



# Seasonal Report

## 2023 Ozone

### OVERVIEW

Maryland saw an increase in ozone in 2023 due to the historic Canadian wildfire season. Surface ozone is a secondary air pollutant created through the interaction between nitrogen oxides (NO<sub>x</sub>) and volatile organic compounds (VOCs) in the presence of sunlight. Some of the major sources of NO<sub>x</sub> and/or VOCs include combustion processes, transportation, and industry. Another source, which is becoming a growing sector in more recent years is biomass burning from both controlled burns and wildfires. Biomass burning is a source of both NO<sub>x</sub> AND VOCs which as a result, can lead to increases in ozone concentrations.

Given ozone's dependency on sunlight, higher ozone concentrations occur during the April – September timeframe when more direct sunlight and warm temperatures provide a more suitable environment for formation. Surface ozone concentrations are closely monitored and forecast during this period to safeguard public health. Unlike the protective ozone layer in the upper atmosphere, ground-level ozone poses significant risks to human health, particularly affecting the respiratory system. [Symptoms](#) may include decreased lung function, airway inflammation, chest tightness, and breathlessness. To communicate air quality effectively to the public, the Environmental Protection Agency (EPA) developed the Air Quality Index (AQI) (see bottom of page). When the daily 8-hour average ozone concentration surpasses 70 parts per billion (ppb), or 100 on the AQI scale, it is considered unhealthy for sensitive groups (USG). Days meeting this criterion are termed "exceedance days". A total count of exceedance days each year can be a key indicator of the ozone season's severity. Maryland recorded 20 ozone exceedance days in 2023 (see Figure 1).

### Maryland Ozone Exceedance Days

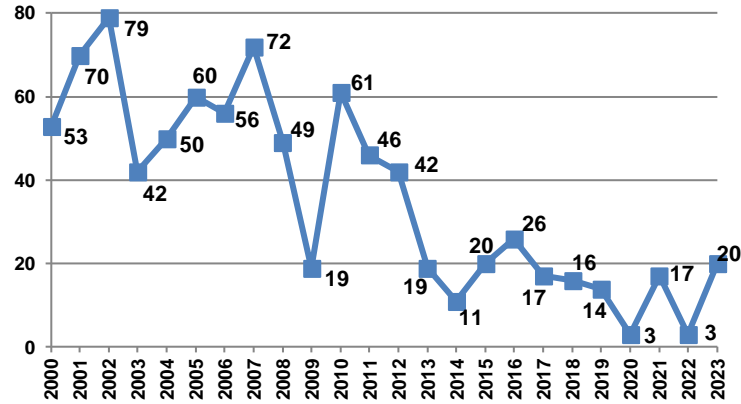


Figure 1: Total number of Maryland ozone exceedance days using the EPA 2015 70 ppb ozone standard, 2000 – 2023.

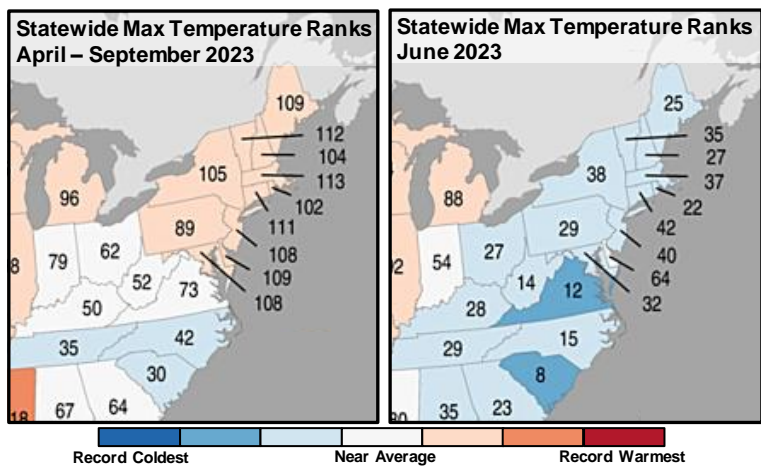


Figure 2: April – September 2023 statewide temperature ranks (left) and June 2023 temperature ranks (right). Numerical values represent the ranking warmest over the past 129 years of record. Source: NOAA/NCDC Climate Division.

June temperatures across Maryland and the entire Mid-Atlantic being below or even well below seasonal norms (see Figure 2). July was also quite active with 7 total ozone exceedance days, the most for the month going back to 2016. Temperatures in July were a bit warmer versus June, ranking in the ~85th percentile. July 2023 temperatures were comparable to July 2022, a year which only had one ozone exceedance for the entire month. Precipitation in July 2023 was also above normal (96<sup>th</sup> out of 129 years), which typically supports less ozone production. This raises a very significant question: With less than favorable meteorology, what caused the June-July 2023 time period to be so severe?

The answer to this burning question lies north of the border in Canada. Canadian wildfires played a large role in the air quality across Maryland, the Mid-Atlantic and large portions of the continental United States during the 2023 ozone season. Between April and September 2023 over 45 million acres were burned in Canada which is roughly the equivalent size of North Dakota! Late spring and summer wildfires are quite common across the northern provinces and territories of Canada, but not nearly to the degree that was seen in 2023. Over the past 40 years, the average annual area burned across Canada was around 5.4 million acres. The area in Canada in 2023 burned over 8 times the typical norm! Massive plumes of smoke pushed south into the continental United States, particularly during the months of June and July, which provided a significant bump up to ozone levels given the additional NO<sub>x</sub> and VOCs. Nearly all the ozone exceedances across Maryland in 2023 were partly attributable to smoke.

### SEASONAL HIGHLIGHTS & STATISTICS

Temperatures across Maryland were warmer than normal but not to the extremes of recent years. The April – September maximum temperatures in Maryland ranked in the top 80<sup>th</sup> percentile of recorded history (108<sup>th</sup> out of 129 years) (see Figure 2) though the number of days reaching or exceeding 90°F at BWI Airport was right around seasonal norms at 35 (Normal: 33 days). The 35 90-degree days in 2023 was the lowest annual total since 2017. In fact, over the previous 5 years Maryland experienced an average of nearly 49 90-degree days! Over this same period (2018 – 2022), Maryland averaged just 10.6 ozone exceedance days annually (16, 14, 3, 17, & 3 exceedance days respectively). Despite temperatures in 2023 being cooler than recent years, Maryland saw a nearly doubling of the average number of ozone exceedance days.

June was an active month for ozone. The 9 June exceedance days experienced was triple the 2022 seasonal total and were the most for the month of June going back to 2012! This was despite June temperatures across Maryland and the entire Mid-Atlantic being below or even well below seasonal norms (see Figure 2).

AQI	0-50	51-100	101-150	151-200	201-300	301-500
	Good	Moderate	USG*	Unhealthy	Very Unhealthy	Hazardous

\*Unhealthy for Sensitive Groups  
Based on 2015 8-hour ozone NAAQS

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### SEASONAL HIGHLIGHTS & STATISTICS (cont.)

To get a better sense of the severity of the 2023 Canadian wildfire season, NOAA's Hazard Mapping System (HMS) smoke product was seasonally compared between 2023 and a more typical year, 2022. HMS uses a suite of environmental satellites to create a daily smoke analysis map over the US and Canada. HMS also can roughly compute smoke density based on the apparent thickness (opacity) in the satellite imagery. The density is broken down into 3 breakpoints (light, medium and heavy). Figure 3 shows the total number of days during the 2023 ozone season (April - Sept) where heavy smoke was analyzed by HMS versus 2022.

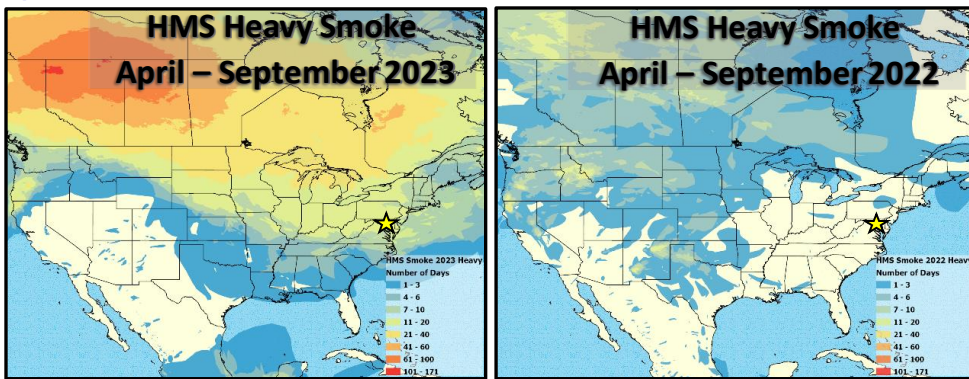


Figure 3: Count of the number of days HMS analyzed heavy smoke between April – September 2023. Location of Baltimore is indicated by a yellow star.

A stark difference exists between smoke frequency across not only Canada, but stretching south into the Great Lakes, Northeast and Mid-Atlantic. Across Maryland in 2023, HMS analyzed roughly 10-15 days of heavy smoke. Compared to 2022, a year with just 3 total ozone exceedance days, HMS analyzed 0 days of heavy smoke.

### FEATURED EVENT – JUNE 29-30 2023

Numerous wildfires were initiated by lightning, produced by a passing storm system across wildland areas of Quebec on June 1, 2023, with well over a 100 fires burning across the province by June 4. These fires lingered through the middle of June, with a resurgence in late June. During the week preceding the event in Maryland on June 29 and 30, roughly 4.2 million acres of land, roughly the size of Connecticut, burned across Canada, primarily in Quebec. Smoke was first concentrated across Quebec where PM<sub>2.5</sub> concentrations climbed to the upper AQI thresholds. In some locations, the concentrations were so great they exceeded the AQI scale. Smoke gradually meandered from Quebec to over the Great Lakes, aging in the process which allowed for enhanced ozone production. Finally, the smoke moved into Maryland from northwest to southeast (Figure 4), guided by pin-wheel-like transport around a storm system centered over Southeastern Canada.

Maryland 2023 Ozone Exceedance Days				
Date	Day	No. of Monitors	Highest AQI Monitor	8-Hr Average Ozone AQI
13 Apr	Thur	8	So. Maryland	115
21 Apr	Fri	1	Frederick	108
12 May	Fri	2	Rockville	105
1 Jun	Thur	5	Frederick	126
2 Jun	Fri	11	Essex	154
3 Jun	Sat	1	Frederick	112
7 Jun	Wed	3	Horn Point	119
11 Jun	Sun	1	Padonia	112
15 Jun	Thur	2	PG Equest Center	105
19 Jun	Mon	1	South Carroll	101
29 Jun	Thur	17	Essex	215
30 Jun	Fri	3	Millington	101
11 Jul	Tue	3	Essex & Edgewood	115
12 Jul	Wed	3	Edgewood & Aldino	108
13 Jul	Thur	1	Lake Montebello	112
17 Jul	Mon	6	Essex	126
18 Jul	Tue	3	PG Equest Center	108
26 Jul	Wed	3	Frederick & Padonia	112
28 Jul	Fri	3	Edgewood	126
6 Sept	Wed	1	Essex	105

Table 1: Maryland 2023 ozone exceedance days. Day of week is noted along with highest reading monitor and its color coded 8-hr AQI value.



Figure 4 (left): GOES Visible satellite imagery for June 29<sup>th</sup>, 2023. Smoke areas are indicated and labeled. Location of Baltimore is noted by yellow star. Source: NOAA/AerosolWatch.

By June 29<sup>th</sup>, smoke was thick across the entire Mid-Atlantic with ozone levels quickly climbing in response. In total 17 of Maryland's 20 ozone monitors exceeded USG levels (see Table 1). The Essex monitor, just east of Baltimore City along the Chesapeake Bay coast reached a maximum 8-hour ozone level of 110ppb (215 AQI)! This is the highest ozone level that Maryland has seen dating back to, ironically, June 29<sup>th</sup> of 2012.

Smoke lingered around the area on June 30<sup>th</sup>, although the thickest of it began to slowly push north and out of the state thanks to weak southerly flow. During the early afternoon hours, a line of thunderstorms developed and progressed eastward through the state. This line helped to mix cleaner air from aloft and lower ozone along its eastward progression. Given the late timing of these thunderstorms, elevated ozone levels persisted long enough to reach exceedance level thresholds in extreme eastern Maryland but not nearly to the degree that was experienced on the previous day.

**AQI** 0-50 Good | 51-100 Moderate | 101-150 USG\* | 151-200 Unhealthy | 201-300 Very Unhealthy | 301-500 Hazardous

\*Unhealthy for Sensitive Groups based on 2015 8-hr ozone NAAQS. Denotes the USG\*

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