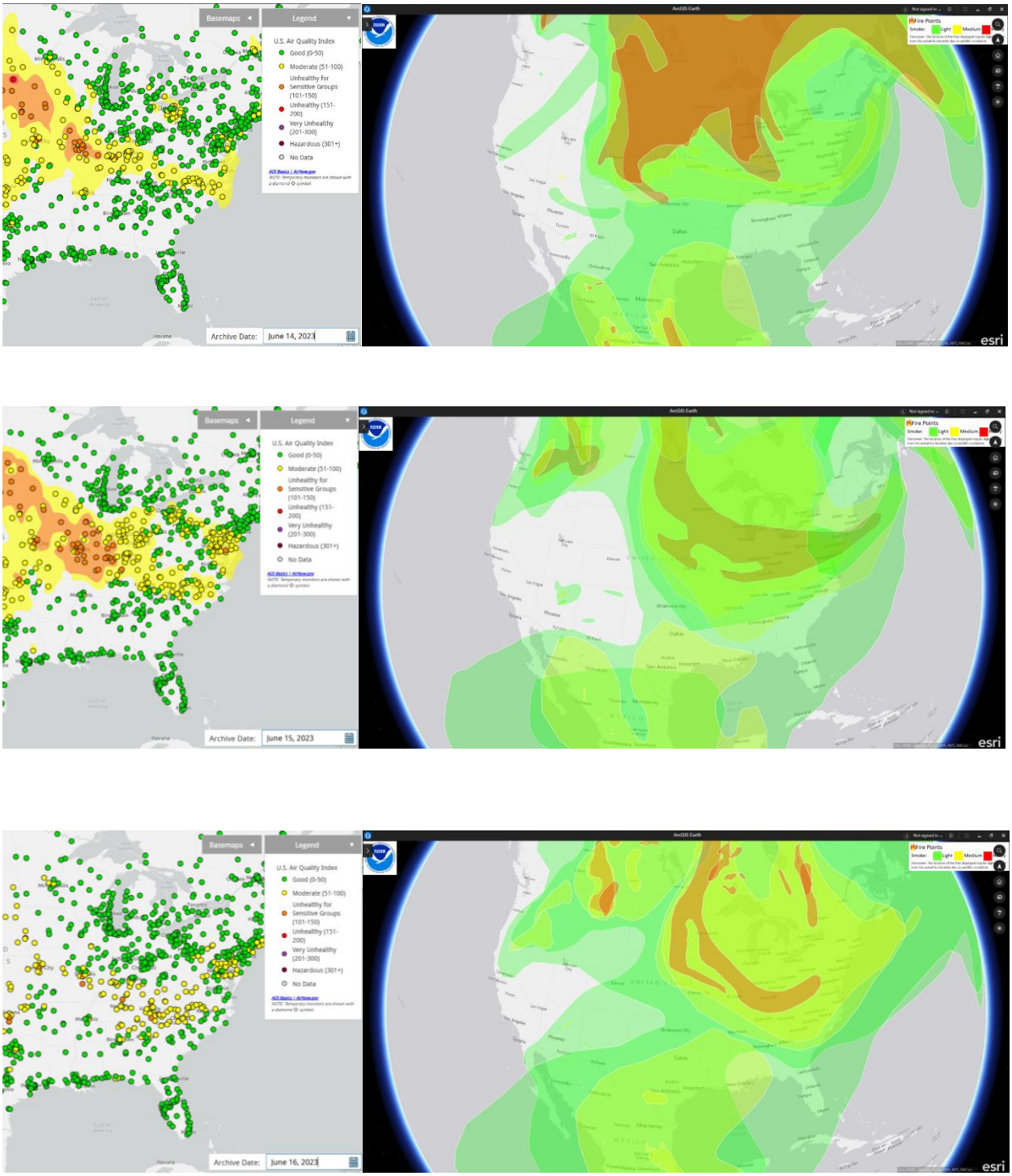


Figure A-11. Ozone AQI and HMS Smoke Plots, June 14 (top), June 15 (middle), and June 16 (bottom), 2023

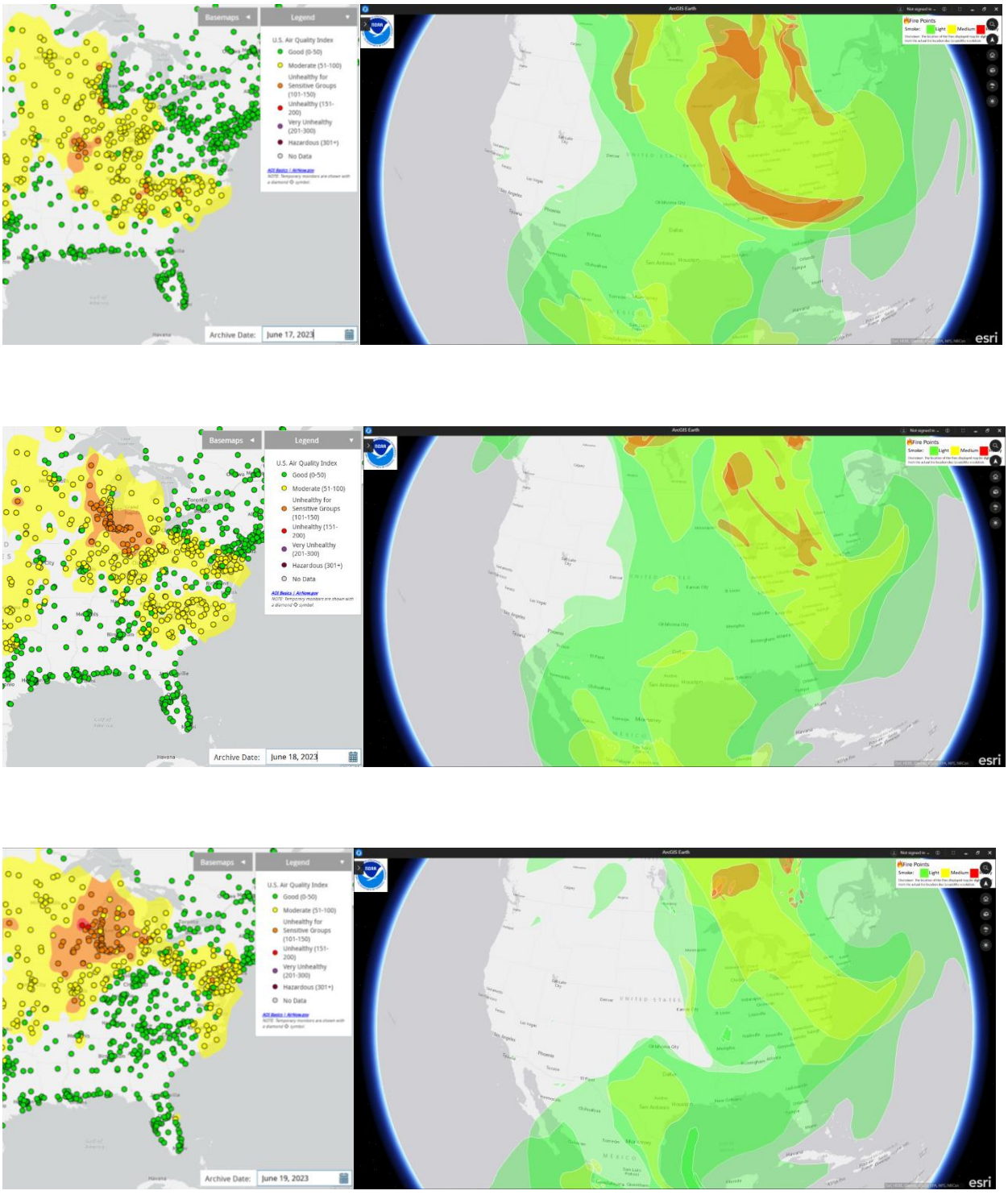


Figure A-12. Ozone AQI and HMS Smoke Plots, June 17 (top), June 18 (middle), and June 19 (bottom), 2023

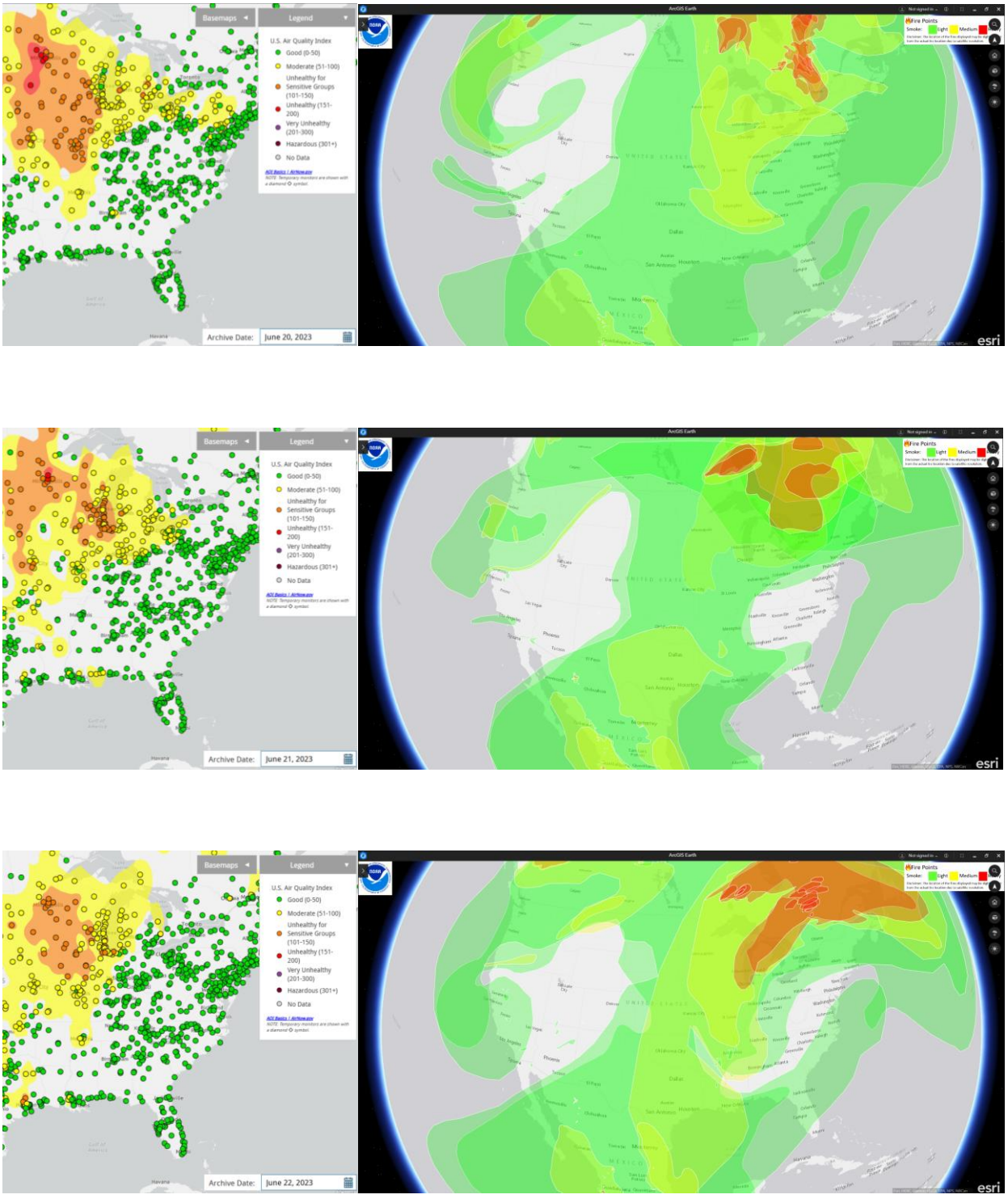


Figure A-13. Ozone AQI and HMS Smoke Plots, June 20 (top), June 21 (middle), and June 22 (bottom), 2023

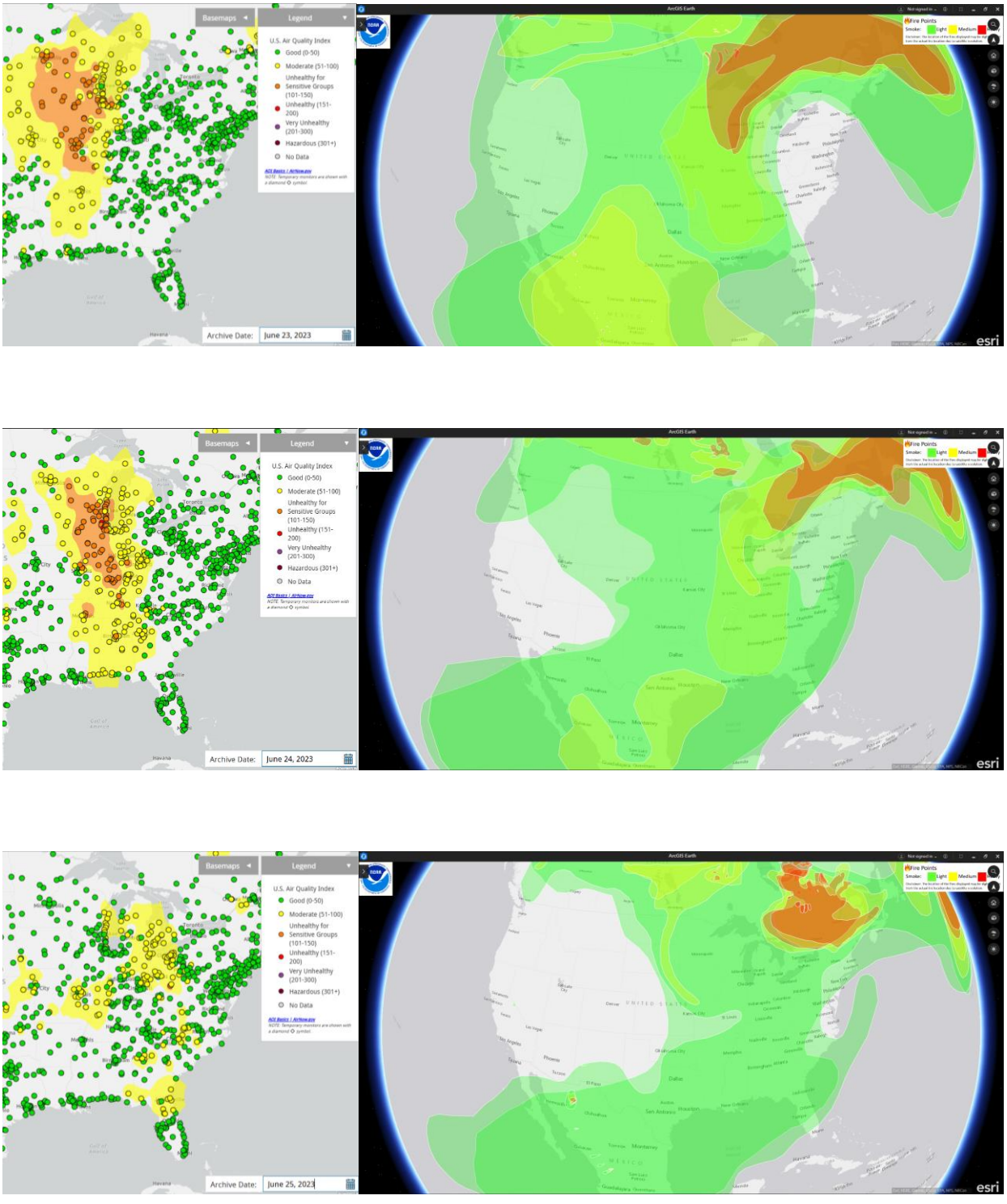


Figure A-14. Ozone AQI and HMS Smoke Plots, June 23 (top), June 24 (middle), and June 25 (bottom), 2023

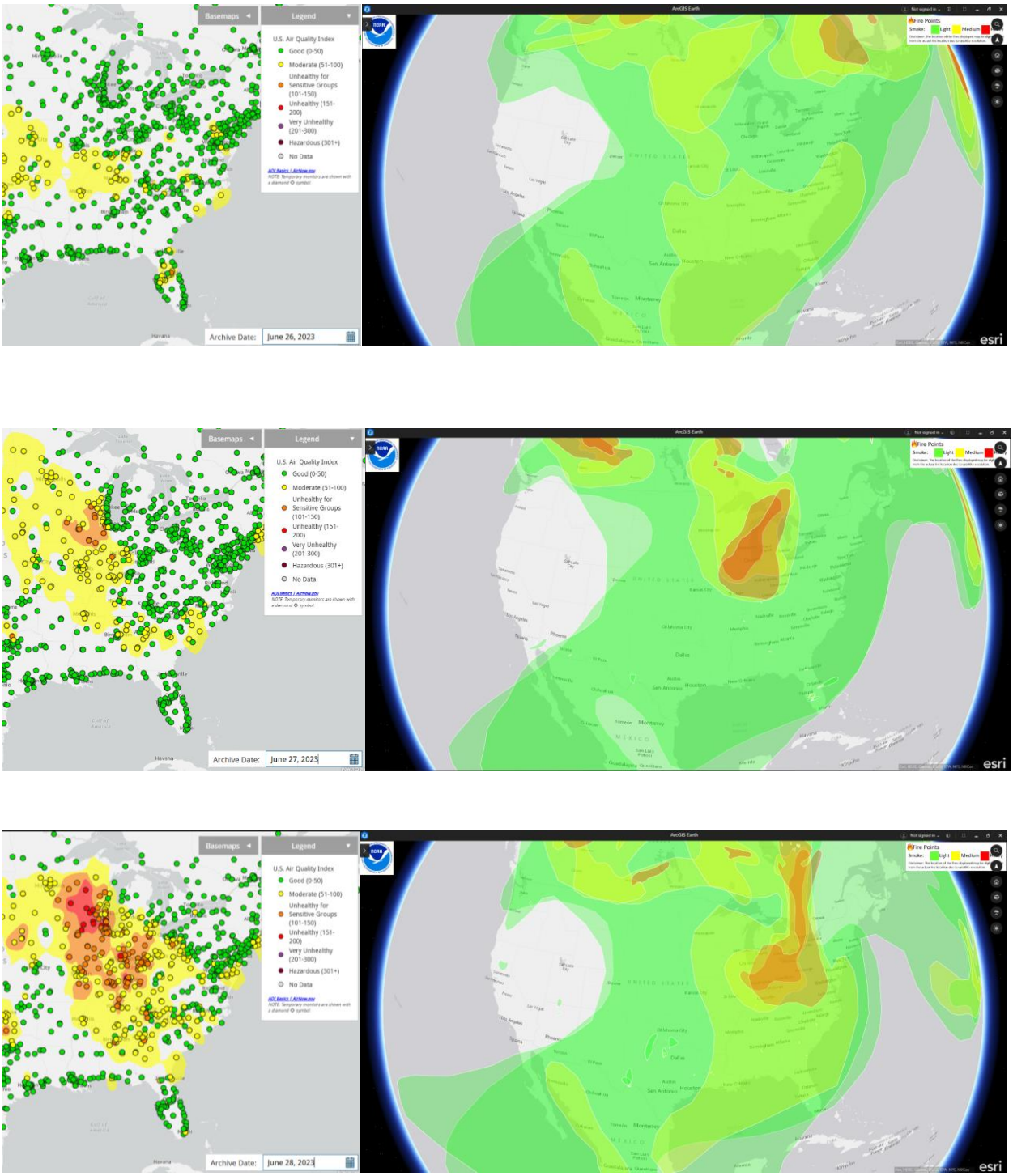


Figure A-15. Ozone AQI and HMS Smoke Plots, June 26 (top), June 27 (middle), and June 28 (bottom), 2023

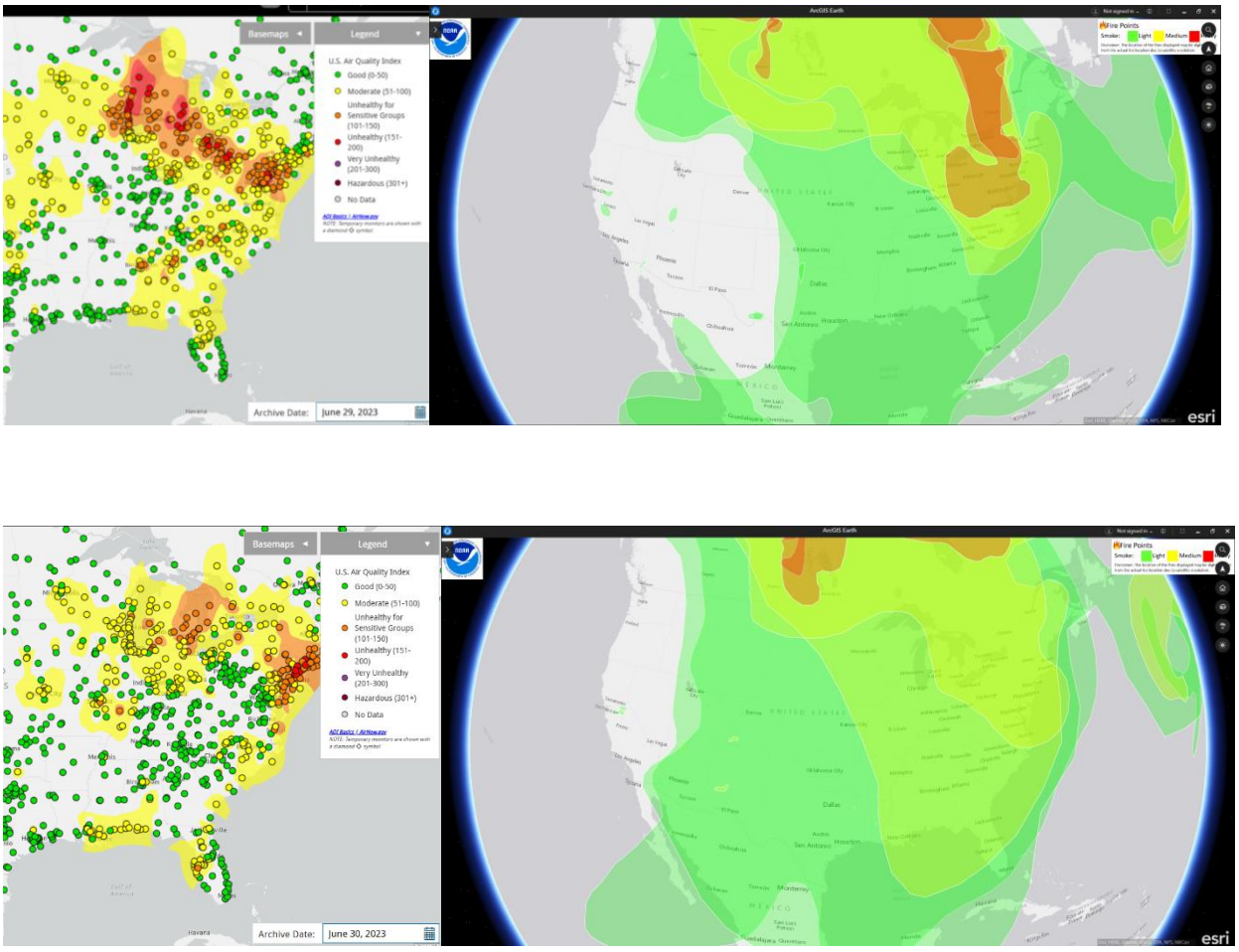


Figure A-16. Ozone AQI and HMS Smoke Plots, June 29 (top) and June 30 (bottom), 2023