NJ DEPARTMENT OF ENVIRONMENTAL PROTECTION
AIR QUALITY, ENERGY, AND SUSTAINABILITY
DIVISION OF AIR QUALITY

Notice of Proposed Exceptional Event Demonstration:

Take notice that the State of New Jersey is currently accepting public comments on its draft Exceptional Event Demonstration. This demonstration aims to exclude certain ozone monitoring data from April 13, 2023, June 2, 2023, and June 29 - 30, 2023, due to the impact of multiple wildfires on New Jersey's ozone air quality. Wildfires originating from Canada and Midwest United States significantly affected New Jersey's air quality during this period, however, small, local fires in New Jersey were also included as part of the analysis. The New Jersey Department of Environmental Protection (NJDEP) conducted an exceptional event demonstration that analyzes the influence of the pollutants from the wildfires on air quality in the New Jersey portion of the Philadelphia-Wilmington-Atlantic City ozone nonattainment area (hereafter referred to as Southern New Jersey NAA.) The analysis considers the meteorological conditions associated with the exceptional events, as well as historical trends in ozone air quality at specific New Jersey air monitors. The analysis finds that in the Southern New Jersey NAA, the ozone air quality during the specified period would not have exceeded the ozone National Ambient Air Quality Standards (NAAQS) if not for the wildfire influence. Although, the wildfires also contributed to exceedances of the ozone NAAQS in the New Jersey portion of the Northern New Jersey-NY-CT Nonattainment area, New Jersey is not conducting an Exceptional Event Demonstration for this area because it would not change any regulatory requirements associated with that area. In this demonstration, New Jersey asserts that the specified dates qualify as exceptional events due to the transport of wildfire smoke, which led to New Jersey exceeding the 2015 70 parts per billion (ppb) NAAQS for ozone in the Southern Nonattainment area. The demonstration provides a description and discourse of the wildfires, comparison between event concentrations and non-event concentrations, establishment of clear causal relationship, satellite observations, wind trajectory analysis, visual photographic evidence, and demonstration that the exceptional event was beyond reasonable control or prevention and was a natural occurrence.

The Department is only accepting written comments. Written comments may be submitted by close of business, April 27, 2024. Please email comment(s) as a document attachment to: NJDEP-BAQP@dep.nj.gov and include "2023 Ozone Exceptional Event Demonstration" in the subject line of the e-mail.

If you have any questions about this notice, you can email your questions to NJDEP-BAQP@dep.nj.gov or call the Bureau of Evaluation and Planning at (609) 292-6722.

DRAFT

The State of New Jersey
Department of Environmental Protection

Exceptional Event Demonstration Analysis for Ozone During April 13, 2023, June 2, 2023, June 29 and 30, 2023

March 2024

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Acronyms and Abbreviations

AGL	Above Ground Level
AOD	Aerosol Optical Depth
AQI	Air Quality Index
AQS	Air Quality System
BC	Black Carbon
C_6H_6	Benzene
CAA	Clean Air Act
CO	Carbon Monoxide
CWFIS	Canadian Wildland Fire Information System
DV	Design Value
EC	Elemental Carbon
EER	Exceptional Events Rule
EST	Eastern Standard Time
FEM	Federal Equivalent Method
FRP	Fire Radiative Power
HC	Hydrocarbon
HCHO	Formaldehyde
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
K	Potassium
km	kilometer
mb	millibar
NAAQS	National Ambient Air Quality Standards
NJDEP	New Jersey Department of Environmental Protection
NMHC	Non-Methane Hydrocarbon
NMVOC	Non-Methane Volatile Organic Compounds
NOAA	National Oceanic and Atmospheric Administration
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
O_3	Ozone
OC	Organic Carbon
OTR	Ozone Transport Region
PAMS	Photochemical Assessment Monitoring Station
PBL	Planetary Boundary Layer
PM	Particulate Matter
PM2.5	Fine Particulate Matter
ppb	parts per billion
ppbC	parts per billion of Carbon
ppbv	parts per billion by volume
ppm	parts per million
Q/d	Emissions divided by distance
RSIG	Remote Sensing Information Gateway
tpd	tons per day
ug/m^3	micrograms per cubic meter
USEPA	United States Environmental Protection Agency
USG	Unhealthy for Sensitive Groups

UTC	Coordinated Universal Time
VOC	Volatile Organic Compound

Executive Summary

During the spring and summer of 2023, numerous wildfires had devastating impacts on air quality across the United States. The plumes of smoke produced by these fires extended for hundreds of miles, impacting several regions. Wildfires originating from Canada and Midwest United States significantly contributed to New Jersey's degraded air quality during this period. While significantly smaller in size, New Jersey also assessed the contribution from local fires that burned in New Jersey during one exceptional event. Due to the transported emissions from these wildfires, New Jersey recorded multiple ambient air quality exceedances of the 2015 70 parts per billion (ppb) 8-hour average ozone National Ambient Air Quality Standards (NAAQS).

The Clean Air Act (CAA) section 319(b) and USEPA regulations allow the exclusion of air quality monitoring data influenced by exceptional events from use in determinations of exceedances or violations of the NAAQS as these occurrences are not representative. This analysis demonstrates that certain 8-hour ozone concentrations that exceeded the 2015 70 ppb ozone standard at monitoring stations in the state during 2023 qualify as exceptional events. Therefore, these exceedances should be excluded from Design Value (DV) calculations used to assess New Jersey's ozone attainment status.

The dates and ambient air quality monitors included in this Exceptional Event Demonstration are in the Philadelphia-Wilmington-Atlantic City nonattainment area (also referred to as Southern NJ-PA-DE-MD Nonattainment Area) and include the following:

- April 13, 2023 – Clarksboro, Colliers Mills, Washington Crossing
- June 2, 2023 – Camden, Clarksboro, Colliers Mills
- June 29 and 30, 2023 – Camden, Clarksboro, Colliers Mills, Washington Crossing

Accordingly, New Jersey monitoring data for ozone on these days has been flagged in the United States Environmental Protection Agency's (USEPA) Air Quality System (AQS) as being an exceptional event. On October 24, 2023, in accordance with 40 CFR 50.14(c)(2) of the Exceptional Events Rule, New Jersey notified the USEPA of the intent to request exclusion of ambient air quality data due to the exceptional events noted above (Appendix 1) and submitted supplemental information to USEPA on December 14, 2023 (Appendix 2). New Jersey is seeking approval of this exceptional event demonstration to qualify for an extension of the August 2024 ozone attainment date for the 2015 70 ppb Ozone NAAQS per Clean Air Act Section 181(a)(5) and 40 CFR 51.1307. The exceptional events rule (EER) at 40 CFR 50.14 stipulates that an exceptional event must have regulatory significance for the USEPA to consider the demonstration.

This document presents the following evidence that the wildfires in Canada, Midwest United States, and New Jersey caused exceedances of the ozone standard in New Jersey:

- The location of the fires and the resulting levels of smoke in the air traced by satellite from the fire source location to New Jersey.
- Air quality levels in the states downwind of the fire source locations became elevated and unhealthful after the smoke plume traveled to those areas and, under the presence of wildfire smoke, favorable weather conditions developed to enhance ozone formation.
- Satellite observations of the Aerosol Optical Depth (AOD) on the days leading up to and including the exceptional event dates show that wildfire emissions were transported into New Jersey.

- Ambient air levels of potassium, organic and elemental carbon (known tracer compounds for wood smoke), were found in greater levels on the days that coincided with the exceptional event dates. Other tracers monitored included light extinction, non-methane hydrocarbons and non-methane VOCs.
- Ozone levels on the exceptional event dates were exceptionally high with most of the monitors recording levels greater than 99th percentile of the highest ozone levels typically monitored during the last five years (2019 – 2023).
- New Jersey measured elevated levels of fine particle (PM2.5) concentrations throughout the state on exceptional event days.
- HYSPLIT back trajectories on the days of the exceptional events in New Jersey show that the wind patterns would have carried the wildfire emissions from the location of the fires into New Jersey on each of the exceptional event dates. The trajectory analyses are further supported by AOD concentrations and satellite imagery.
- An analysis of days with similar meteorological conditions as those observed during exceptional event days, but without the presence of wildfires, shows that ozone levels in New Jersey did not reach the same widespread and elevated ozone levels as experienced during the exceptional event days under similar meteorological conditions.
- Overlays of the satellite image of wood smoke with the ground level monitored ambient air levels of ozone show that the movement of the smoke plume from the location of the wildfires to New Jersey match with the elevated ozone levels on the ground.
- Visual Photographic Evidence of Ground-level Smoke at the Monitor (HazeCam Pictures from Brigantine)

Regulatory Significance of Data Exclusion

The Clean Air Act (CAA) section 319(b) allows states to exclude air quality monitoring data influenced by exceptional events from use in determinations of exceedances or violations of the NAAQS. According to the Exceptional Events Rule (EER) at 40 CFR 50.1(j), the definition of an “exceptional event” means “an event(s) and its resulting emissions that affect air quality in such a way that there exists a clear causal relationship between the specific event(s) and the monitored exceedance(s) or violation(s), is not reasonably controllable or preventable, is an event(s) caused by human activity that is unlikely to recur at a particular location or a natural event(s), and is determined by the Administrator in accordance with 40 CFR 50.14 to be an exceptional event.”

New Jersey is seeking approval of this exceptional event demonstration to qualify for an extension of the August 2024 ozone attainment date for the 2015 70 ppb Ozone NAAQS pursuant to CAA section 181. The EER states that an exceptional event must have regulatory significance for EPA to consider the demonstration. The EER clarifies at 40 CFR 50.14(a)(1) that the regulatory significance of a demonstration applies to the treatment of data showing exceedances or violations for *attainment date extensions*.[1] As a result, excluding the exceptional event days would reduce the 4th highest ozone exceedance levels in New Jersey to less than 70 ppb, and thereby satisfy the requirements of 40 CFR 51.1307, which states that “*a nonattainment area will meet the requirement of CAA section 181(a)(5)(B) pertaining to 1-year extensions of the attainment date if: For the first 1-year extension, the area's 4th*

[1] USEPA. (2023). Analytical Tools for Preparing Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone and Particulate Matter Concentrations. https://www.epa.gov/system/files/documents/2023-09/Wildfire%20Resource%20Document_Final_Revised.pdf

highest daily maximum 8-hour average in the attainment year is no greater than the level of that NAAQS."[2]

The Southern NJ-PA-DE-MD Nonattainment Area is classified as moderate for the 2015 70 ppb Ozone NAAQS with an attainment deadline of August 3, 2024. The exclusion of ozone levels associated with the exceptional event would have an impact on the calculation to determine if the multi-state nonattainment area attained the ozone NAAQS. Attainment of the ozone NAAQS is based on the 3-year average of the 4th highest daily maximum 8-hour average.

The Camden, Colliers Mills, Clarksboro, and Washington Crossing monitors in the Southern NJ-PA-DE-MD nonattainment area would have 4th highs attaining the 2015 70 ppb 8-hour ozone NAAQS if not for the impact of smoke from the aforementioned wildfires. Table 1 compares the current 4th highest ozone concentrations in parts per billion (ppb) for these monitors with the influence of wildfire smoke versus the values calculated with the data excluded.

Table 1: Adjusted 4th Highs for Exceptional Event (EE) Days for Monitors in the Southern NJ-PA-DE-MD Nonattainment Area

Site Name	Monitor AQS ID	Date	Smoke Influenced, Daily Maximum 4th High without USEPA concurrence (ppb)	Daily Maximum 8-hour 4th High with EE days removed and with USEPA concurrence (ppb)	**Reduction in** 4th High (ppb)	Preliminary Design Value without EPA Concurrence	Preliminary Design Value with EPA Concurrence
Camden	340070002	9/5/2023	71	67	4	67	65
Colliers Mills	340290006	6/30/2023	73	68	5	70	68
Clarksboro	340150002	7/12/2023	74	68	6	70	68
Washington Crossing	34029991	4/13/2023	71	68	3	67	66

[2] 40 CFR 51.1307

Exceptional Event Demonstration Analysis for Ozone During April 13, 2023

I. A Narrative Conceptual Model and a Discussion of the Event that Led to Exceedances at New Jersey Monitors

1. A Description of New Jersey's Ozone Nonattainment Areas

New Jersey is associated with two multi-state nonattainment areas: the New York-Northern New Jersey-Long Island Nonattainment area (hereafter referred to as the Northern New Jersey-New York-Connecticut or Northern NJ-NY-CT Nonattainment area) and the Philadelphia-Wilmington-Atlantic City Nonattainment area (hereafter referred to as the Southern New Jersey-Pennsylvania-Delaware-Maryland or Southern NJ-PA-DE-MD Nonattainment Area). The Northern NJ-NY-CT Nonattainment area includes counties in the states of New York and Connecticut and the New Jersey counties of: Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union, and Warren. The Southern NJ-PA-DE-MD Nonattainment area includes counties in the states of Pennsylvania, Delaware, and Maryland and the New Jersey counties of: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Ocean, and Salem. The entire State of New Jersey is classified as Moderate nonattainment for the ozone health standard of 70 parts per billion (ppb) with an attainment deadline of August 2024.

2. Non-Event Ozone Formation in the New Jersey Nonattainment Areas

New Jersey typically experiences high ambient air ozone levels in the summer months. This section of the document discusses the normal patterns of ozone formation in New Jersey's air to characterize how the April 13, 2023, June 2, 2023, June 29 and 30, 2023, exceptional events caused by various wildfires differs from the usual weather patterns and locations of emissions that cause New Jersey to exceed the National Ambient Air Quality Standard (NAAQS) for ozone.

The evolution of elevated ozone episodes in the eastern U.S. often begins with the movement of a large air mass from the Midwest to the middle or southern Atlantic states, where it assimilates into and becomes an extension of the Atlantic (Bermuda) high pressure system.[3] During its movement east, the air mass accumulates air pollutants emitted by large coal-fired power plants and other sources located outside the Ozone Transport Region (OTR). As the air mass passes over the eastern U.S., sources within the OTR contribute to the air pollution. These expansive weather systems are conducive to the formation of ozone by creating a vast area of clear skies and high temperatures. These two prerequisites for elevated ozone formation are further compounded by a circulation pattern favorable for pollution transport over large distances. In the worst cases, the high-pressure systems stall over the eastern U.S. for days, creating ozone episodes of strong intensity and long duration.

The transport patterns (high pressure) that are conducive to ozone formation often carry ozone/pollutants within them, which can come from locations of farther distance. High pressure systems have a gentle sinking motion (subsidence) that causes air to sink and enhances stagnation of pollutants at the surface. As a result, air traveling more slowly and being trapped at the surface allows the pollutants to accumulate. Under a strong area of high pressure, the mechanisms that usually disperse

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[3] NJDEP. (2007). *State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard 8-Hour Ozone Attainment Demonstration Final, Chapter 2: Nature of the ozone air quality problem in the northeast – the conceptual model*. https://dep.nj.gov/wp-content/uploads/airplanning/1997-8-hour-ozone-2007/final_completesip.pdf

pollutants are not present, which leads to a shorter boundary layer giving the pollutants less "volume" to disperse among compared to if the boundary layer was higher/taller. Also, winds that typically disperse pollutants over large areas are not present, so all the pollution generated/transported becomes trapped in very low levels.

One transport mechanism that can play a key role in moving pollution long distances is the nocturnal, low-level jet stream. The jet is a regional scale phenomenon of higher wind speeds that often forms during ozone events a few hundred meters above the ground. It can convey air pollution several hundreds of miles overnight from the southwest to the northeast, directly in line with the major population centers of the Northeast Corridor stretching from Washington, D.C. to Boston, Massachusetts. The nocturnal, low-level jet extends the entire length of the corridor from Virginia to Maine and has been observed as far south as Georgia. It can thus be a transport mechanism for bringing ozone and other air pollutants into the OTR from outside the region, as well as to move locally formed air pollution from one part of the OTR to another. Other transport mechanisms occur over smaller scales, including land, sea, mountain, and valley breezes that can selectively affect relatively local areas.[4]

The different transport regimes into and within the OTR provide a conceptual picture of unhealthy ozone air quality days. Normally air cools as elevation increases above ground level. However, a nocturnal temperature inversion can occur after sunset if the ground cools faster than the air above it. In this instance, air temperature increases with elevation, which creates a stable boundary layer that prevents the vertical movement of air and thus traps pollutants near the ground. The stable boundary layer extends from the ground to only a few hundred meters in altitude. The air movement within the stable boundary layer is also minimal due to friction from the ground, and ground-level structures. Above this stable boundary layer, a nocturnal low-level jet can form with higher velocity winds due to the absence of frictional forces. Ozone contained in the low-level jet is unable to mix down to the ground because of the presence of a temperature inversion and is thus not subject to removal on surfaces or chemical destruction. Ozone in high concentrations can be entrained in the nocturnal low-level jet and transported several hundred kilometers downwind overnight. The next morning, as the sun heats the Earth's surface, the nocturnal boundary layer begins to break up, and the ozone transported overnight mixes down to the surface where concentrations rise rapidly, partly from mixing and partly from ozone generated locally. By the afternoon, abundant sunshine combined with warm temperatures promotes additional photochemical production of ozone from local emissions. As a result, ozone concentrations reach their maximum levels through the combined effects of local and transported pollution.

During unhealthy ozone exceedance episodes associated with high pressure systems, these multiple transport features are embedded within a large ozone reservoir arriving from source regions to the south and west of the OTR. Thus, ozone exceedance episodes can contain elements of long-range air pollution transport from outside the OTR, regional scale transport within the OTR from channeled flows in nocturnal low-level jets, and local transport along coastal shores due to bay, lake, and sea breezes. These typical patterns that usually result in unhealthful ozone levels were not present in New Jersey on April 13, 2023, June 2, 2023, June 29 and 30, 2023, when air flowed from a direction not normally associated with high ozone levels in New Jersey as explained later in this document.

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[4] Downs, T., Fields, R., Hudson, R., Kheirbek, I., Kleiman, G., Miller, P., & Weiss, L. (2006). *The Nature of the Ozone Air Quality Problem in the Ozone Transport Region: A Conceptual Description*. NESCAUM. Retrieved January 22, 2024, fromhttps://www.nescaum.org/documents/2010_o3_conceptual_model_final_revised_20100810.pdf

Ozone formation within the OTR is primarily due to nitrogen oxides (NOx), but volatile organic compounds (VOCs) are also important because they influence how efficiently ozone is produced by NOx, particularly within urban centers. Recent studies suggest that aged wildfire smoke, containing VOCs, transported into urban areas like New Jersey where an abundant supply of NOx exists, will lead to the creation of higher ozone levels because of the extra VOC from the wood smoke.[5] This is discussed in more detail in the Conceptual Model of Ozone Formation from Wildfires section of this document.

3. Wildfire Description

In spring 2023, numerous fires burned across the grassy Flint Hills region of eastern Kansas. Evidence from satellite imagery shows fire activity started to accelerate in late March and early April due to widespread drought conditions across the plains.[6] Strong winds, unseasonably warm air temperatures, and extremely dry prairie grasses created a favorable environment for large and small wildfires to spread in Kansas between late March and early April 2023. Some fires were spread due to escaped fires that were ignited to manage land.[7] According to the Riley County government website, multiple major fires in Riley County between April 6-10, were prescribed burns that got out of control. The county reported that "shifting and swirling winds rekindled one of the fires overnight," as well as "…several miles of active fire-line among various controlled burns and lots of smoke in the area," as seen in Figure 1.[8] Firefighters were called to four other fires over the weekend, but Riley County Fire Department stated that the two major fires between April 6 and 7 were particularly large and burned more than 3,500 acres alone.

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[5] Val Martin, M., Honrath, R.E., Owen, R.C., Pfister, G., Fialho, P., & Barata, F. (2006). Significant enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires. *Journal of Geophysical Research: Atmospheres, 111*(D23). DOI: 10.1029/2006JD007530

[6] "Burn Scars in Kansas", NASA Earth Observatory, April 17, 2023, https://earthobservatory.nasa.gov/images/151223/burn-scars-in-kansas, Date Accessed: January, 25, 2024

[7] "Burn Scars Across Eastern Kansas", MODIS, April 12, 2023, https://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2023-04-14, Date Accessed: January 25, 2024

[8] "Two out-of-control Fires Burn Thousands of Acres in Riley County" Riley County Kansas, April 10, 2023, https://www.rileycountyks.gov/CivicAlerts.aspx?AID=1582, Date Accessed: January 25, 2024

Figure 1: Active Fire Line Spans Miles Through Riley County, Kansas – April 10, 2023

Image courtesy of rileycountyks.gov

Prescribed burns in Riley County, Kansas are used to manage agricultural lands and prairie grassland, and spring is the preferred time for such burns. These burns are typically closely managed but may escape control even in the best of conditions. In extreme fire weather, such as experienced in central and eastern Kansas during April 2023, escaped burns can quickly become catastrophic.[9]

Sixty-one permitted agricultural fires were recorded the previous week (April 3 - April 7), with about 21,000 acres burned in Riley County.[10] Figure 2 shows Riley County Fire Department vehicle at the burn site.

[9] Ibid(2)

[10] "3500+ Acres Burned in Two Major Riley County Fires", 13 WIBW, April 10, 2023, https://www.wibw.com/2023/04/10/3500-acres-burned-two-major-riley-co-fires/, Date Accessed: January 25, 2024

Figure 2: Riley County Fire Department at Burn Site

Image courtesy of rileycountyks.gov

4. Conceptual Model of Ozone Formation from Wildfires (Interaction of Emissions and Chemistry of event) and Ozone Chemistry that Characterized the Episode Including the Meteorological Conditions and Transport Patterns

Smoke from wildfires has been known to cause elevated ozone levels downwind and expanding observational evidence has demonstrated a clear connection between vegetation fires and photochemical ozone formation within their plumes.[11] Long-range transport of boreal wildfire emissions can result in greater levels of carbon monoxide (CO), organic and black carbon (BC) aerosol, NOx, PM2.5, and aerosol mass downwind of the fire location. Also, greater amounts of CO in the plume can also enhance ozone formation.[12]

A study of the impacts from a 2002 Quebec, Canada wildfire event on the northeastern U.S. reported that ozone levels within the plume are also much greater, reaching 75 parts-per-billion by volume (ppbv) in one instance. [13]

Smoke from wildfires also appears to have a greater effect on enhancing ozone formation in urban areas compared to rural areas. One previous study of Canadian wildfires (not related to this exceptional event)

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[11] Andreae, M.O. (1983). Soot carbon and excess fine potassium: Long range transport of combustion-derived products. *Science, 220*(4602), 1148-1151. DOI: 10.1126/science.220.4602.1148

[12] Val Martin, M., Honrath, R.E., Owen, R.C., Pfister, G., Fialho, P., & Barata, F. (2006). Significant enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires. *Journal of Geophysical Research: Atmospheres, 111*(D23). DOI: 10.1029/2006JD007530

[13] DeBell, L.J., Talbot, R.W., Dibb, J.E., Munger, J.W., Fischer, E.V., & Frolking, S.E. (2004). A major regional air pollution event in northeastern United States caused by extensive forest fires in Quebec, Canada. *Journal of Geophysical Research: Atmospheres, 109*(D19). DOI: 10.1029/2004JD004840

found that in urban areas, or any region modified by nearby NOx sources, ozone levels were more sensitive to long-range fires compared to less populated or polluted regions."[14]

In this study, researchers proved that:

> "Both observations and model results show enhanced O_3 from air transported from the Northwest Territory. The model results imply that, during the period of strongest fire influence, a 10 to 30 ppbv enhancement of O_3 throughout a large region of the central and eastern United States was due to these fires."

4.1 Conceptual Model Overview

The months of March and April 2023 in the plains were characterized by prolonged drought with precipitation totals falling below normal. Kansas entered its second year of drought with some locations not seeing meaningful precipitation for nearly 200 days. Since the start of 2023, numerous locations in the plains received less than 0.50 inches of precipitation after near record dryness in 2022. The end of March favored a return of frequent weather disturbances moving through the jet stream flow allowing Pacific and Gulf of Mexico moisture to relieve some dry portions of the west. Many of these weather systems and storm tracks would have provided much needed relief for dry portions of the plains, but resulted in missed opportunities for precipitation and prolonged the extensive drought across this area.[15] The initial burn in Flint Hills began on approximately April 6th, however conditions had been ripening since mid-March in the plains as many days of "Extreme Fire Weather" were declared leading up to this event.[16] On April 10th, an expansive and strong area of high pressure was located over the eastern US, centered over the Mid-Atlantic region providing clear skies and calm winds to New Jersey. Meanwhile, in the plains, another smaller area of high pressure was located in the central US with a weakening area of low pressure and surface trough separating these two air masses. Here, this boundary between the two air masses allowed smoke to rise into the atmosphere. During the next several days, as high pressure gradually moved off the coast, smoke traveling cross-country in the upper atmospheric levels traveled around the perimeter of high pressure and gradually returned to the lower levels of the atmosphere via subsidence (a gentle sinking motion associated with strong, widespread, high pressure). The migration of high pressure along with the smoke plume pathway is shown in the simplified illustration, Figure 3.

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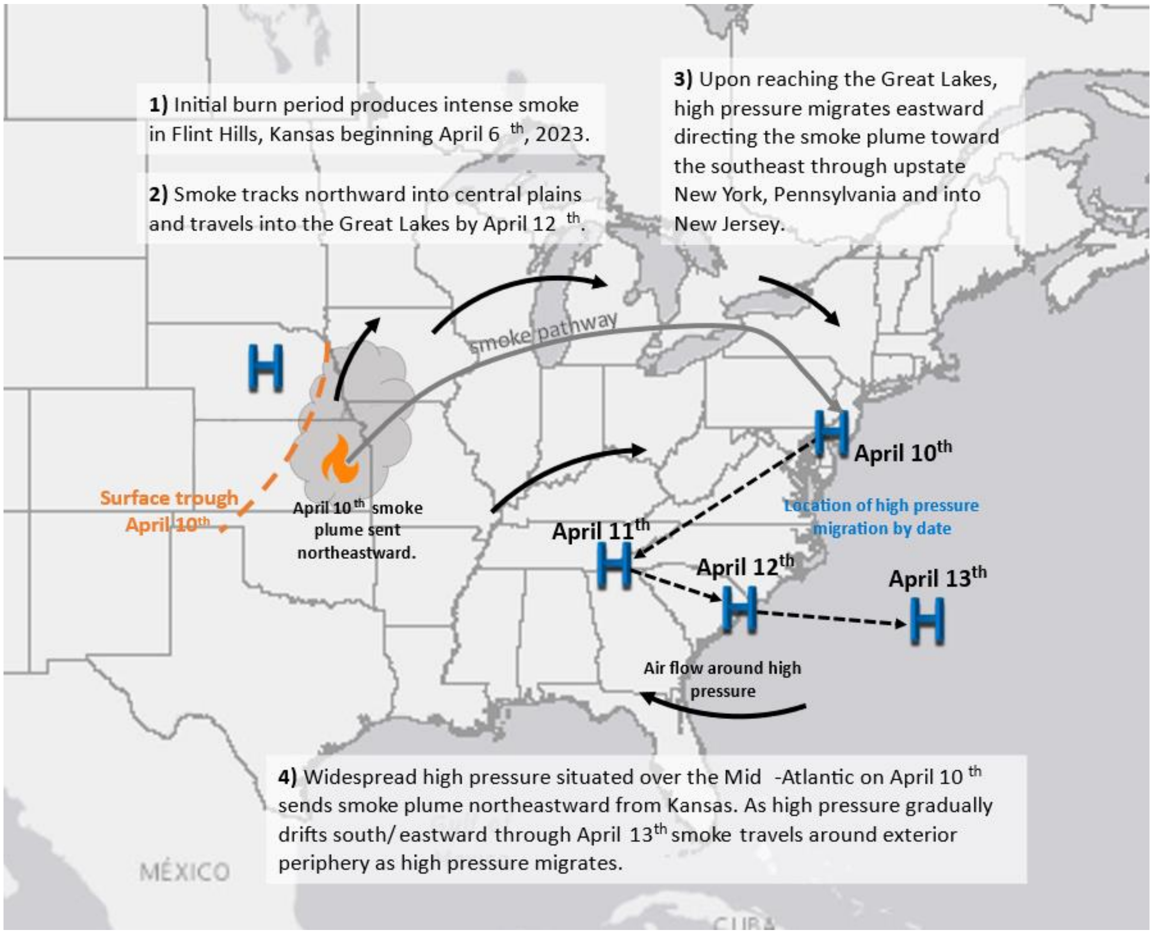
[14] McKeen, S.A., Wotawa, G., Parrish, D.D., Holloway, J.S., Buhr, M.P., Hübler, G., Fehsenfeld, F.C., & Meagher, J.F. (2002). Ozone production from Canadian Wildfires during June and July of 1995. *Journal of Geophysical Research: Atmospheres, 107*(D14). DOI: 10.1029/2001JD000697

[15] NOAA National Centers for Environmental Information. (Published Online April 2023). *Monthly Drought Report for March 2023*. Retrieved on January 24, 2024, from https://www.ncei.noaa.gov/access/monitoring/monthly-report/drought/202303

[16] Kansas Flint Hills Smoke Management. (Published Online April 2023). *Flint Hills wildland Fire Update for April 7, 2023.* Retrieved January 25, 2024, from https://www.ksfire.org/new-media-archives/weeklyupdates/2023/Flint_Hills_Update_April_7_2023.pdf

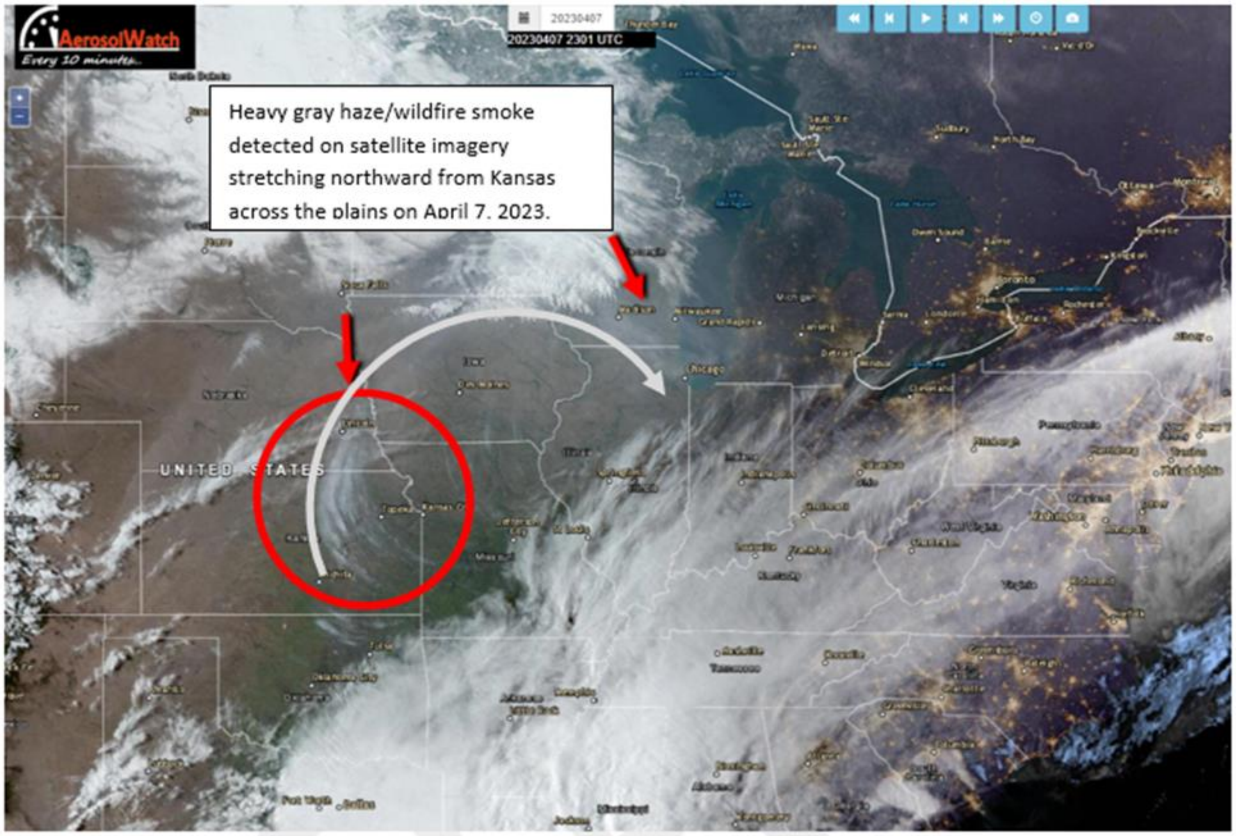
Figure 3: Simplified, Illustrated Conceptual Model Diagram of April 13, 2023, Wildfire Event



4.2 Surface Analysis – Transport & Wind Pattern

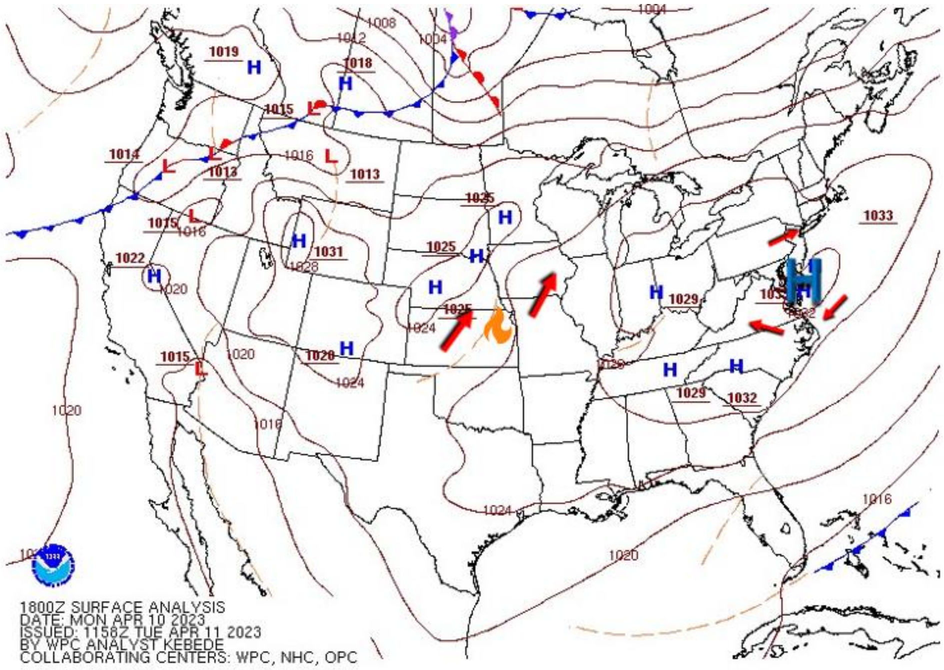
Beginning on April 6 and 7, a large wildfire in the Flint Hills area in Kansas created intense smoke plumes that sent wildfire smoke billowing into the atmosphere. Here, strong high pressure was providing mild temperatures, light northerly winds, and clear skies to the region. At this time, northerly winds sent smoke drifting north/northeastward into Nebraska and Iowa (Figure 4).

Figure 4: Aerosol Watch Satellite Imagery – April 7, 2023, 23:01UTC



In the subsequent days, high pressure strengthened across the eastern half of the US allowing plumes of smoke from Kansas to continue following this pattern while drifting northward and getting wrapped into the airmass. This strong area of high pressure was in place over much of the eastern half of the US providing warm temperatures, sunny skies, and calm winds to the region on April 10. Meanwhile, in the central plains, another localized area of high pressure was providing similar conditions to this area separated by a surface trough that was dividing the two airmasses. This set up allowed wildfire smoke from the Flint Hills, Kansas region to be directed northward around the periphery of high pressure (Figure 5).

Figure 5: Surface Analysis for April 10, 2023, 18UTC



By April 11, these two air masses had combined to create a large high-pressure system centered over the southeastern United States. This weather set-up (Figure 6) is characterized by a general westerly flow (on the northern side of the high) at the surface and at higher altitudes, which helped to steer the smoke plume eastward. As a result, smoke from the wildfire was transported eastward via clockwise winds circulating around this area of high pressure. Figure 7 shows the widespread nature of the Kansas fire in addition to many other fires occurring on this day that were scattered across the central and southeastern US that had smoke plumes swept into this large air mass.

Figure 6: Surface Analysis for April 11, 2023, 18UTC

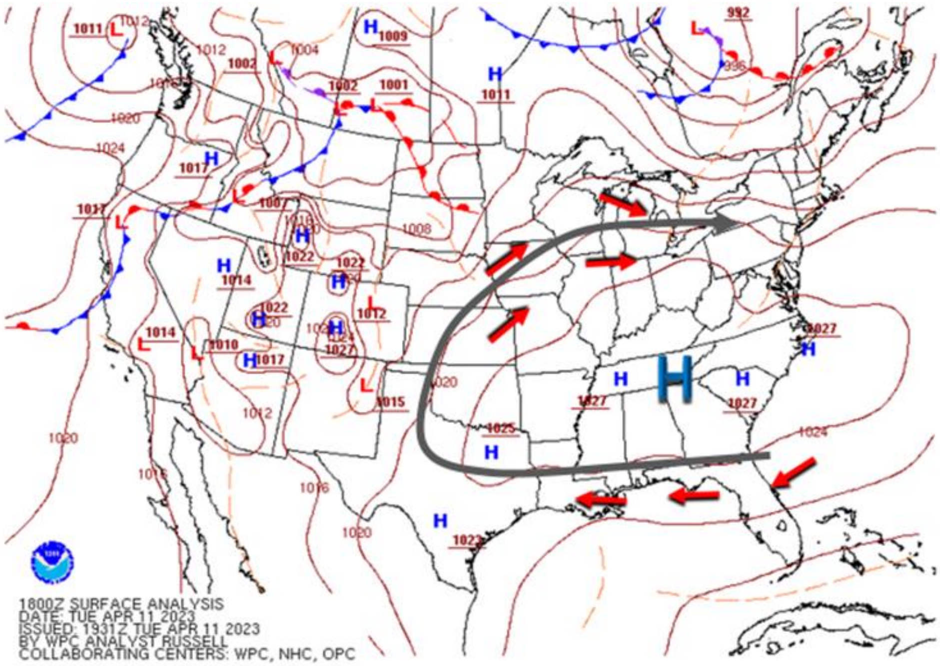
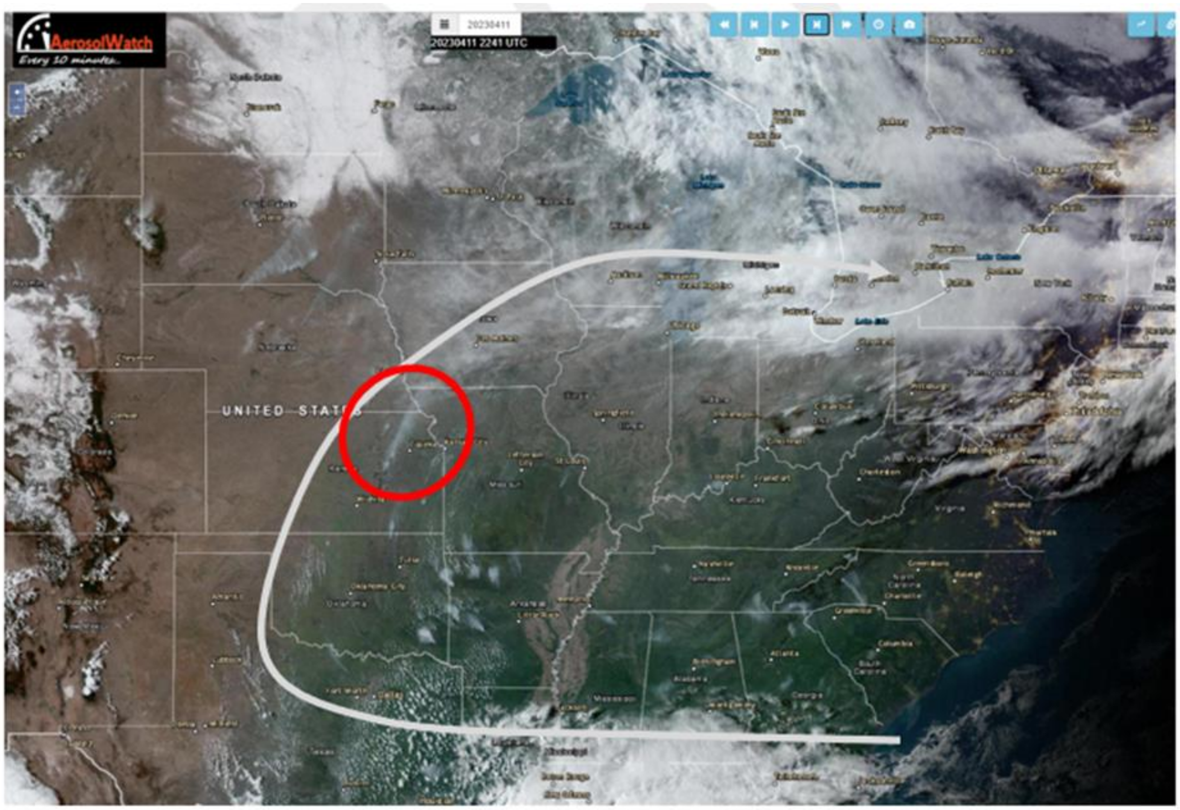


Figure 7: Aerosol Watch Satellite Imagery – April 11, 2023, 22:41UTC



By April 12, the day before the event, high pressure gradually moved offshore/southward into the lower portion southeastern US while still maintaining control of the weather across the Mid-Atlantic, Central Plains, and Great Lakes regions (Figure 8). At this time, air had reached the Great Lakes region while continuing its eastward progression. On this day, wildfire smoke was already detected on satellite imagery (Figure 9) over the Mid-Atlantic region. In Figure 9, wildfire smoke is noted with a red circle over the Great Lakes and hazy conditions are visible over the Mid-Atlantic and off the New Jersey coastline.

Figure 8: Surface Analysis for April 12, 2023, 18UTC

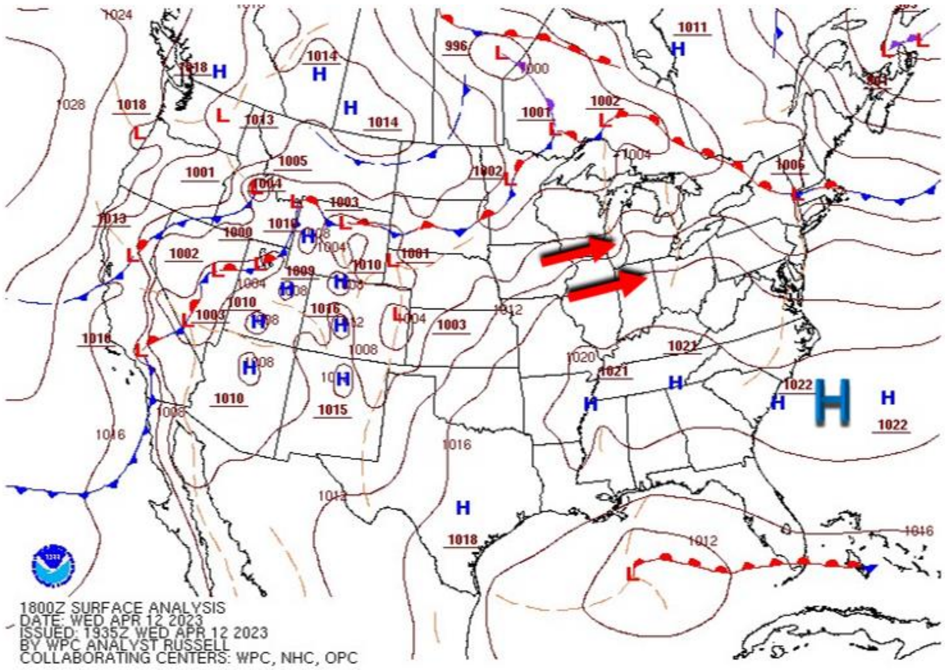
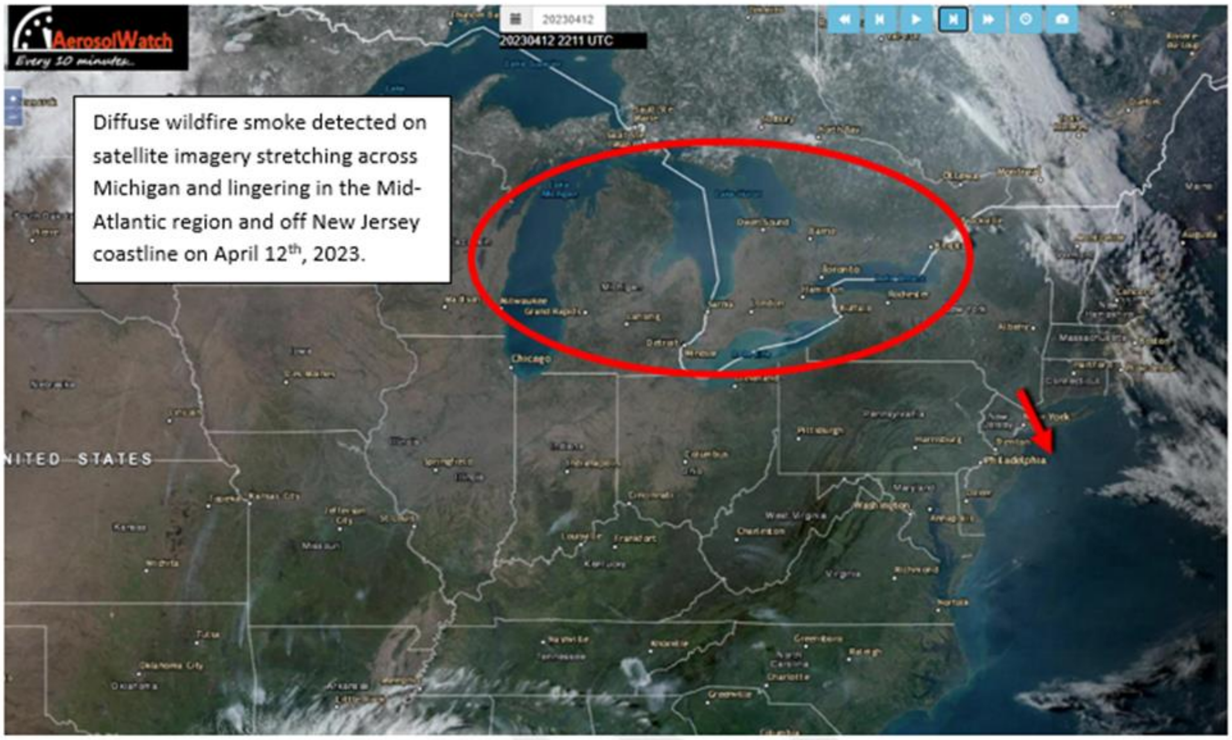


Figure 9: Aerosol Watch Satellite Imagery – April 12, 2023, 22:11UTC



In the early morning hours of April 13th, (Figure 10), diffuse smoke was again visible on satellite imagery lingering over the east coast. By mid-day, high pressure had migrated just off the southeast US coast (Figure 11) providing breezy westerly winds (noted with red arrows in Figure 11), and unseasonably warm temperatures soaring into the upper 80s. Meanwhile, a surface trough developed over the nonattainment area allowing warm and polluted air aloft to mix down to the surface leading to many exceedances nearby and along this boundary.

Figure 10: Aerosol Watch Satellite Imagery – Early Morning April 13, 2023, 11:31UTC

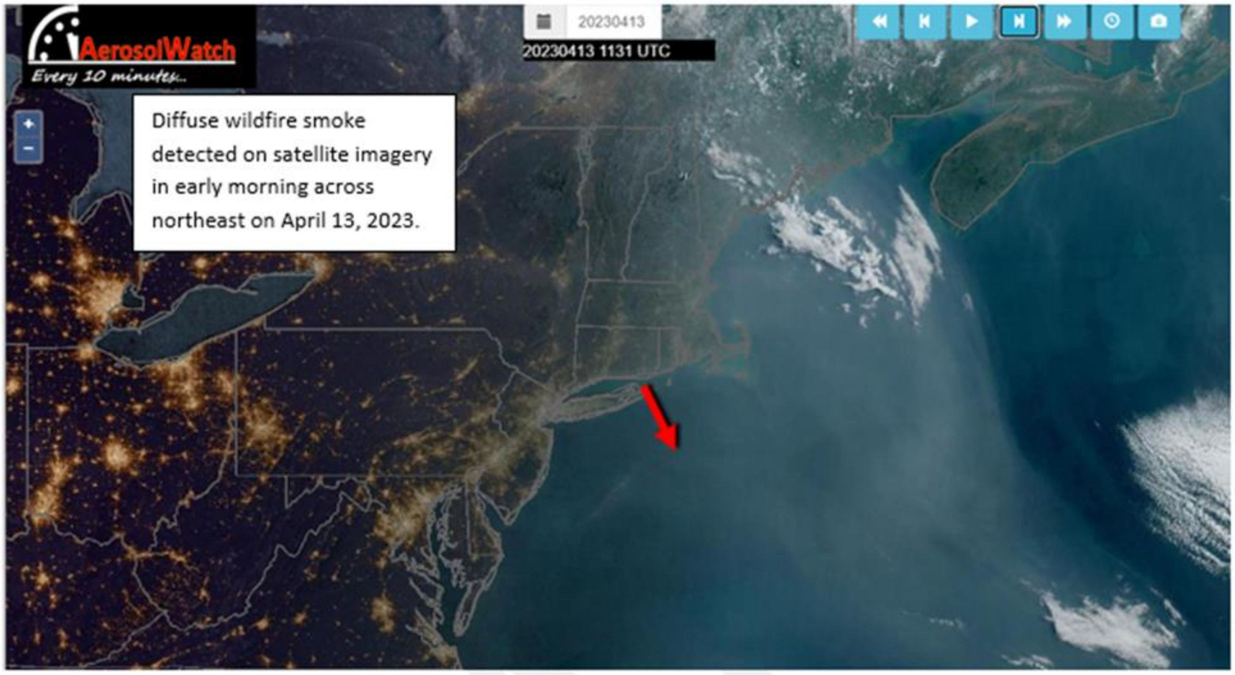
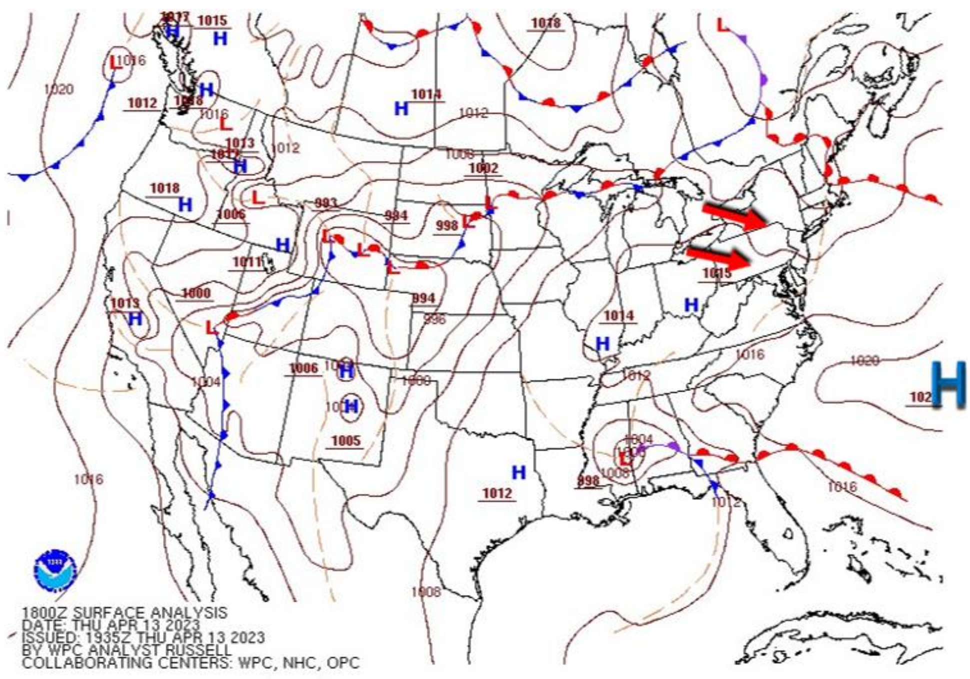


Figure 11: Surface Analysis for April 13, 2023, 18UTC



4.3 Upper Air Analysis

The 850 millibar (mb) upper air level is approximately 1500 m above sea level and sits near the top of the planetary boundary layer (PBL), the atmospheric layer in which ozone pertinent to surface observations and human health develops. For this reason, the 850mb upper air level serves as a guide for the transport of pollutants. The analysis of this atmospheric level is given for April 9 – April 13, 2023.

Beginning on April 9, (Figure 12), high pressure centered over the Great Lakes in the upper levels allowed smoke from the fires in Kansas to get wrapped into the periphery of high pressure, while rising higher into the atmosphere. This initial set up allowed wildfire smoke to remain trapped in the airmass as it tracked eastward. As a result, any air departing from this general region would transport smoke to the ending location in New Jersey. By April 10 and 11, (Figures 13 and 14) high pressure migrates south and has a more horizontal (east-west) shape encompassing much of the southeastern United States (Figure 14. Initially, the area of high pressure sent the smoke plume on a northeastward journey into the Great Lakes. However, at this time, the elongated shape and southward migration of high pressure allowed the smoke plume to be directed eastward. On April 12 – 13 (Figure 15 and 16) high pressure strengthens as it moves offshore while the smoke plume is caught in a fast-moving pocket of air in the upper levels. Here, the impact of subsidence (sinking air within high pressure system) allows the smoke to migrate down to lower levels of the atmosphere and ultimately, the surface. The smoke plume follows this pathway until it reaches its endpoint in New Jersey.

Figure 12: 850mb Upper Air Analysis, April 9, 2023

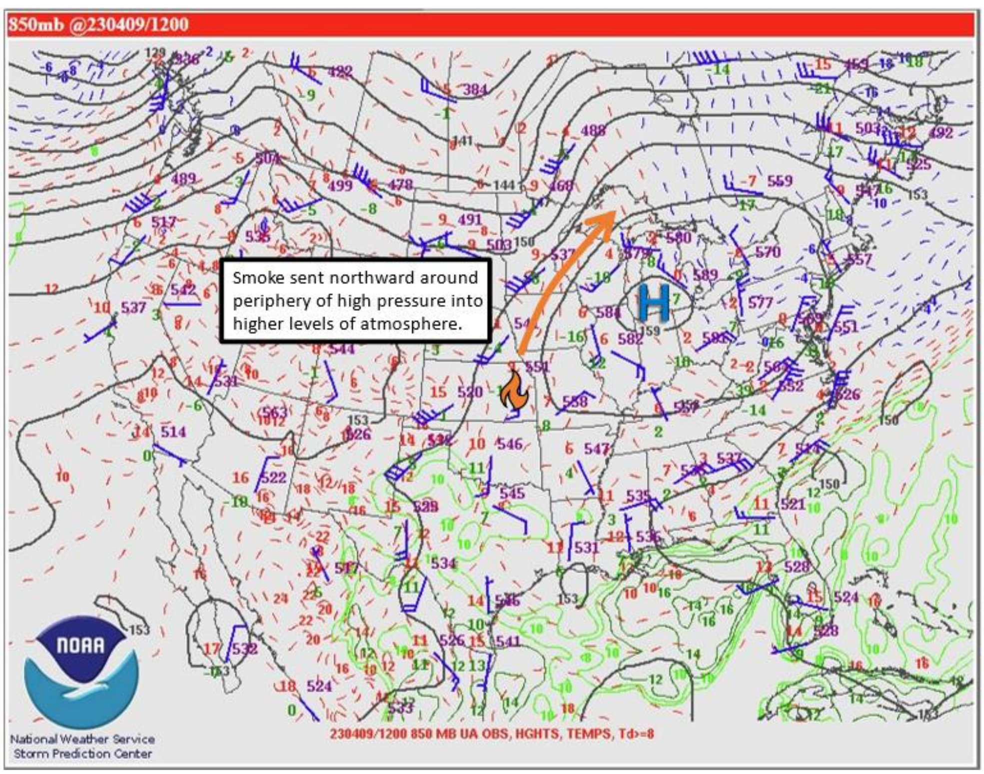


Figure 13: 850mb Upper Air Analysis, April 10, 2023

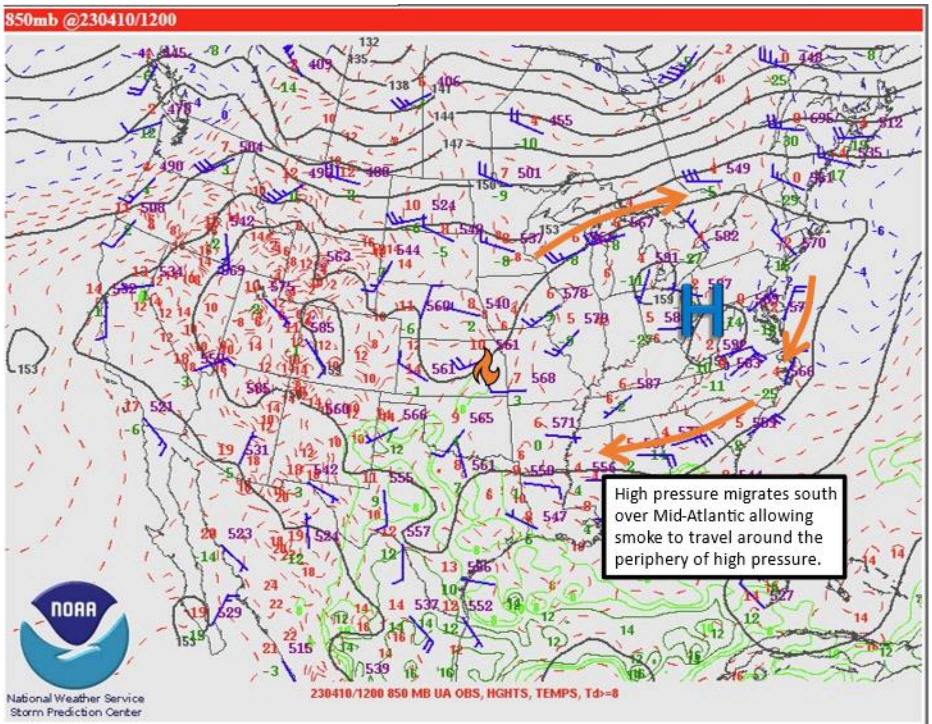


Figure 14: 850mb Upper Air Analysis, April 11, 2023

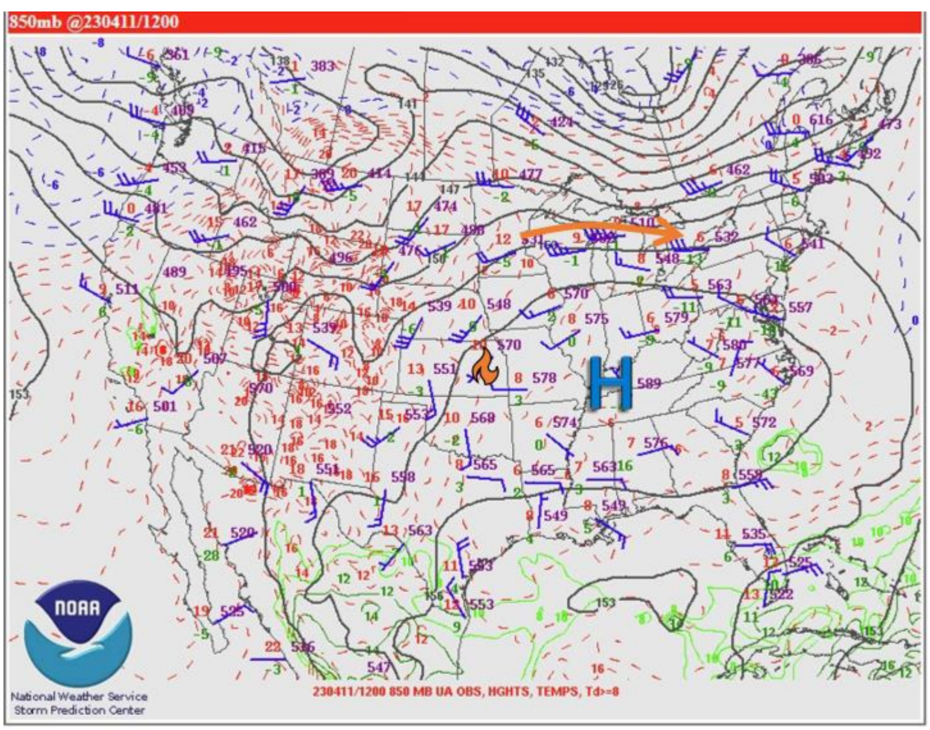


Figure 15: 850mb Upper Air Analysis, April 12, 2023

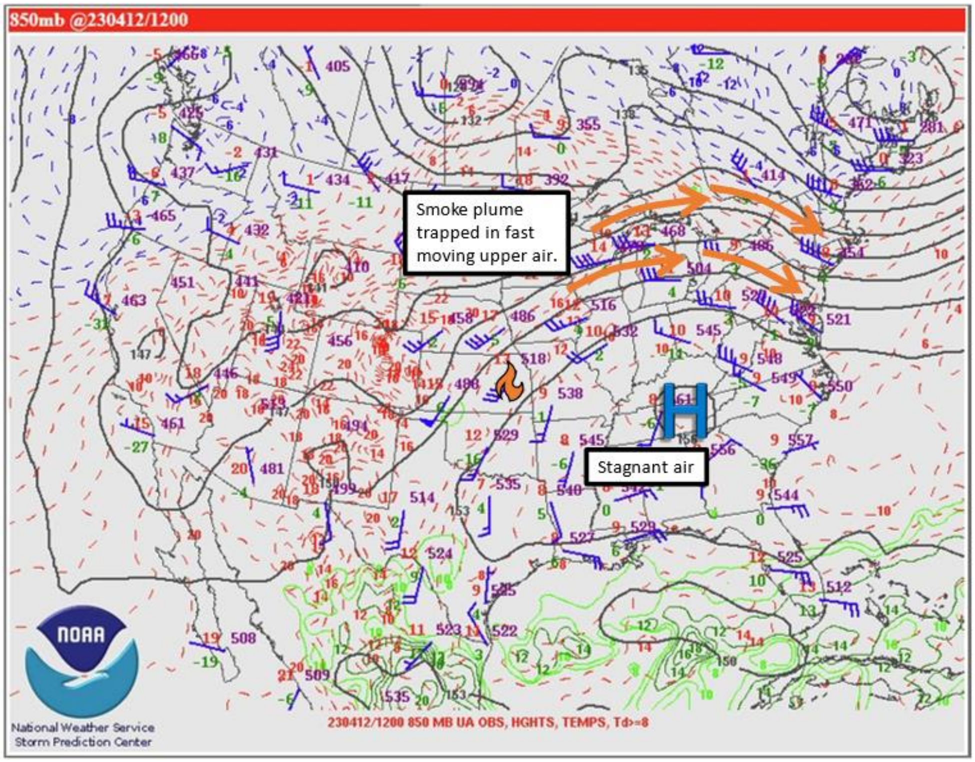
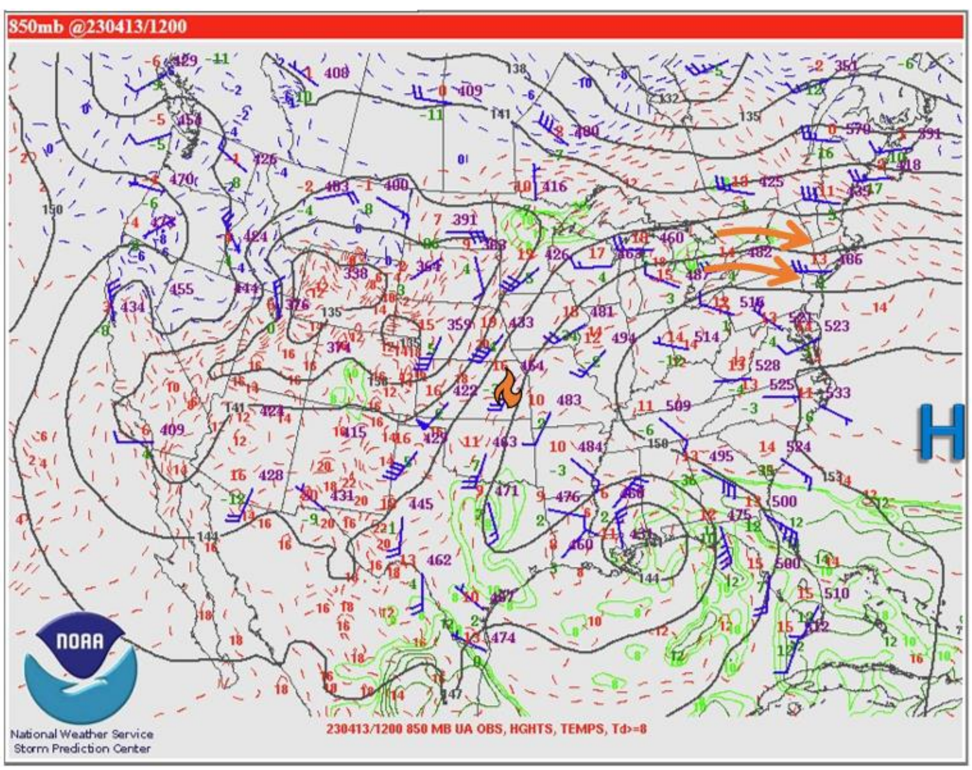
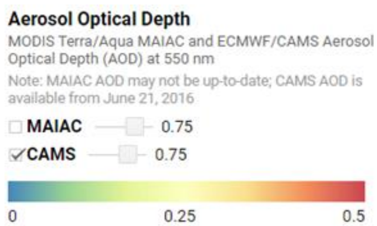


Figure 16: 850mb Upper Air Analysis, April 13, 2023



4.4 Aerosol Optical Depth

Figures 17 - 21 show aerosol optical depth (AOD) in the days leading up to the high ozone exceedance event on April 13, 2023. AOD is a measure of smoke in the atmosphere that is blocking sunlight. Therefore, it is a helpful indicator of wildfire smoke and how much direct sunlight is prevented from reaching the ground by aerosol particles. "A value of 0.01 corresponds to an extremely clean atmosphere (dark blue) and a value of 0.4 would correspond to a very hazy condition".[17] In the following images, AOD is indicated by the color scale from cool tones (blue) to warm tones (red), which represents a scale from 0.0 to 0.5.



Figures 17 and 18 show the initial smoke progression with dense AOD shown in red on April 9 and 10 coming from the fire source location in Flint Hills, Kansas. During this time, the dense plume is sent northeastward around high pressure as described earlier in the surface analysis. As the plume wraps around high pressure, it migrates into New England on April 11 (Figure 19) where it is still dense but slowly dissipating. After the initial plume dissipates, the aged plume makes its way into the Mid-Atlantic on April 12 (shown in Figure 20 as a pale-yellow color observed over New Jersey). By April 13, the smoke plume has mostly dissipated, however, is still measurable in the AOD image (Figure 21). At this time, the aged smoke plume has reacted with other pollutants and is impacting air quality at the surface. The aged smoke plume is observed on April 13 in Figure 21 over New Jersey indicated by the pale green color.

[17] NOAA, Earth System Research Laboratories. (n.d.). *SURFRAD Aerosol Optical Depth*. Retrieved December 13, 2023, from https://gml.noaa.gov/grad/surfrad/aod/#:~:text=Aerosol%20optical%20depth%20is%20a,ground%20by%20these%20aerosol%20particles

Figure 17: Aerosol Optical Depth, April 9, 2023

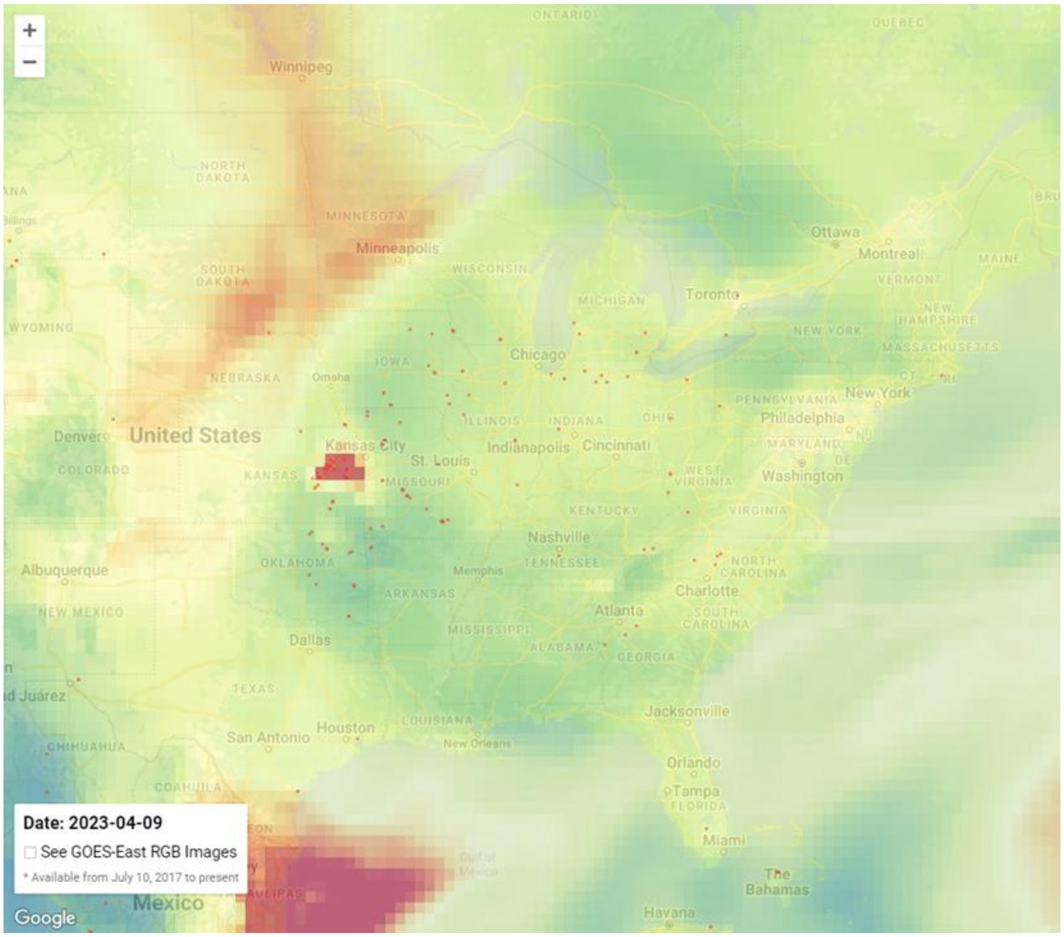


Figure 18: Aerosol Optical Depth, April 10, 2023

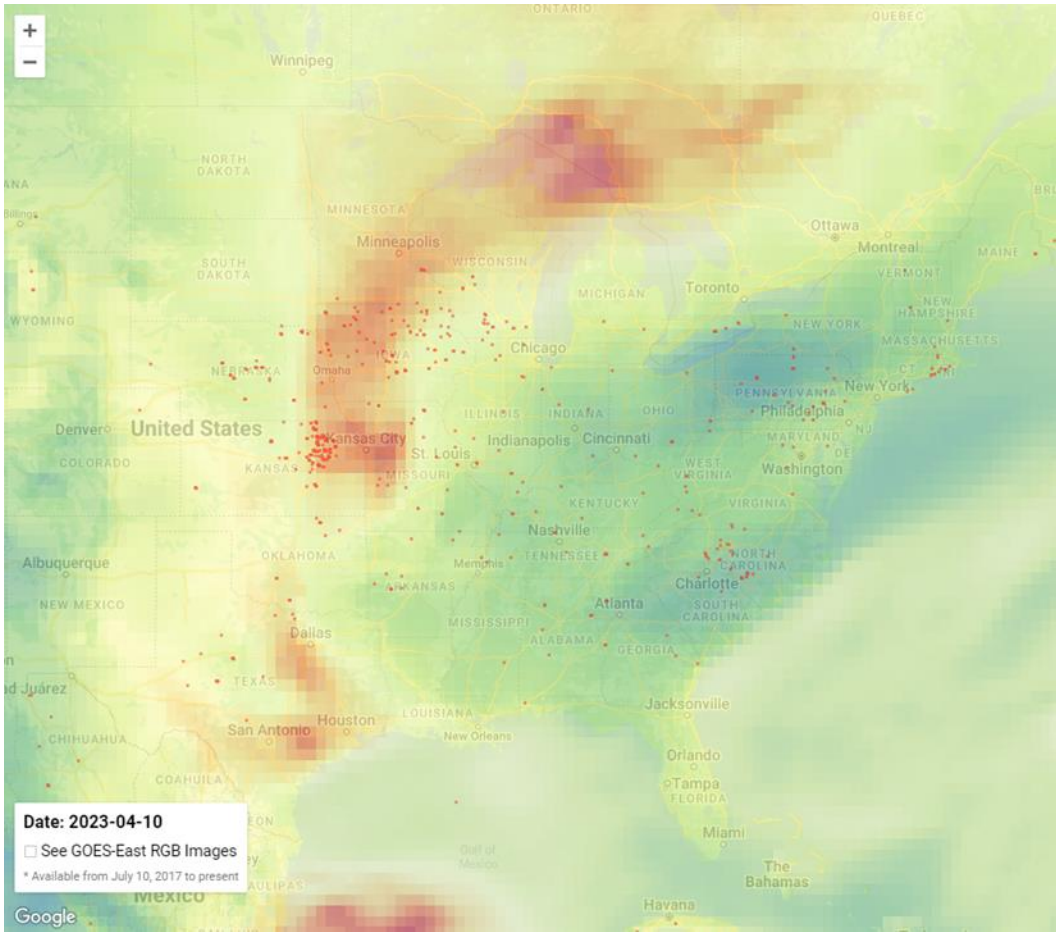


Figure 19: Aerosol Optical Depth, April 11, 2023

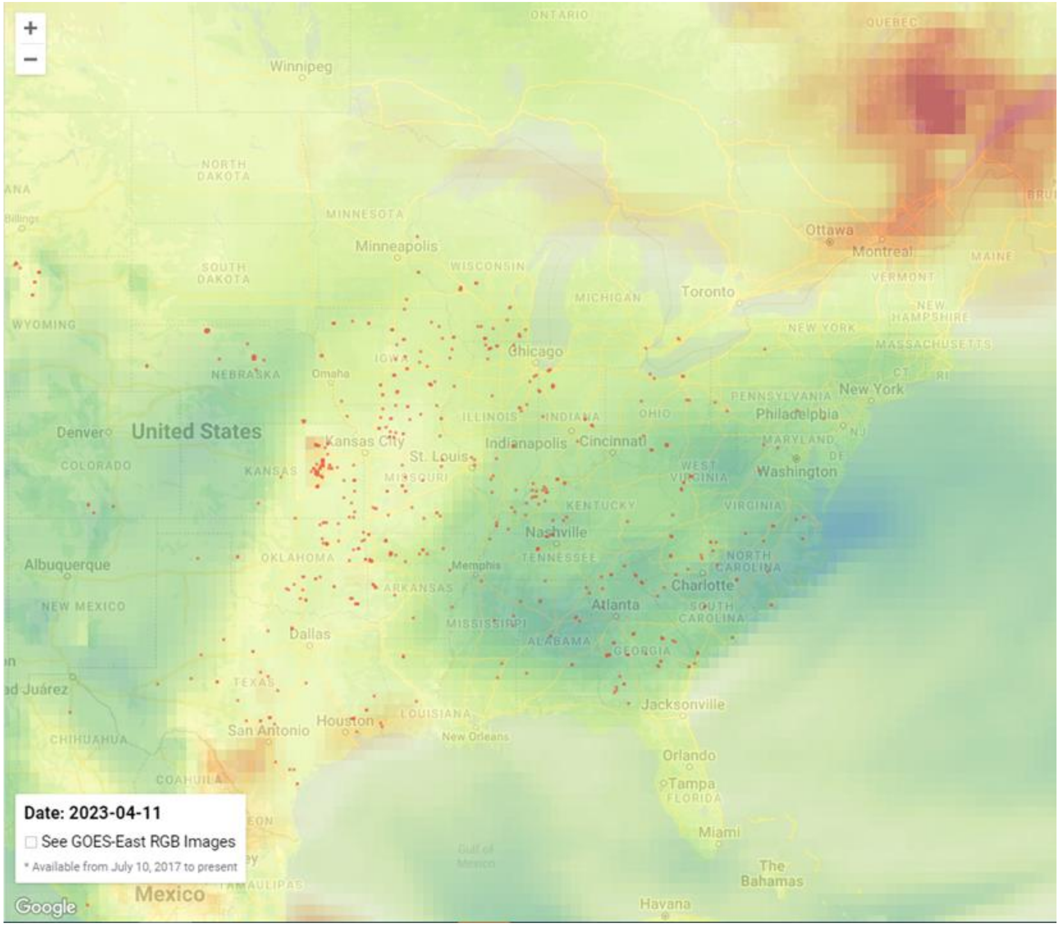


Figure 20: Aerosol Optical Depth, April 12, 2023

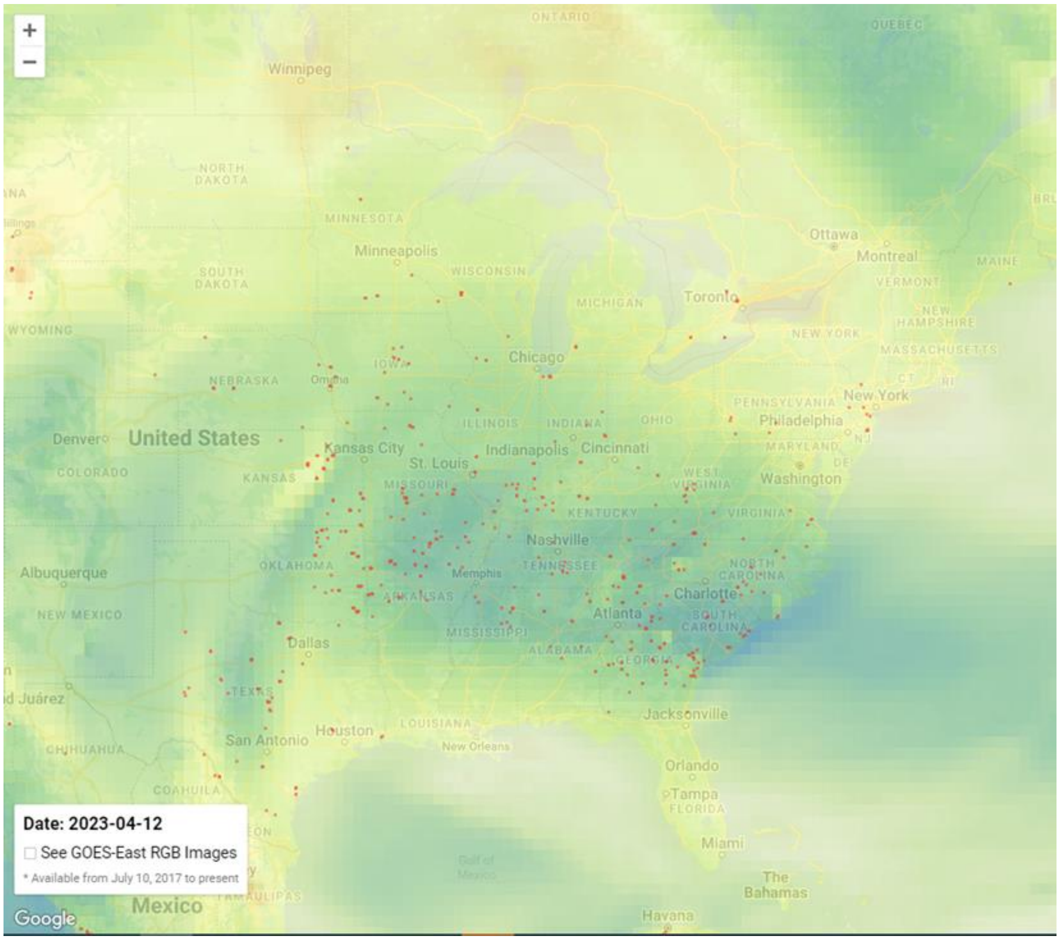
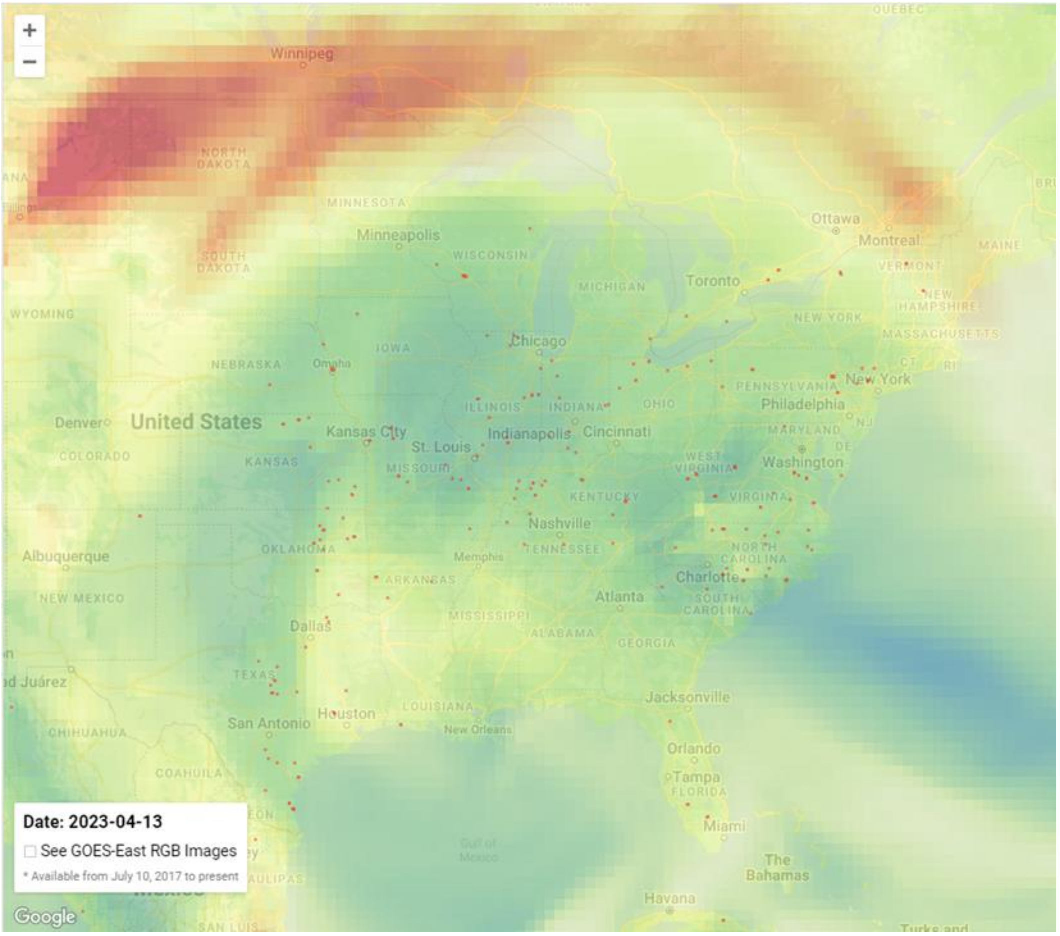


Figure 21: Aerosol Optical Depth, April 13, 2023



4.5 Daily Ozone AQI Maps

The following images (Figures 22-26) show Daily Air Quality Index (AQI) levels observed across the continental United States during the days leading up to and including the exceptional event occurring on April 13, 2023. In the images, an exceedance of the ozone standard (70 ppb) is represented by the colors red and orange. Red signifies Unhealthy ozone levels where the concentrations of ozone (86 – 105 ppb) can begin to have adverse effects on the general population. Orange shows where ozone concentrations (71 – 85 ppb) reached levels that are Unhealthy for Sensitive Groups (USG), such as asthmatics and the elderly. Yellow represents Moderate ozone (55 – 70 ppb) and air quality is acceptable at this level except for those that are unusually sensitive. Green represents Good ozone levels (0 – 55 ppb) and poses little risk.

In the following five AQI images, the location of the fire in Flint Hills, Kansas, is identified by a fire icon. The air quality in the Flint Hills and surrounding areas began to show deterioration from the wildfire smoke beginning on April 9 (Figure 22) indicated by yellow showing widespread moderate air quality. As shown in the above-mentioned satellite imagery and surface maps, the smoke plume was sent northeastward from the fire location. This pattern is also shown in the AQI images and indicates that ozone AQI was influenced along the wildfire smoke plume pathway as it traveled across the United States and the impact to locations downwind of the wildfire. After the initial burn period, the plume of moderate air quality followed along the pathway as described earlier around the periphery of high pressure entering the Great Lakes region (Figure 23 and 24) impacting air quality along the way. As the smoke plume continued to wrap around the area of high pressure, air quality at the surface continued to increase into the northeast climbing into the moderate category across much of the eastern US on April 12 (Figure 25). On April 13, (Figure 26) the air quality in the Mid-Atlantic region increases to Unhealthy for Sensitive Groups as the smoke plume enters the region and migrates down to the surface level due to subsidence and high pressure mentioned previously.

Figure 22: Daily AQI April 9, 2023

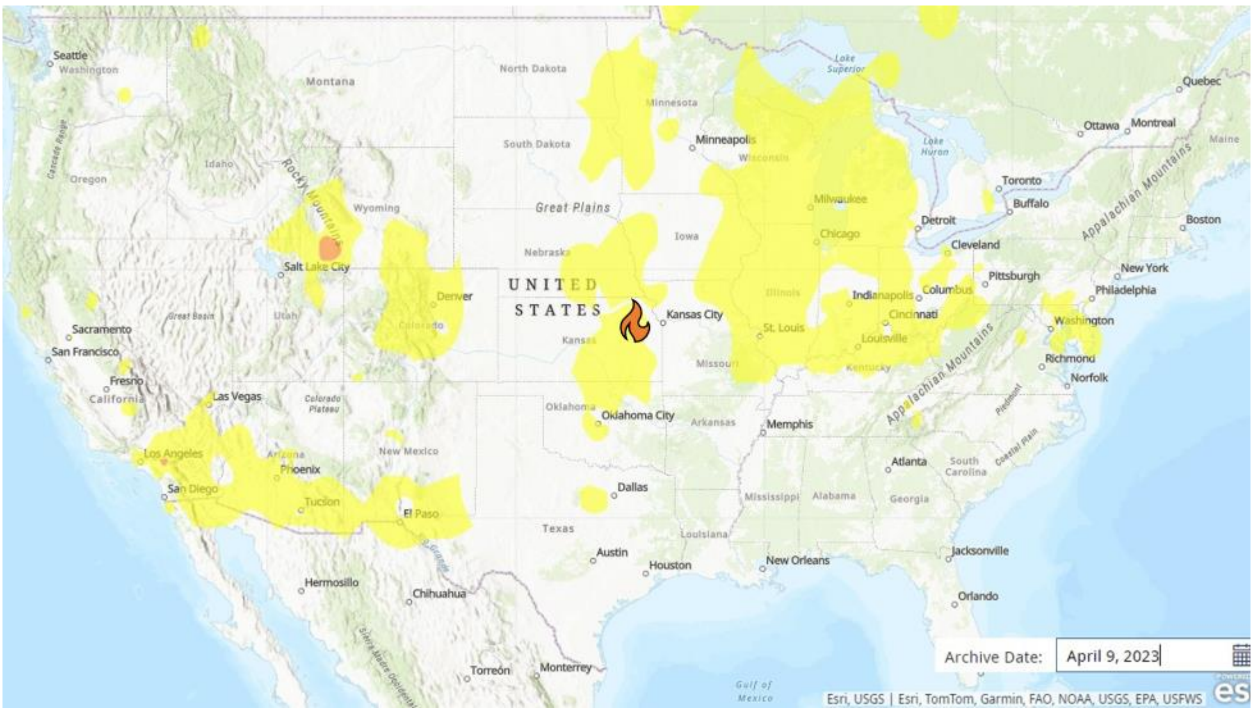


Figure 23: Daily AQI April 10, 2023

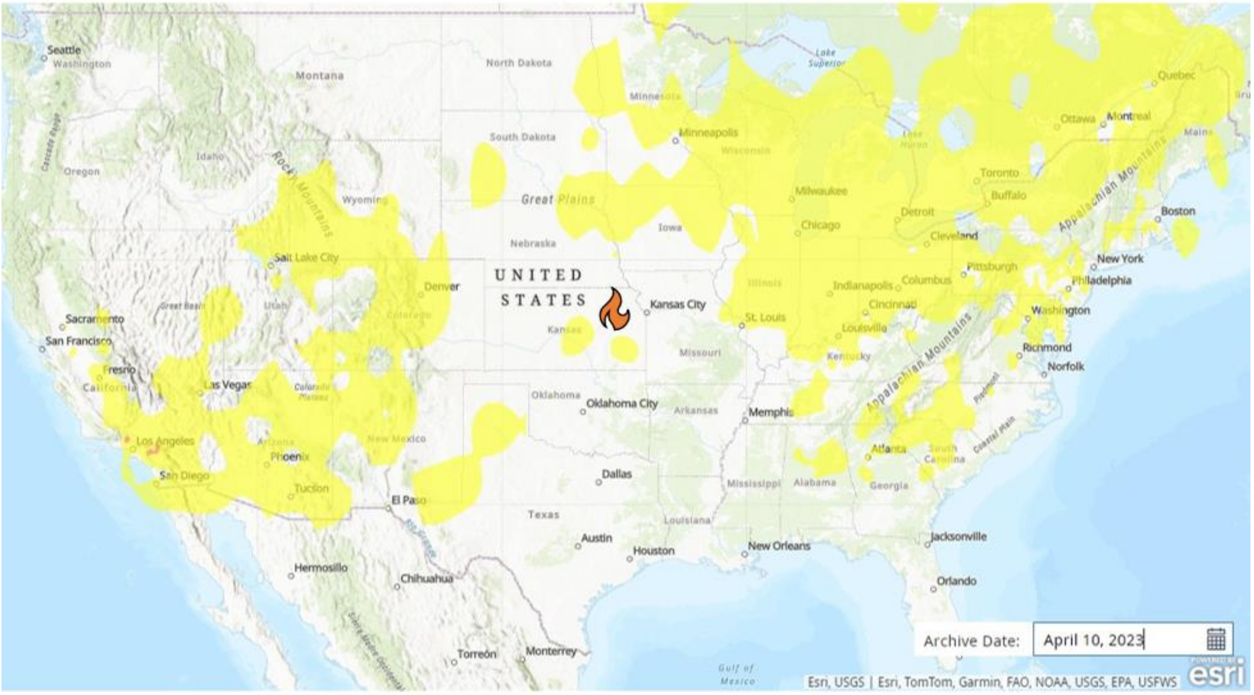


Figure 24: Daily AQI April 11, 2023

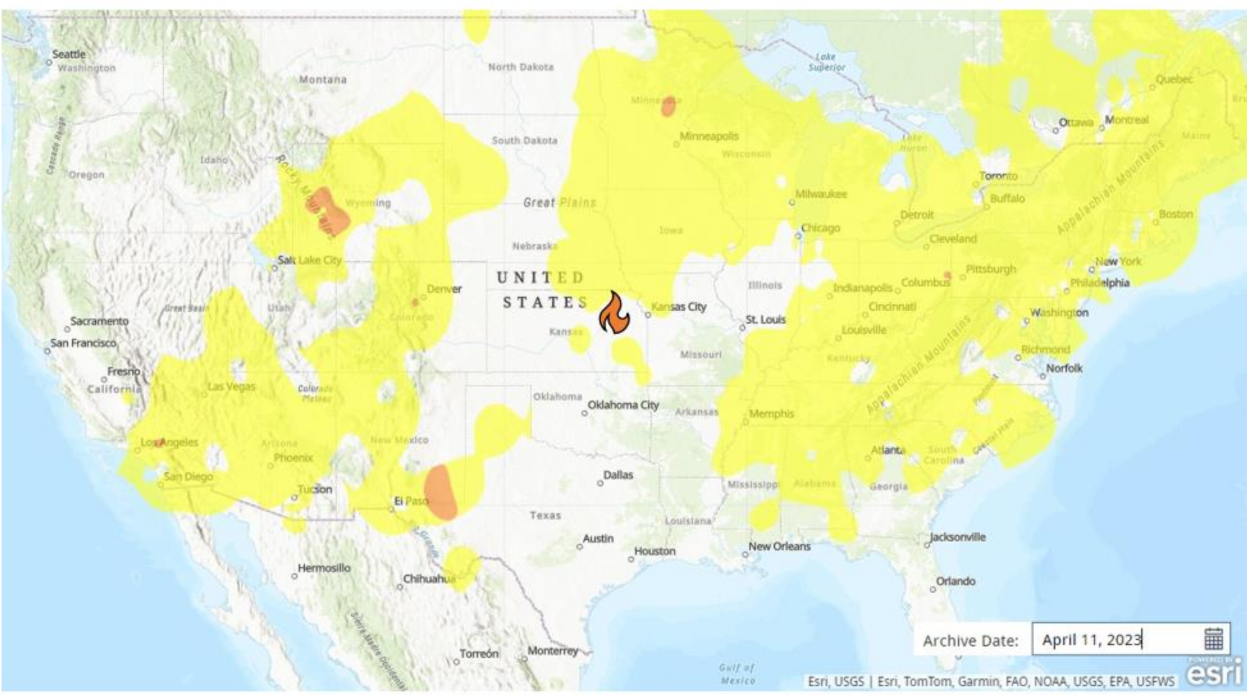


Figure 25: Daily AQI April 12, 2023

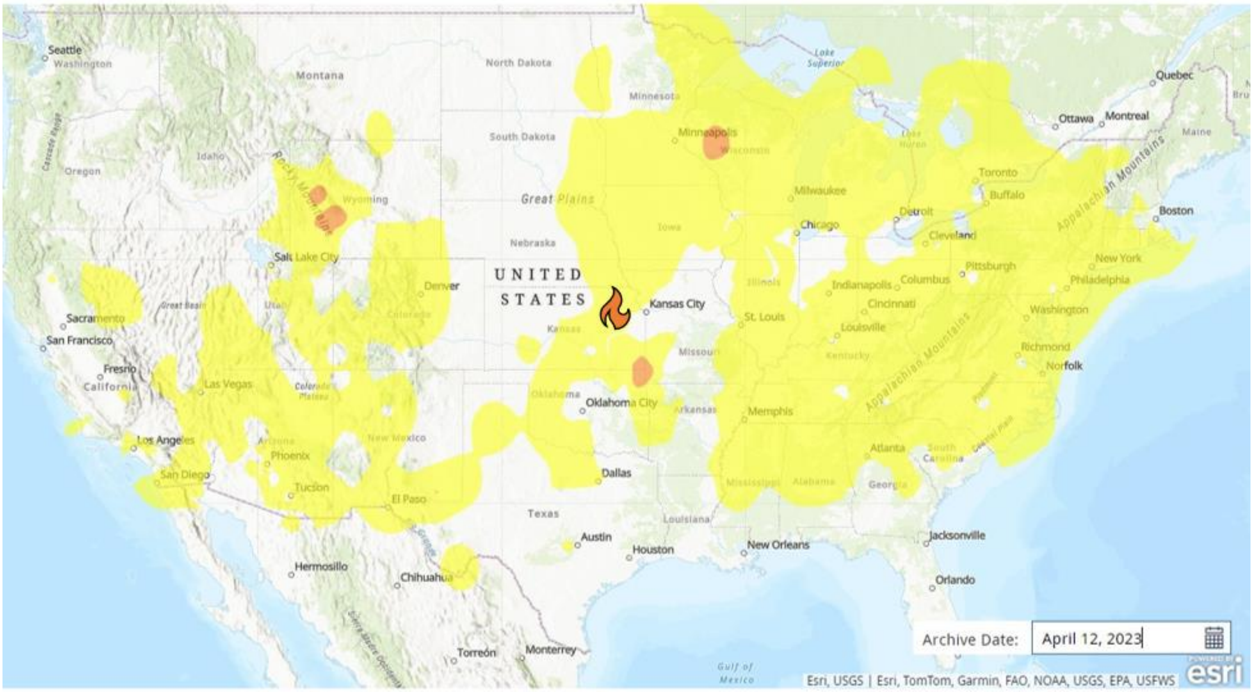
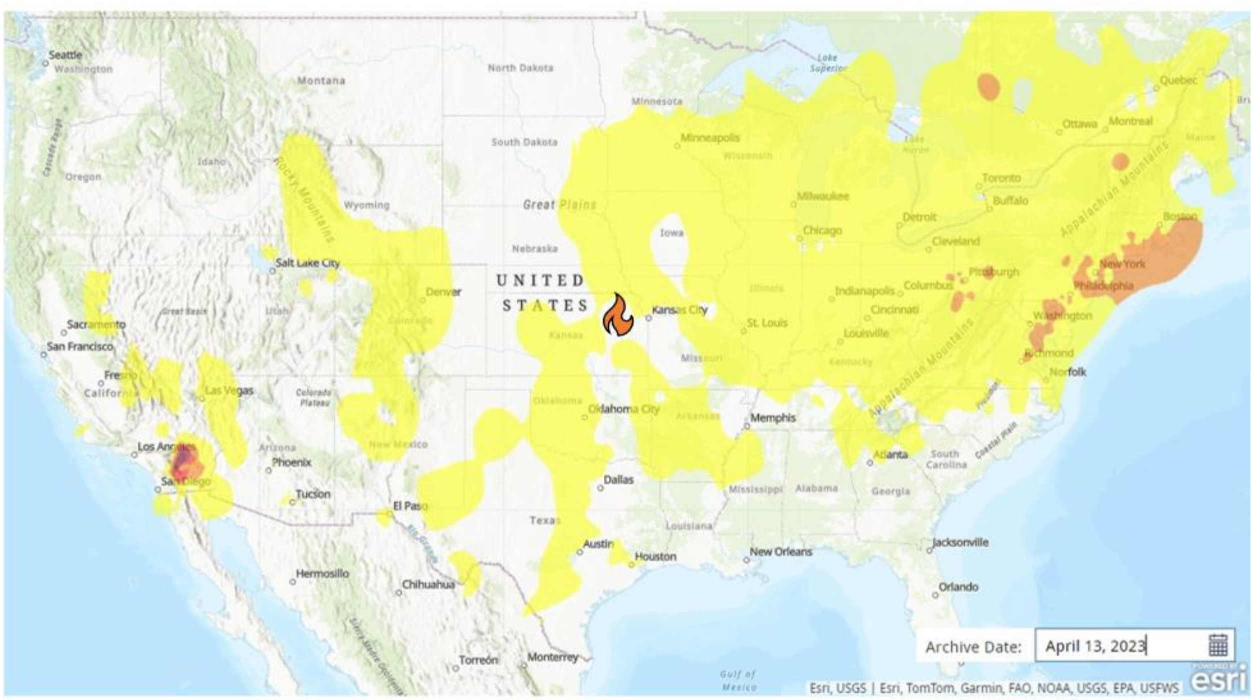


Figure 26: Daily AQI April 13, 2023



II. A Demonstration That the Event Affected Air Quality in Such a Way That There Exists a Clear Causal Relationship Between the Specific Event and the Monitored Exceedance or Violation

The Exceptional Events Rule demonstrations are required to address the technical element and implicit concept of CAA 319(b) that "the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation"[18]. Demonstrations are required to support the clear causal relationship by a comparison of the ozone data requested for exclusion with historical concentrations at the air quality monitor. For a Tier 2 analysis, it needs to be demonstrated that the wildfire event's ozone influences are higher than non-event related concentrations, as well as consider the fire's distance from the affected monitor(s) to indicate a clear causal relationship.[19]

The April 13, 2023, event serves as an example of how smoke can affect air quality in the region. The evidence presented in this report compliments the conceptual model in section 1 and shows that smoke impacted air quality in New Jersey and caused higher-than-normal ozone concentration levels, which resulted in the ozone exceedances on April 13.

The analyses presented in this section include the requirements of a Tier 2 analysis, as well as a Tier 3 weight of evidence component. The Tier 2 and Tier 3 analyses consist of comparisons to historical concentrations, Q/d analysis, analysis of the 99th percentile or higher of the 5-year distribution of ozone monitoring data, analysis of the four highest ozone concentrations within one year, trajectory analysis, satellite evidence, evidence of spatial/temporal patterns of ozone and/or NOx, changes in supporting ground level measurements, visibility impacts, and similar day analysis. These analyses demonstrate that smoke transport caused elevated levels of ozone which resulted in the exceedances at New Jersey monitors on April 13, 2023.

1. Comparison Between Ozone Data Requested for Exclusion with Historical Concentrations

The comparison of monitored concentrations with historical observations is used to demonstrate a clear causal relationship between ozone concentrations and a fire event. To do so, it is necessary to compare the event-related exceedance with historical concentrations measured at the affected monitor or at other monitors in the area during the same season.[20] According to USEPA Guidance, monitored observations at or above the 99th percentile in the past five years from the event-related ozone concentration can be used to establish statistical evidence that the event was likely influenced by an

[18] 40 CFR 50.14(c)(3)(iv)(B)-(C).
[19] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf
[20] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

exceptional event.[21] The NJDEP has officially certified the ozone data presented in this analysis, which includes the 2023 ozone season data.[22]

Scatter plots of the daily maximum 8-hour ozone concentrations at the three New Jersey monitors, Clarksboro (340150002), Colliers Mills (340290006), and Washington Crossing (340219991), included in the exclusion request for April 13, 2023, show that all three sites uncharacteristically exceeded the 70-ppb ozone NAAQS, highlighting the exceptional nature of the event. See Figures 27 through 32.

Each monitor's ozone data from March 1, 2019, through October 31, 2023, were plotted against that monitor's multi-season 99th percentile. The data for periods outside of the ozone season (November 1 through February 28/29) for the intervening years are not included in the plots. A dotted line indicates the level of the 99th percentile concentration for each plot. Concentrations from April 13, 2023, and the other Exceptional Event dates in 2023, are highlighted in each plot as a red mark.

Table 2 presents the ranking, from 2019 to 2023, of the data requested for exclusion on April 13, 2023, at each monitor.

Table 2: 2019 to 2023 Ranking of Data Requested for Exclusion on April 13, 2023, at Each Monitor

AQS Code	Site Name	Ozone Concentration (ppb)	Annual Ranking (%)
340150002	Clarksboro	73	99.2
340290006	Colliers Mills	75	99.5
340219991	Washington Crossing	71	99.4

[21] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[22] Certification Letter for 2023 Oozne Monitoring Data (December 18, 2023). See Appendix 3.

Figure 27: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Clarksboro Monitor

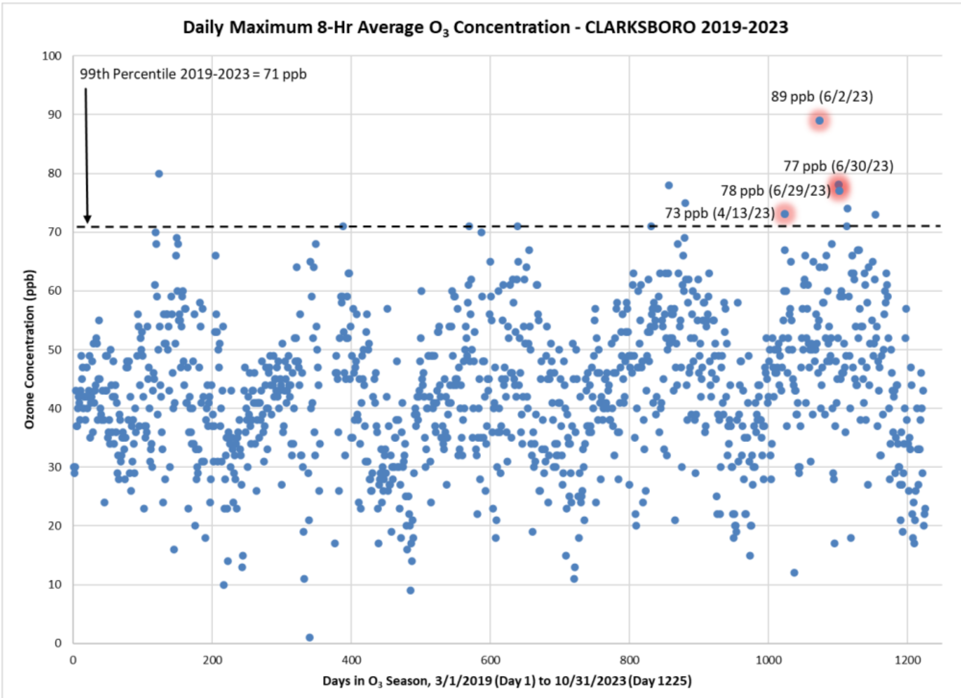


Figure 28: Clarksboro Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

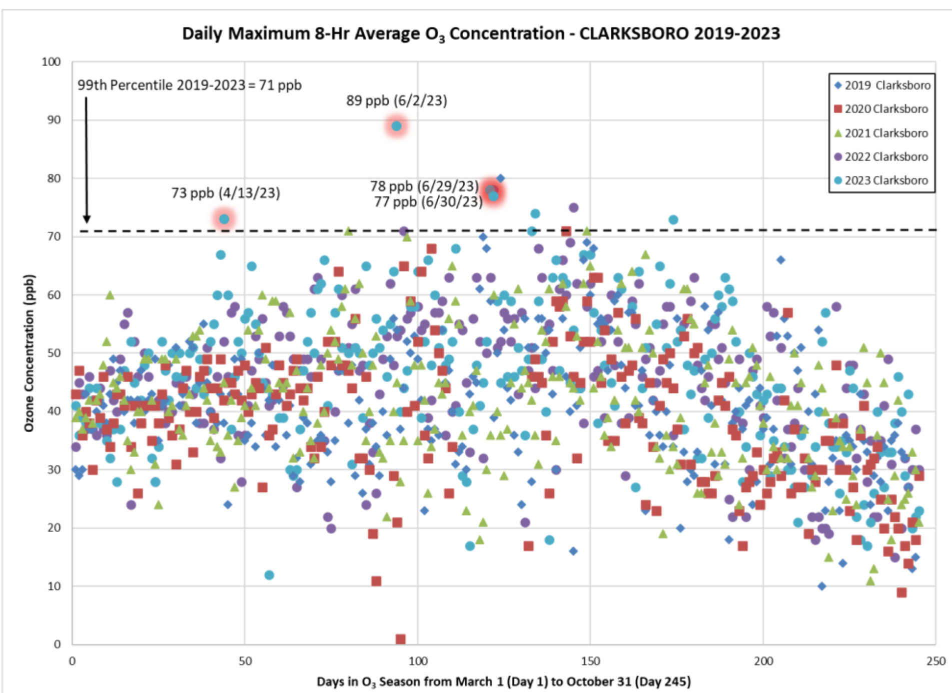


Figure 29: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Colliers Mills Monitor

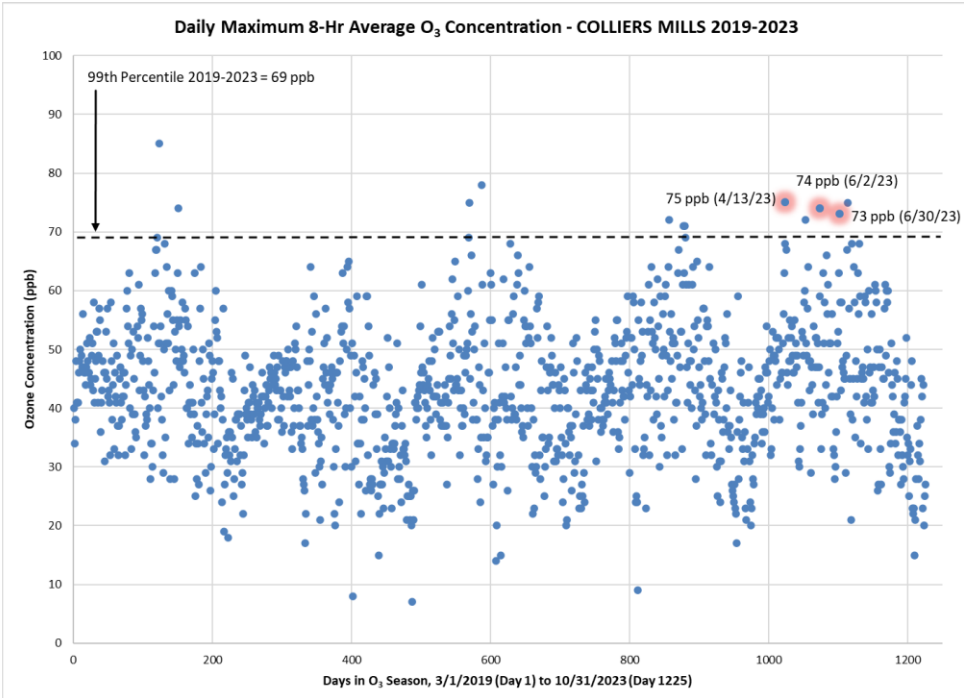


Figure 30: Colliers Mills Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

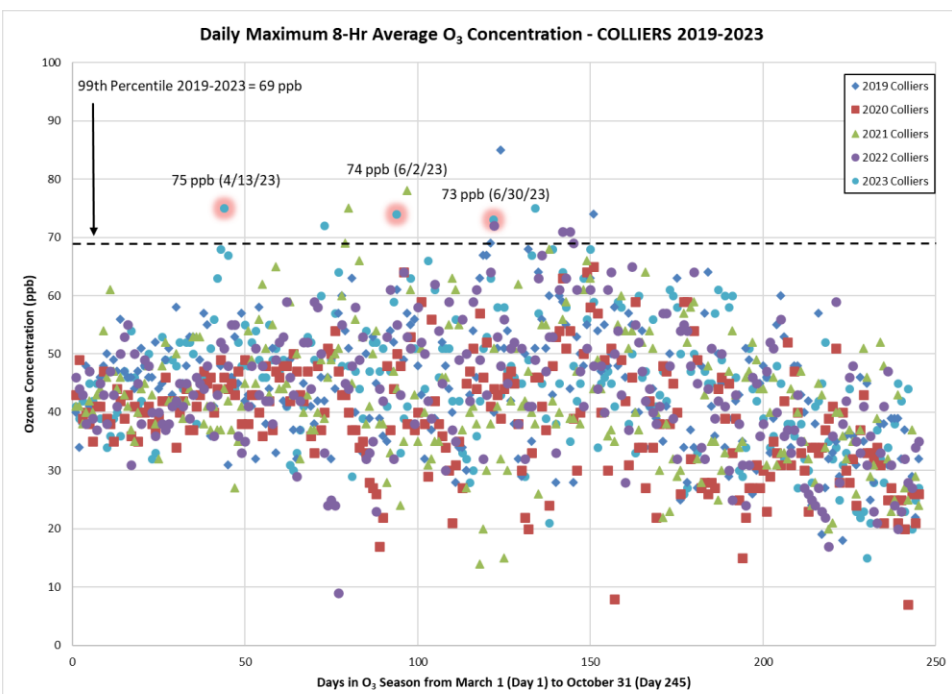


Figure 31: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Washington Crossing Monitor

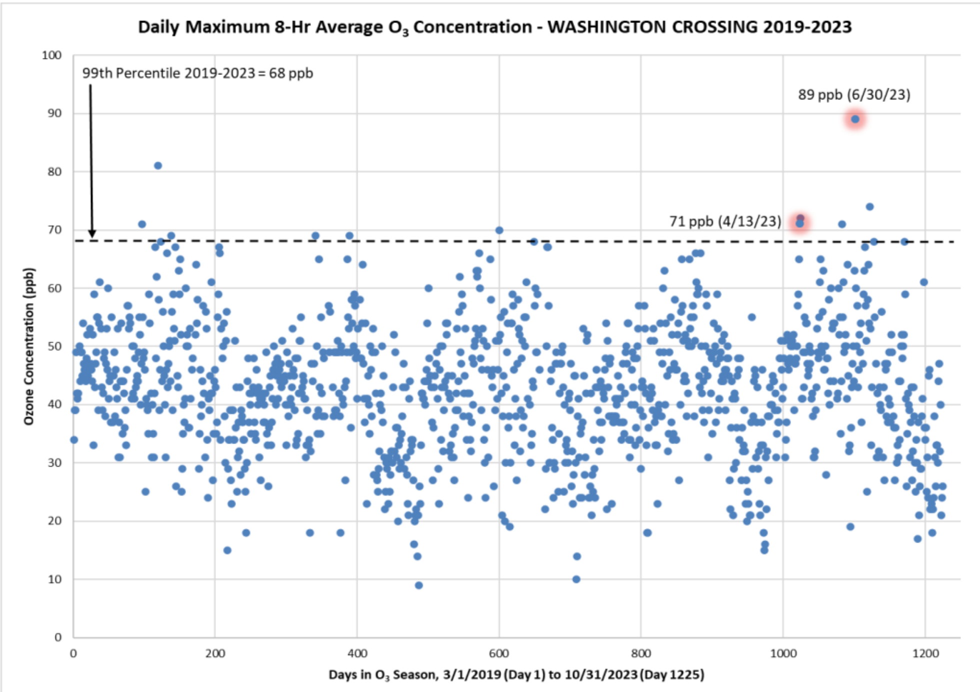
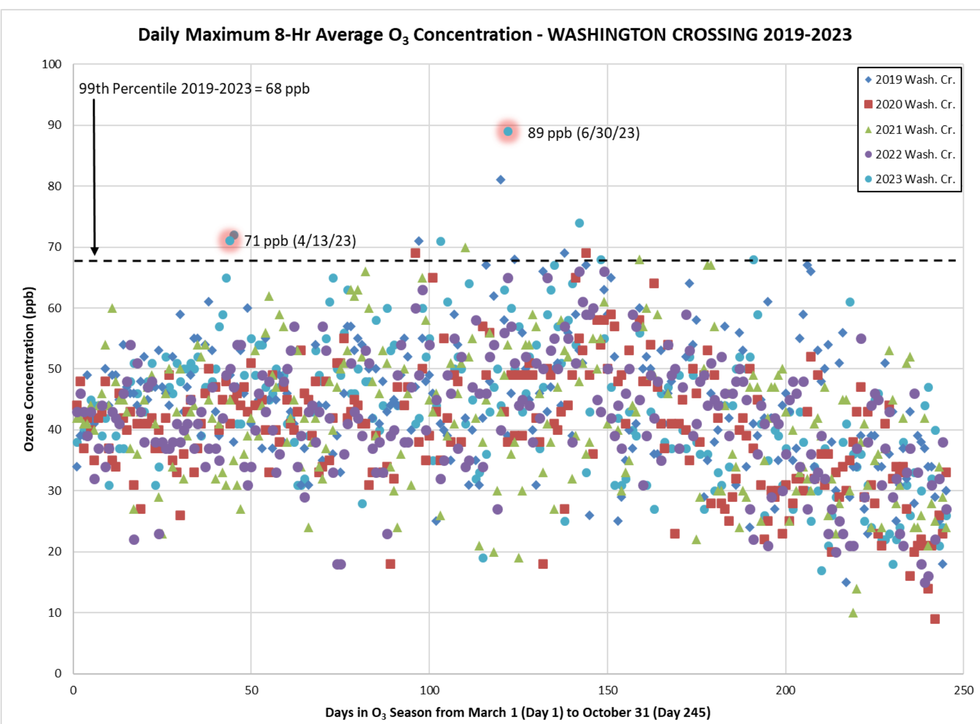


Figure 32: Washington Crossing Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations



In accordance with the USEPA Exceptional Events Guidance documents, the 99th percentile was calculated for the monitors in the Southern NJ-PA-DE-MD nonattainment area based on the daily maximum 8-hour ozone values for March through October in the last five years, 2019-2023. The distinctive nature of the 2023 data is evident when comparing them to data from the previous four years, 2019-2022. On April 13, 2023, five of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area recorded daily maximum concentrations at or greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period. For one of the remaining three monitors, the daily maximum concentrations recorded on April 13, 2023, was greater than the 98th percentile concentration for the 5-year period. For this reason, the evidence presented in this section indicates a clear causal relationship and satisfies the comparison of the fire-influenced exceedance with historical concentration element of the Exceptional Events demonstration.

New Jersey also considered the ozone concentrations on the days preceding, on, and following the April 13 exceptional event. On Thursday, April 13, 2023, three out of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area recorded exceedances of the 2015 70 ppb 8-hour ozone NAAQS. Table 3 summarizes the daily maximum 8-hour average ozone concentrations recorded in the Southern NJ-PA-DE-MD nonattainment area from April 9, 2023, through April 17, 2023, with the exceedances highlighted.

Table 3: Daily Maximum Ozone Levels in the New Jersey Portion of the Philadelphia-Wilmington-Atlantic City, Southern NJ-PA-MD-DE, Nonattainment Area Before and After the April 13, 2023, Exceptional Event

AQS Code	Site Name	4/9	4/10	4/11	4/12	4/13	4/14	4/15	4/16	4/17
340071001	Ancora State Hospital	50	54	59	64	66	58	35	33	50
340010006	Brigantine	41	41	44	55	54	42	29	29	42
340070002	Camden Spruce St	49	52	53	54	62	54	35	42	47
340150002	Clarksboro	52	55	60	67	73	60	37	46	52
340290006	Colliers Mills	51	56	63	68	75	67	46	44	52
340110007	Millville	51	52	57	63	68	54	39	42	50
340210005	Rider University	49	56	58	65	70	67	39	42	49
340219991	Washington Crossing*	50	57	59	65	71	72	41	41	49

*Operated by USEPA

exceeds 70 ppb NAAQS of 2015

2. Evidence that The Event, Monitors, and Exceedance Meet the Key Factors for Tier 2 Clear Causal Analyses

Emissions from the burning of forests and vegetation have been shown to add several pollutants that enhance ozone formation to the ambient air including fine particle matter, black carbon, and carbon monoxide.[23] According to a study by the National Oceanic and Atmospheric Administration (NOAA), the effects of fire emissions on the atmosphere are even larger and far more widespread than previously

[23] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

believed, and substantially contribute to ozone, one of the most common and harmful constituents of air pollution.[24]

2.1 Emissions over Distance (Q/d) Analysis

According to the USEPA guidance, a Q/d analysis is recommended as a rough assessment of the ability of a wildfire to cause increased ozone concentrations.[25] The Q/d analysis is a simple comparison of the ratio of the emissions (Q), the daily tons of VOC and NOx emitted from the fire to distance, (d), in kilometers, from the fire to the point of concern. The guidance indicates that a fire should have a Q/d in excess of 100 tons per day per kilometer of distance (tpd/km) in order to be considered to have a clear causal impact on ozone. This value was developed based on analyses of four fires which occurred in 2011.[26]

2.1.1 Estimate of Emissions, Q

According to the USEPA Guidance, the emissions from wildfires can be estimated using information from Section 13.1, Wildfires and Prescribed Burning, of USEPA's AP-42, Compilation of Air Emission Factors.[27] This section presents emission factors for various pollutants by fire and fuel configurations for the fire from AP-42. The emissions and emission factors are calculated using the following formulas:

$$F_i = P_i * L \quad \text{(Equation 1)}$$
$$E_i = F_i * A \quad \text{(Equation 2)}$$

Combining equations 1 and 2, we have:

$$E_i = P_i * L * A \quad \text{(Equation 3)}$$

where:
F_i = emission factor (mass of pollutant/unit area of forest consumed)
P_i = yield for pollutant "i" (mass of pollutant/unit mass of forest fuel consumed), where:
= 12 kg/Mg (24 lb/ton) for total hydrocarbon (as CH_4)
= 2 kg/Mg (4 lb/ton) for nitrogen oxides (NOx)
L = fuel loading consumed (mass of forest fuel/unit land area burned)
A = land area burned
E_i = total emissions of pollutant "i" (mass pollutant)

The values of Pi above are for total hydrocarbons and for nitrogen oxides. The fuel loading, L, provided in AP-42 for different regions of the United States ranges from 8 to 60 tons per acre.[28] Kansas is in US Forest Service Region 2, which has an estimated fuel loading of 30 tons per acre. This analysis will

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[24] NOAA. (2022, January 10). *Smoke from wildfires influences ozone pollution on a global scale.* https://research.noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/

[25] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.USEPA.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[26] Ibid.

[27] USEPA. (1996). AP42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.1: Wildfires and Prescribed Burning. https://www.epa.gov/sites/default/files/2020-10/documents/13.1_wildfires_and_prescribed_burning.pdf

[28] USEPA. (1996). AP42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.1: Wildfires and Prescribed Burning. https://www.epa.gov/sites/default/files/2020-10/documents/13.1_wildfires_and_prescribed_burning.pdf

present a range of emissions, starting with an emission rate of 30 tons per acre, and extending to the upper limit of 60 tons per acre.

According to Kansas Flint Hills Smoke Management, the Flint Hills wildland fire across Kansas State consumed 946,185 acres between February 3 and April 12, 2023, based on information provided by the Kansas Department of Health and Environment.[29] The initial burn in the Flint Hills region began around April 6th. However, the conditions had been gradually intensifying since mid-March across the plains. Many days of "Extreme Fire Weather" were declared leading up to the April 13, 2023, significant event.[30]

According to the April 14, 2023, Flint Hills Wildfire Update report, significant prescribed fire activity took place in both the central and northern Flint Hills during the period, April 7 to April 13. Friday, April 7, and Saturday, April 8, witnessed intense fire activity in the region. On Sunday, April 9, the prescribed fire activity subsided, but lingering smoke still led to Moderate Air Quality Index (AQI) across the region. Monday, April 10, saw a resurgence of prescribed fire activity in the northern Flint Hills and the region, contributing once again to widespread Moderate AQI and some short-term higher impacts. On Tuesday, April 11, increasing winds began to limit prescribed fire activity. This trend continued through Wednesday, April 12, and Thursday, April 13, with red flag warnings issued for several counties, indicative of dangerous fire weather conditions.[31]

Figure 33 presents the acreage burned by the Flint Hills wildland fire obtained from reports by the Kansas Department of Health and Environment and is available on the Kansas Flint Hills Management website.[32]

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[29] Kansas Flint Hills Smoke Management. (Published Online April 2023). *Flint Hills Wildland Fire Update for April 21, 2023*. Retrieved February 21, 2024, from https://www.ksfire.org/new-media-archives/weeklyupdates/2023/Flint_Hills_Update_April_21_2023.pdf

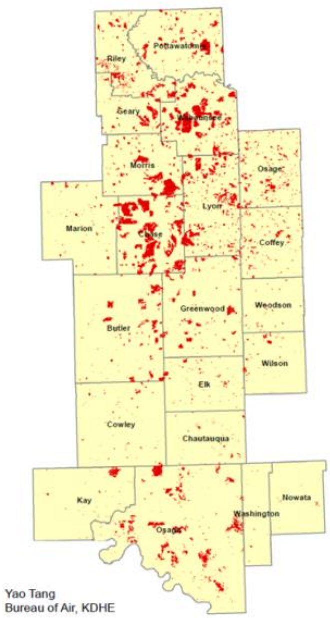
[30] Kansas Flint Hills Smoke Management. (Published Online April 2023). *Flint Hills wildland Fire Update for April 7, 2023.* Retrieved January 25, 2024, from https://www.ksfire.org/new-media-archives/weeklyupdates/2023/Flint_Hills_Update_April_7_2023.pdf

[31] Kansas Flint Hills Smoke Management. (Published Online April 2023). *Flint Hills Wildland Fire Update for April 14, 2023*. Retrieved February 21, 2024, from https://www.ksfire.org/new-media-archives/weeklyupdates/2023/Flint_Hills_Update_April_14_2023.pdf

[32] Kansas Flint Hills Smoke Management. (n.d.). *News/Media Archives*. ksfire.org/new-media-archives/index.html

Figure 33: Flint Hills Wildland Fire Acreage Burned Across Kansas State

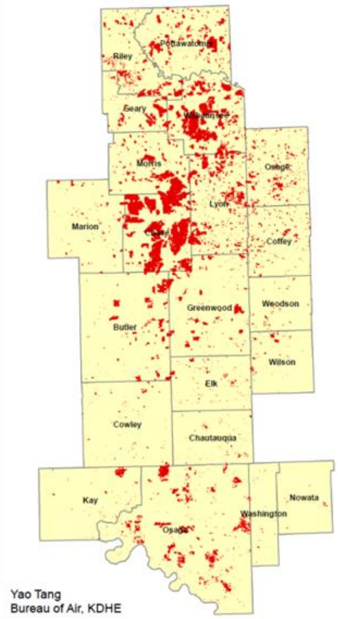
Flint Hills Acreage Burned (February 3 – April 8, 2023)



Counties	Acres Burned	
Butler	36,526	
Chase	123,694	
Chautauqua	4,355	
Coffey	16,803	
Cowley	6,255	
Elk	8,433	
Geary	20,680	
Greenwood	30,070	
Lyon	70,936	
Marion	10,781	
Morris	47,538	
Osage (KS)	29,128	
Pottawatomie	36,572	
Riley	37,746	
Wabaunsee	90,813	
Wilson	6,131	
Woodson	3,382	
Nowata (OK)	896	
Osage (OK)	82,813	
Washington (OK)	1,282	
Kay (OK)	8,047	
Total	672,881	

* Denotes county was partly or completely covered by clouds during latest analysis.

Flint Hills Acreage Burned (February 3 – April 12, 2023)



Counties	Acres Burned	
Butler	45,221	
Chase	215,835	
Chautauqua	5,684	
Coffey	20,556	*
Cowley	6,935	
Elk	10,440	
Geary	29,066	
Greenwood	37,808	
Lyon	91,693	
Marion	13,097	
Morris	62,627	
Osage (KS)	36,835	*
Pottawatomie	59,693	
Riley	45,607	
Wabaunsee	140,420	
Wilson	7,475	*
Woodson	4,788	*
Nowata (OK)	1,251	*
Osage (OK)	99,926	
Washington (OK)	1,637	
Kay (OK)	9,591	
Total	946,185	

* Denotes county was partly or completely covered by clouds during latest analysis.

The Q/d for the April 13, 2023, exceptional event, is calculated from April 9, when the lingering smoke started through April 12. The transported smoke resulted in residual smoke across the New Jersey region for the April 13 event.

For the Flint Hills fires, the total hydrocarbon emissions over April 9 through April 12 can be estimated to be:

$E_{hc} = P_{hc} * L * A$

= 24 lbs of HC / ton of forest fuel consumed * 30 tons fuel / acre * 273,304 acres
= 196,778,880 pound of HC or
= **98,389 tons of HC emitted during the period from April 9 – 12, 2023**

If the high end of fuel loading is considered, the total hydrocarbon emissions become:

= 24 lbs of HC / ton of forest fuel consumed * 60 tons fuel / acre * 273,304 acres

= 393,557,760 pounds of HC or

= **196,779 tons of HC emitted during the period from April 9 - 12, 2023**

Similarly for NOx:

$E_{NO_x} = P_{NO_x} * L * A$

= 4 lbs of NOx / ton of forest fuel consumed * 30 tons fuel / acre * 273,304 acres

= 32,796,480 pounds of NOx

= **16,398.2 tons of NOx emitted during the period from April 9 - 12, 2023**

If the maximum fuel load is considered, the total nitrogen oxides emissions become:

= 4 lbs of NOx / ton of forest fuel consumed * 60 tons fuel / acre * 273,304 acres

= 65,592,960 pounds of NOx

= **32,796.5 tons of NOx emitted during the period from April 9 - 12, 2023**

Q is the total daily emission rate in tons per day of reactive hydrocarbons and nitrogen oxides. USEPA recommends in the Exceptional Events Guidance,[33] that only 60% of the hydrocarbons from wildfires should be considered reactive. Therefore, the reactive hydrocarbon emissions become:

Q = rHC + NOx.

rHC = 0.6 * Ehc or

0.6 * 98,389 = **59,033.4 tons of reactive HC emitted daily during the period from April 9 - 12, 2023.**

If the maximum fuel load is considered, the reactive hydrocarbon emissions become:

0.6 * 196,779 = **118,067.4 tons of reactive HC emitted during the period from April 9 -12, 2023**.

No adjustments are suggested for the NOx emissions to account for reactivity.

Therefore, the total rHC and NOx emissions over the period are **59,033.4 + 16,398.2, or 75,432 tons over the four days, or 118,067.4 + 32,796.5, or 150,864 tons over the four days,** if maximum fuel load is considered**.**

On average this results in a **daily emission rate, or Q, of 18,858 tons per day or 37,716 tons per day,** if maximum fuel load is considered.

2.1.2 Estimate of Distance from the Fire, d.

New Jersey estimated the distance, d, from the approximate centroid of the fire region, which was around Morris and Wabaunsee counties, (roughly 39.016144, -96.289452), to the Clarksboro monitor (39.800339, -75.212119), since this monitor is centrally located within the Southern NJ-PA-DE-MD nonattainment area and experienced ozone violations during the Exceptional Event. Google maps was used to determine the straight-line distance between the approximate fire region centroid, around Morris and Wabaunsee counties and the Clarksboro monitor resulting in an approximate value of **1,232 miles (1,982 kilometers),** for d.[34]

[33] 42 U.S.C. 7619(b)(1)(iii), Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations. USEPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. https://www.USEPA.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[34] Map Developers. (n.d.). *Distance From To - Calculate distance between two addresses, cities, states, zipcodes, or locations*. https://www.mapdevelopers.com/distance_from_to.php?&from=39.016144%2C%20-96.289452&to=39.800339%2C%20-75.212119

2.1.3 Q/d Estimate

Using the values and days burned determined in the previous section for the Flint Hill fires, Q/d is calculated to be 9.5 tpd/km [18,858 tpd divided by 1,982 km] (Table 4). If we assume maximum fuel loading of 60, New Jersey's Q/d value becomes 19 tpd/km. All Q/d values are below the USEPA recommended level of 100 tpd/km above which would indicate clear causality. The Q/d approach falls short of meeting the criteria for of a clear causal impact, however, additional evidence is provided to establish a link between the smoke originating from the Flint Hill fires and the elevated ozone levels observed in New Jersey.

Table 4: Q/d analysis, Flint Hills Fires, Kansas, April 9 – 12, 2023

ACRES	Ehc (tons)	Enox (tons)	Q (tons)	No. days burning	d (km)	Q/d (tons/day/km)	DESCRIPTION
273,304	**196,779**	**32,796**	**150,864**	**4**	**1,982**	**19.0**	**Fuel loading at maximum of 60 tons/acre instead of 30, April 9 - 12 only**
273,304	98,389	16,398	75,432	4	1,982	9.5	Standard Q/d, April 9 - 12 only

2.2 Discussion of 5-years of Ozone Data from 2019-2023- 99th Percentiles

Observations at monitors measuring at or above the 99th percentile in the past five years are considered statistical evidence that the values were likely influenced by an Exceptional Event. The Exceptional Events Guidance documents were used to calculate the 99th percentile for all the monitors in the Southern NJ-PA-DE-MD nonattainment area for all the days in March through October over the last five years (2019-2023). These percentiles are presented in scatterplots in Figures 27-32 and summarized in Section 1.

Table 5 summarizes the daily maximum 8-hour ozone concentrations measured by monitors in the Southern NJ-PA-DE-MD nonattainment area on April 13, 2023, along with each monitor's respective 99th percentile daily maximum 8-hour ozone concentrations for the 5-year period 2019-2023. The values highlighted in blue are at or over the 99th percentile for the 5-year period for each monitor. The last column highlights the monitors that exceeded their 99th percentile (YES) on April 13, 2023. Blanks indicate that the monitor did not exceed the 99th percentile.

Table 5: 5 years (2019-2023) of Daily Maximum 8-hour Average Ozone Concentrations for New Jersey Exceptional Event Monitors

	Daily Maximum 8-Hour O_3 (ppb)				2019-2023 Daily Max 8-Hr Avg		
	4/12/2023	4/13/2023	4/14/2023	4/15/2023	99th %ile	98th %ile	Exceed 99th %ile (2019-2025) Level on April 13, 2023
Ancora State Hospital	64	66	58	35	66	61	**YES**
Brigantine	55	54	42	29	61	58	
Camden Spruce St	54	62	54	35	69	66	
Clarksboro	67	73	60	37	71	67	**YES**
Colliers Mills	68	75	67	46	69	67	**YES**
Millville	63	68	54	39	68	62	**YES**
Rider University	65	70	67	39	71	68	
Washington Crossing	65	71	72	41	68	66	**YES**

> or = level of 99th Percentile

Table 5 shows that on April 13, 2023, five of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area, including the three monitors seeking an Exceptional Event exclusion, recorded daily maximum concentrations greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period.

2.3 Discussion of Highest Ozone Concentration Within 1 Year

According to the USEPA Guidance, if the exceedance due to an Exceptional Event is one of the four highest ozone concentrations within one year, it satisfies key factor 2 for a Tier 2 analysis. Key factor 2 compares event-related ozone concentration with non-event related high ozone concentrations. New Jersey has satisfied this key factor with the 99th percentile analysis, and the highest daily maximum ozone concentrations in 2023 in Table 6 to showcase the severity and widespread nature of the April 13 event. This unusual occurrence was also repeated during the June 2 and June 29 and 30 Exceptional Event periods in New Jersey.

Table 6 compares the daily maximum 8-hour ozone concentrations measured during the Exceptional Event days with the five highest concentrations for the year. The overall maximums for 2023 ozone season at the Southern NJ-PA-DE-NJ nonattainment area monitors, except Brigantine, occurred on an Exceptional Event Day, indicating the impact of the wildfires on New Jersey monitors. Furthermore, all exceedances on an Exceptional Event Day at all Southern New Jersey's monitors were among the fourth or fifth highest for the year.

Table 6: Ozone Daily Max Values Compared with Five Highest Daily Maximums in 2023

Site Name	Daily Max 8-Hr Ozone (ppb)				2023 Daily Maximum 8-Hr Ozone Concentrations (ppb)				
	4/13/2023	6/2/2023	6/29/2023	6/30/2023	1st Max	2nd Max	3rd Max	4th Max	5th Max
Ancora State Hospital	66	67	73	67	73	69	67	67	66
Brigantine	54	41	51	59	67	64	59	58	55
Camden Spruce St	62	81	71	78	81	78	71	71	70
Clarksboro	73	89	78	77	89	78	77	74	73
Colliers Mills	75	74	63	73	75	75	74	73	72
Millville	68	64	75	72	75	72	68	68	68
Rider University	70	98	61	86	98	86	78	70	69
Washington Crossing*	71	NA	63	89	89	74	72	71	71

*Site is operated by USEPA

Legend: 1st Max | 2nd Max | 3rd Max | 4th Max | 5th Max | Exceedance Day

During the Exceptional Event periods in 2023, seven out of eight monitors in the Southern NJ-PA-DE-MD nonattainment area recorded their highest daily maximum 8-hour average ozone concentrations. All the ozone exceedances that occurred during the Exceptional Event periods exceed the 70 ppb 2015 ozone NAAQS and are among the highest 5 daily maximum 8-hour average for each of the monitors.

3. Evidence that Fire Emissions were Transported to New Jersey Monitors

A trajectory analysis can be used to show that the emissions from the fire were transported to the monitors, based on the methodology recommended in USEPA Guidance.[35] New Jersey presents trajectory modeling results in this section to show that emissions from Flint Hills fires were transported to New Jersey.

3.1 Trajectory Analysis

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was employed to calculate backward trajectories arriving in New Jersey on April 13, 2023. The meteorological model that was used to compute the backward trajectories was obtained from the North American Mesoscale Forecast System, 12km, (NAM 12).

Figure 34 shows trajectories at three different wind heights with the endpoint at the Clarksboro monitor on April 13, 2023. The three wind heights above ground level (AGL) that are plotted on Figure 34 are 10m, 500m, and 1500m. Figures 35 - 37 show the different wind heights AGL for monitored exceedances on the same day. The figures illustrate where the air came from during the 48 hours preceding the 8-hour ozone standard exceedances on April 13, 2023. The Clarksboro monitor is highlighted in Figures 35 – 37 with a yellow star. Trajectories at all levels of the atmosphere followed similar transport pathways through transit while also originating in similar locations throughout the Midwest where wildfire smoke was present from the Flint Hills, Kansas fires.

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[35] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

The surface level back trajectories (Figure 35) show that air originated over several states in the Midwest and traveled in a predominantly easterly direction over the southern Great Lakes and Ohio River Valley regions. Here, all areas that experienced moderate ozone levels the day prior. The air masses then traversed over Pennsylvania and southern New York before arriving at their respective endpoints along the I-95 corridor and into New Jersey.

Mid-level back trajectories (Figure 36) originated over parts of Oklahoma, Arkansas, and Missouri, traveling clockwise around high pressure in a northeasterly direction. These trajectories originated just southeast of where the initial wildfire plume began and likely picked up wildfire smoke along the way. The trajectories then moved over the Great Lakes Region where air quality levels rose into the moderate category. Trajectories at the mid-levels traveling to the Southern NJ-PA-DE-MD nonattainment area traveled over Pennsylvania before arriving at their destinations in southern NJ.

The upper-level back trajectories (Figure 37) originated over Midwestern portions of the United States and traveled in a northeasterly direction. Air then traveled in a slight clockwise rotation throughout portions of the Great Lakes Regions, which saw widespread moderate air quality in the days leading up to the exceedances. Air traversed over the major metropolitan centers of Philadelphia and NYC prior to arrival at their destinations. All trajectories traveled a very long distance, allowing for a buildup of ozone precursors from several different regions. Air at all three levels showed signs of subsidence during transit under the influence of high pressure, allowing for wildfire smoke and precursors aloft to mix down to the surface.

Figure 34: HYSPLIT 60hr Backward Trajectories on April 13, 2023 - Clarksboro – 10, 500, and 1500m AGL

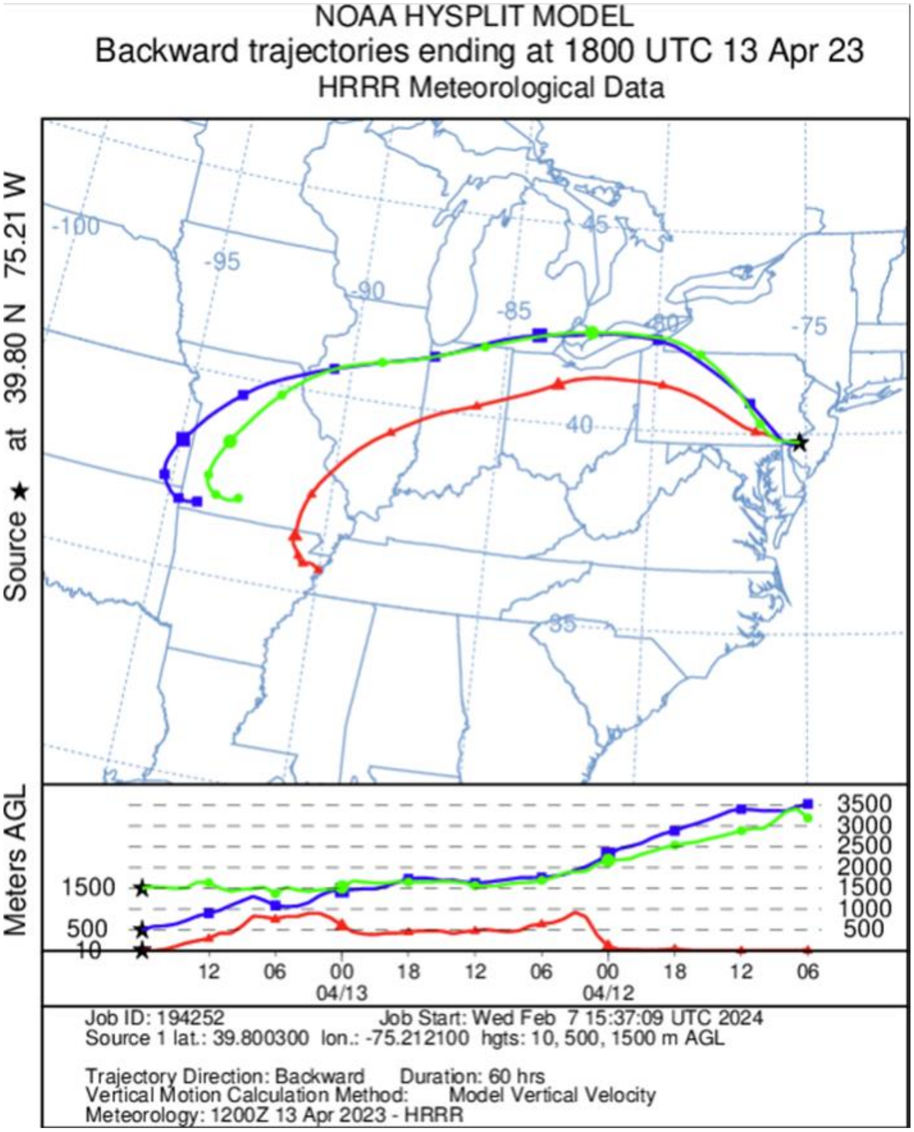


Figure 35: HYSPLIT Backward Trajectories on April 13, 2023, 10m AGL

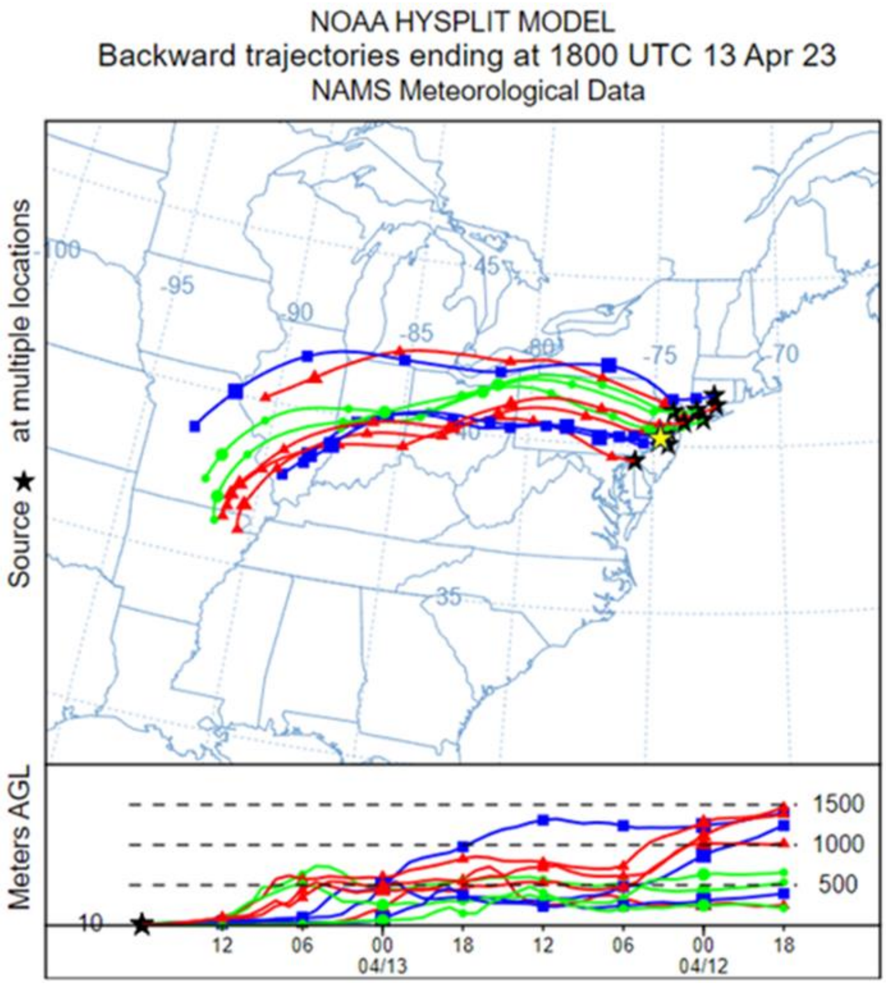


Figure 36: HYSPLIT Backward Trajectories on April 13, 2023, 500m AGL

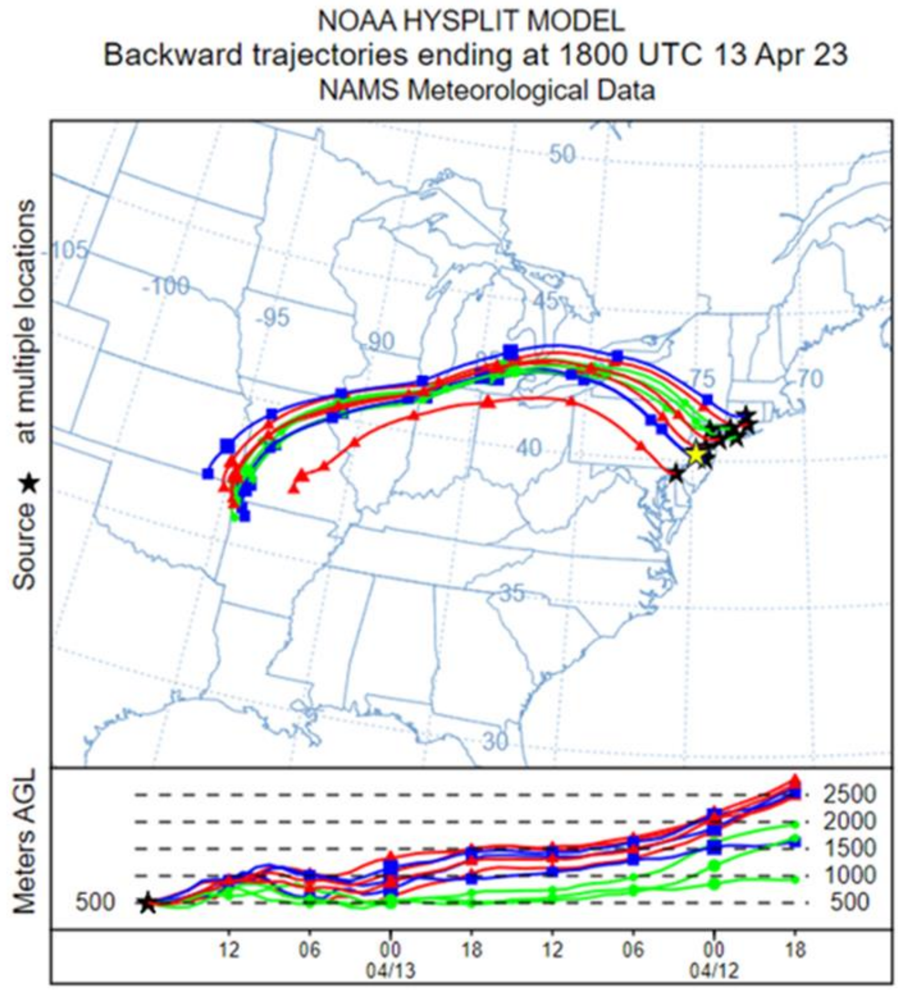
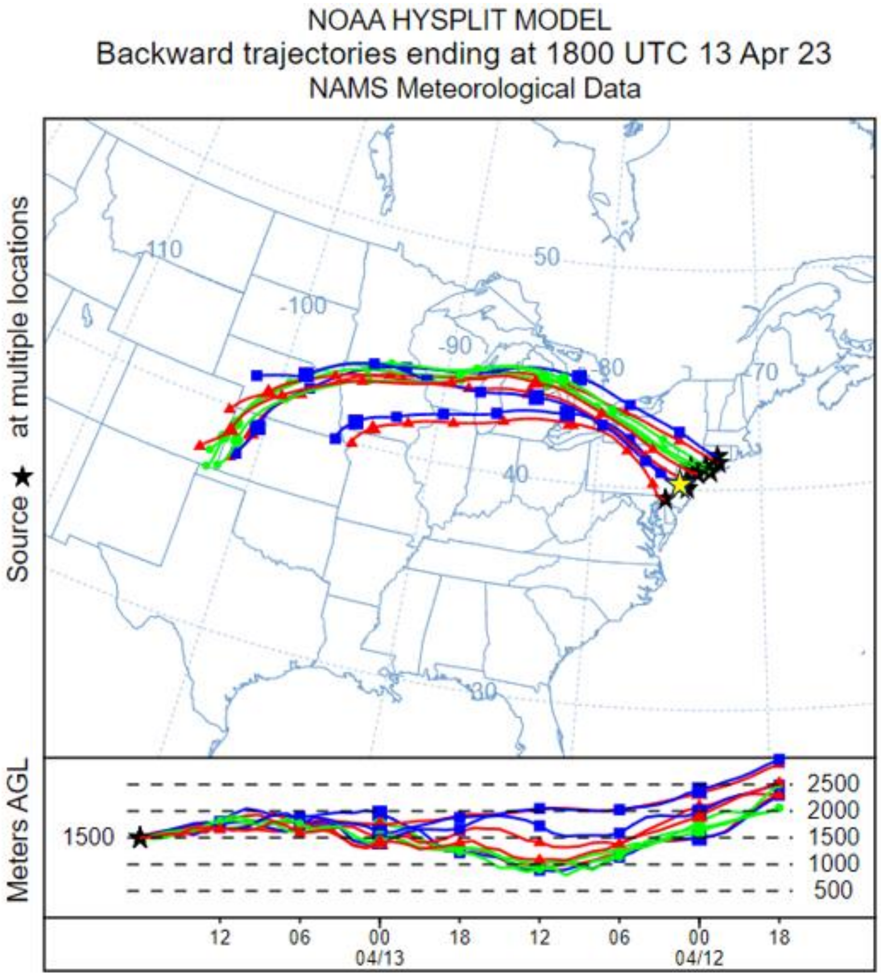


Figure 37: HYSPLIT Backward Trajectories on April 13, 2023, 1500m AGL



4. Evidence that Fire Emissions Affected New Jersey Monitors

This section adds to the weight of evidence that the emissions from the fires affected the monitored ozone concentrations at New Jersey monitors, as recommended by USEPA Guidance.[36]

The primary pollutants emitted from wildland fires include greenhouse gases, NOx, and aerosol.[37] Wildland fires emit a variety of aerosols, including black carbon, organic carbon, and inorganic compounds.

The New Jersey monitoring network measures both total PM2.5 mass and speciated compounds such as ionic potassium (K^+) and organic carbon, as well as other pollutants such as CO, NOx and VOCs. Analyses of the various species that can be attributed to fires are presented in the following sections. The analyses

[36] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

[37] Urbanski, S.P., Hao, W.M., & Baker, S. (2008). Chemical Composition of Wildland Fire Emissions. In Bytnerowicz, A, Arbaugh, M.J., Riebau, A.R., & Andersen, C. (Eds.), *Developments in Environmental Science* (Vol. 8, pp. 79-107). Elsevier. Retrieved January 24, 2024, DOI: 10.1016/S1474-8177(08)00004-1, https://www.fs.usda.gov/rm/pubs_other/rmrs_2009_urbanski_s001.pdf

show that the ozone exceedance in New Jersey was characterized by enhanced precursors attributable to wildfire species. The 2023 data concerning fine particulate matter, potassium, organic carbon, elemental carbon, black carbon, carbon monoxide, nitrogen dioxide presented in this analysis is preliminary and awaits certification by NJDEP.

4.1 Fine Particulate Matter (PM2.5)

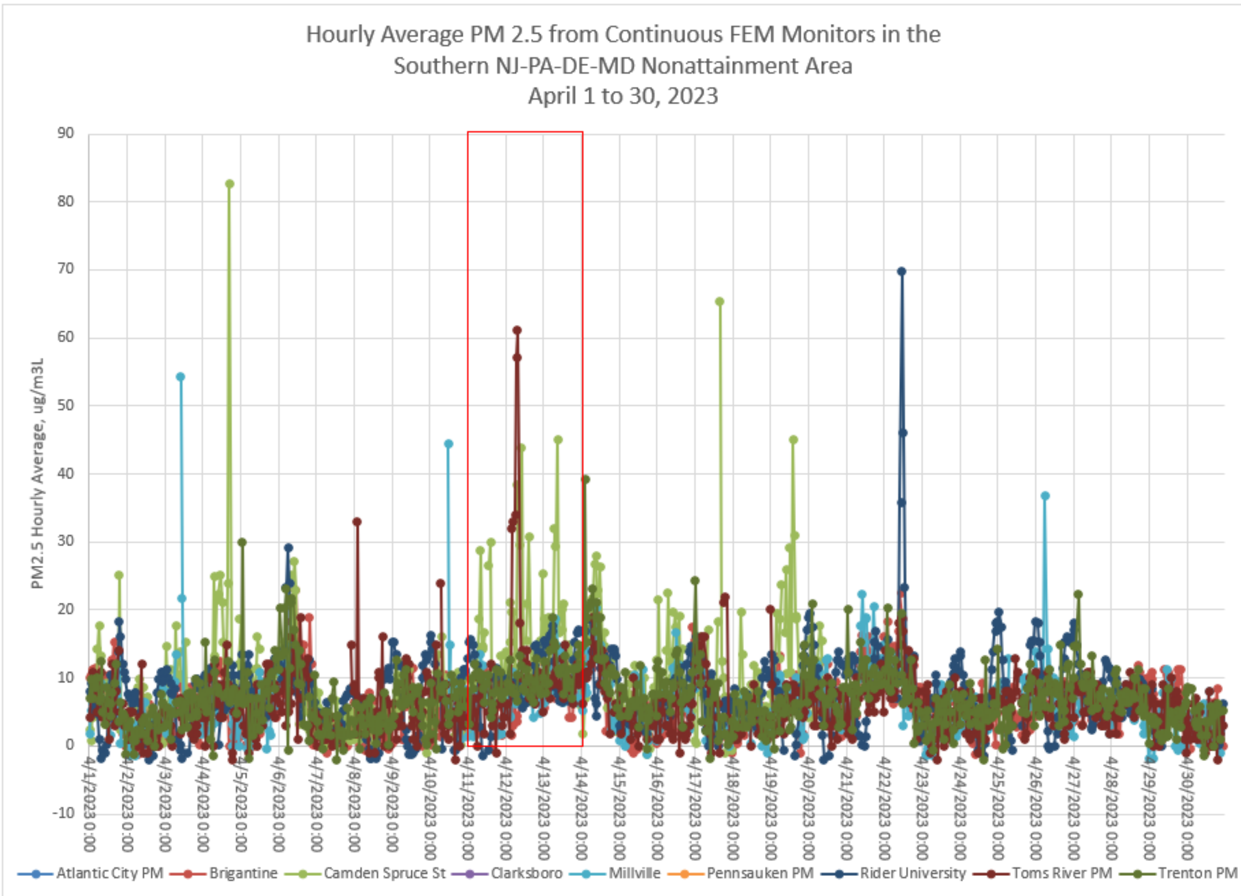
PM2.5 emissions from wildfires can be transported across large distances. PM2.5 is one of the species that accounts for the next largest share of emissions from wildfire after CO_2 and CO.[38] New Jersey monitors PM2.5 levels using filter-based continuous Federal Equivalent Method (FEM) monitors. The National Ambient Air Quality Standard for 24-hour PM2.5 is 35 ug/m^3.

The hourly PM2.5 concentrations for monitors in the Southern NJ-PA-DE-MD nonattainment area during April 2023 are presented in Figure 38. Throughout the entire month, the Flint Hills wildland fire contributed to elevated levels of PM2.5, indicative of emissions from wildfire. In the days leading up to April 13, PM2.5 levels reached an hourly average of 61 ug/m^3, exceeding the 24-hour federal standard for PM2.5. The elevated concentrations highlighted in the red box coincide with the April 13 Exceptional Event date.

Based on analysis in this demonstration combined with this PM2.5 data analysis, the April 13 peak in PM2.5 levels can be attributed to smoke transport from the Flint Hills wildland fires. Therefore, the elevated levels of PM2.5, combined with other contributing factors, led to the April 13 ozone exceedance in New Jersey.

[38] Ibid.

Figure 38: Hourly Average PM2.5 Concentration from Continuous FEM Monitors in the Southern NJ-PA-DE-MD Nonattainment Area for April 2023



4.1.1 Potassium and Organic Carbon

Biomass burning is a significant source of particle pollution, which is mainly composed of organic carbon (OC) and black carbon. These particles also contain potassium ions. Wildfire smoke can be traced using ionic potassium (K^+), which is a reliable indicator of wildfire emissions due to its scarcity in anthropogenic sources and its concentration above background levels.[39]

The presence of smoke from wildfires can be determined in the outside air by looking for elevated levels of certain pollutants, called markers, that are key components of wood smoke but are not usually found in outside air except in trace amounts. Primary markers for wood smoke emissions include potassium (K) and levoglucosan.[40] When there are high levels of potassium in the outdoor air, it is usually an indication

[39] Ma, Y., Weber, R.J., Lee, Y.N., Orsini, D.A., Maxwell-Meier, K., Thornton, D.C., Bandy, A.R., Clarke, A.D., Blake, D.R., Sachse, G.W., Fuelberg, H.E., Kiley, C.M., Woo, J.H., Streets, D.G., & Carmichael, G.R. (2003). Characteristics and influence of biosmoke on the fine-particle ionic composition measured in Asian outflow during the Transport and Chemical Evolution Over the Pacific (TRACE-P) experiment. *Journal of Geophysical Research: Atmospheres, 108*(D21), 37-1 – 37-16. DOI: 10.1029/2002JD003128, https://aerosols.eas.gatech.edu/papers/Ma%20ACE%20Asia%20Biomass%20Smoke.pdf

[40] Gibson, M.D., Haelssig, J., Pierce, J.R., Parrington, M., Franklin, J.E., Hopper, J.T., Li, Z, & Ward, T.J. (2015). A comparison of four receptor models used to quantify the boreal wildfire smoke contribution to surface PM2.5 in

that wood smoke is present and causing an increase in the outdoor air concentrations of other pollutants from wood smoke emissions as well. USEPA's PM2.5 Speciation Trends Network analyzes fine particle samples from sampling locations nationwide to monitor the levels of potassium and other parameters. The samplers generally operate on a three-day sampling schedule. However, some samplers operate on a six-day sampling schedule.

New Jersey has PM2.5 Speciation samplers located in the Camden Spruce Street and Rutgers University air monitoring stations. The Rutgers University sampler operates on a three-day sampling schedule, while the Camden Spruce Street sampler operates on a six-day sampling schedule. Figure 39 presents preliminary data collected in April 2023. The data collected at the Camden and Rutgers monitors clearly show elevated levels of potassium in the air on the day leading up to April 13, suggesting the presence of smoke. No data was collected at either monitor on April 13, however, both monitors recorded the maximum potassium levels for the entire month of April 2023 on April 12, 2023. Higher PM2.5 concentrations were also observed within the Southern NJ-PA -DE-MD nonattainment area on the same day.

In Figure 39, the red box highlights the smoke period that New Jersey is requesting exclusion as an Exceptional Event on April 13, 2023. During this period, organic and elemental carbon concentrations exhibit similar characteristics to potassium at both the Camden and Rutgers monitors, as shown in Figures 40 and 41. The elevated potassium levels observed at these monitors serve as evidence of smoke impact on New Jersey's air quality.

Halifax, Nova Scotia during the BORTAS-B experiment. *Atmospheric Chemistry and Physics, 8*(2), 815-827. DOI: 10.5194/acp-15-815-2015

Figure 39: Preliminary Potassium (K) Concentrations Measured from PM2.5 Speciation Sites at Rutgers and Camden, New Jersey Monitors in April 2023

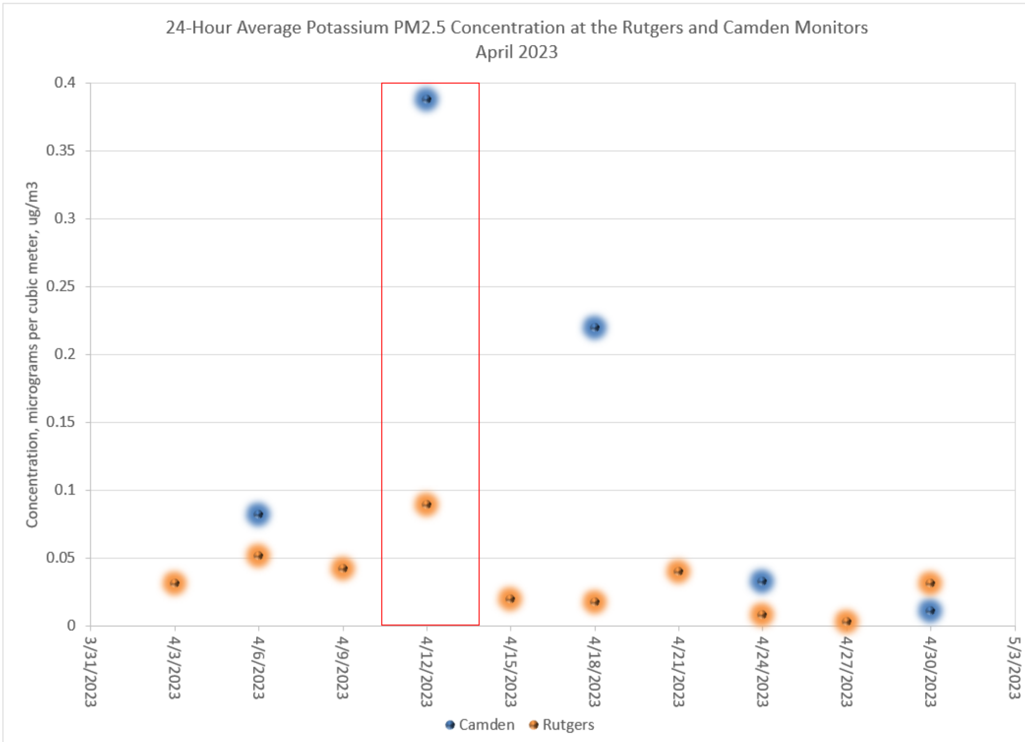


Figure 40: Preliminary Organic Carbon (OC) Concentrations Measured from PM2.5 Speciation Sites at Rutgers and Camden, New Jersey Monitors in April 2023

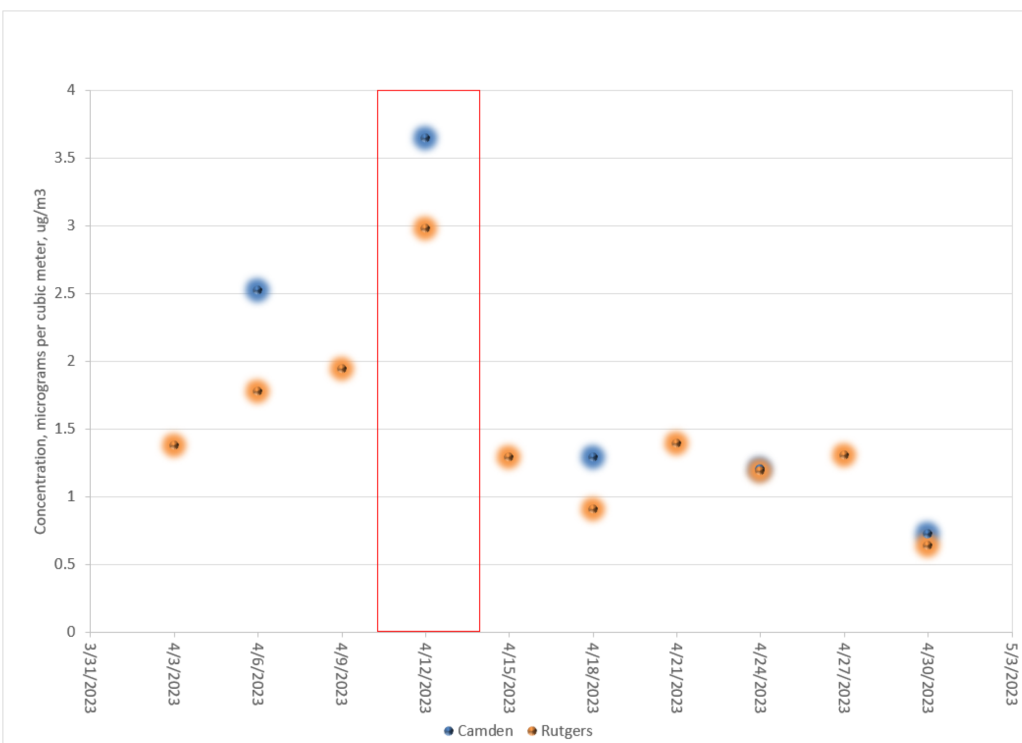
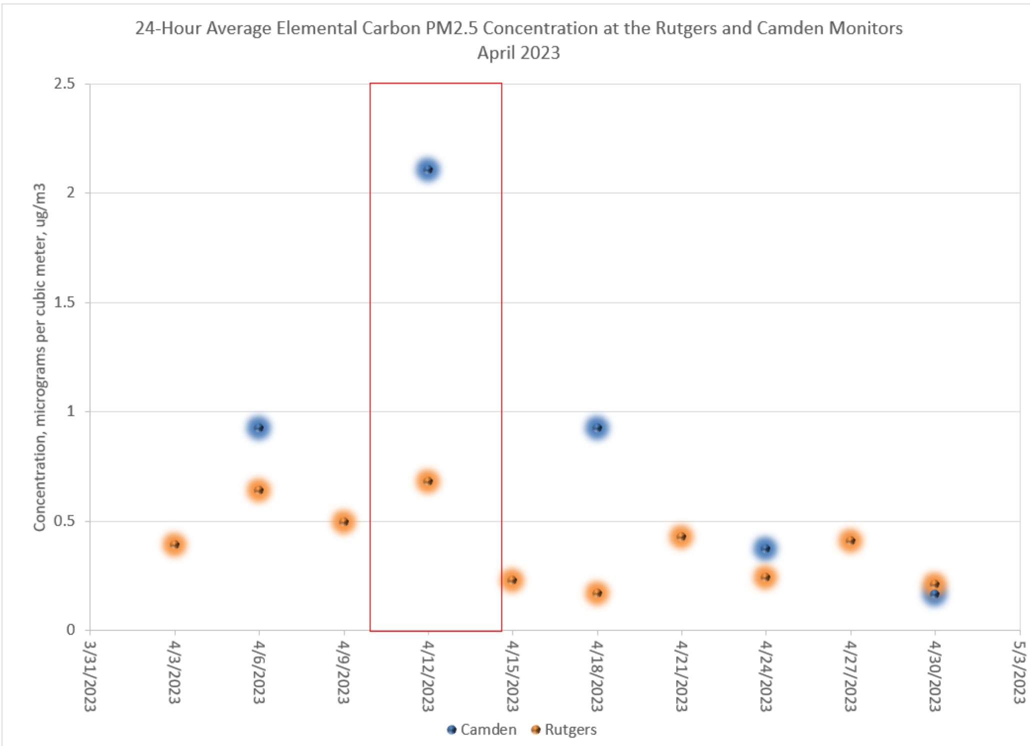


Figure 41: Preliminary Elemental Carbon (EC) Concentrations Measured from PM2.5 Speciation Sites at Rutgers and Camden, New Jersey Monitors in April 2023



4.1.2 Black Carbon

The presence of black carbon (BC) is an indicator of smoke originating from biomass burning during wildfires. As smoke from biomass burnings significantly contributes to ozone formation, detecting elevated levels of BC provides additional evidence of the impact of wildfire smoke on elevated ozone concentrations.[41] New Jersey measures near-real time black carbon in ambient air at five urban monitoring stations throughout the state.[42]

Figure 42 displays the hourly BC concentrations at three NJ monitors in April 2023, and Figure 43 shows the 24-hour daily BC concentrations at four NJ monitors during the same period. On April 13, a noticeable spike in BC concentrations is evident, as highlighted within the red box on the graphs.

In April 2023, the average daily concentration of BC at the Camden Spruce St monitor was 0.344 ug/m^3. However, on April 13, the average daily BC concentration spiked to 0.835 ug/m^3, with the hourly concentrations reaching as high as 1.95 ug/m^3. In addition, the average daily BC concentration on April 13, 2023, was over 150% larger (2.5 times larger) than the average for April over the past five years (long-term average of 0.323 ug/m^3 from 2019 to 2023).

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[41] NOAA. (2022, January 10). *Smoke from wildfires influences ozone pollution on a global scale.* https://research.Noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/

[42] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

Figure 42: Hourly Black Carbon Concentration at New Jersey Monitors in April 2023

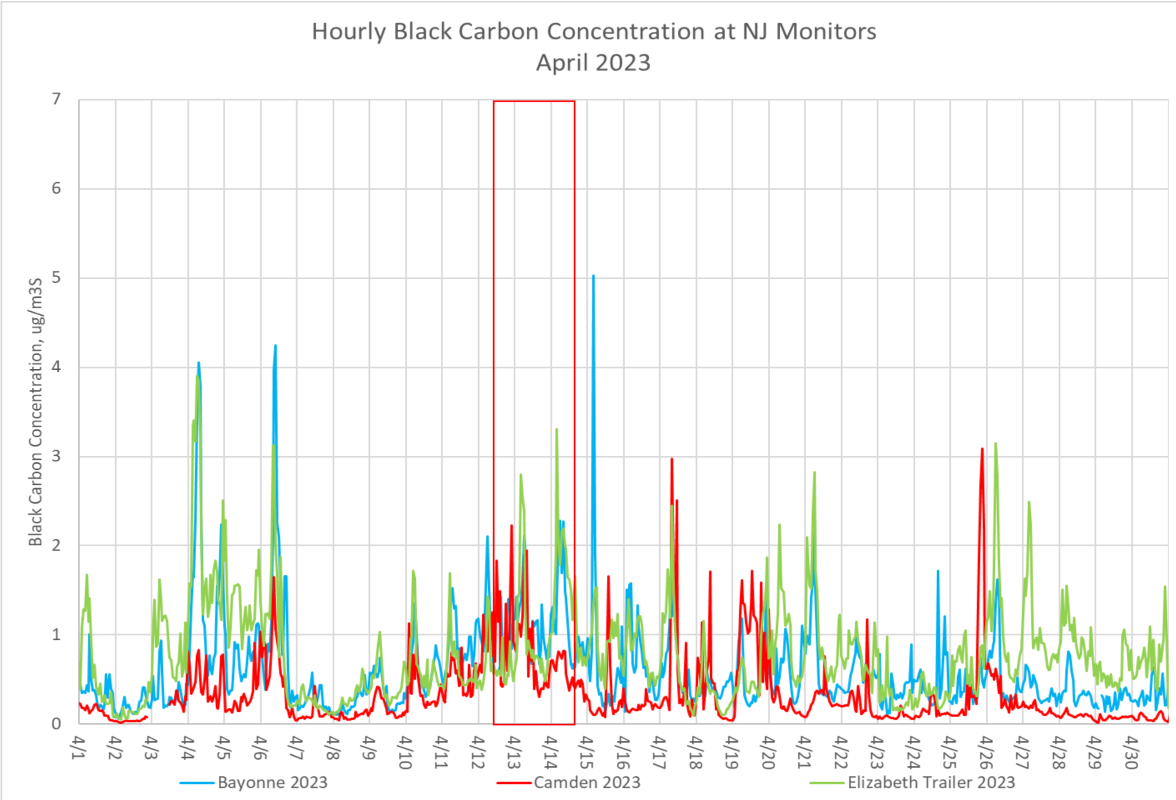
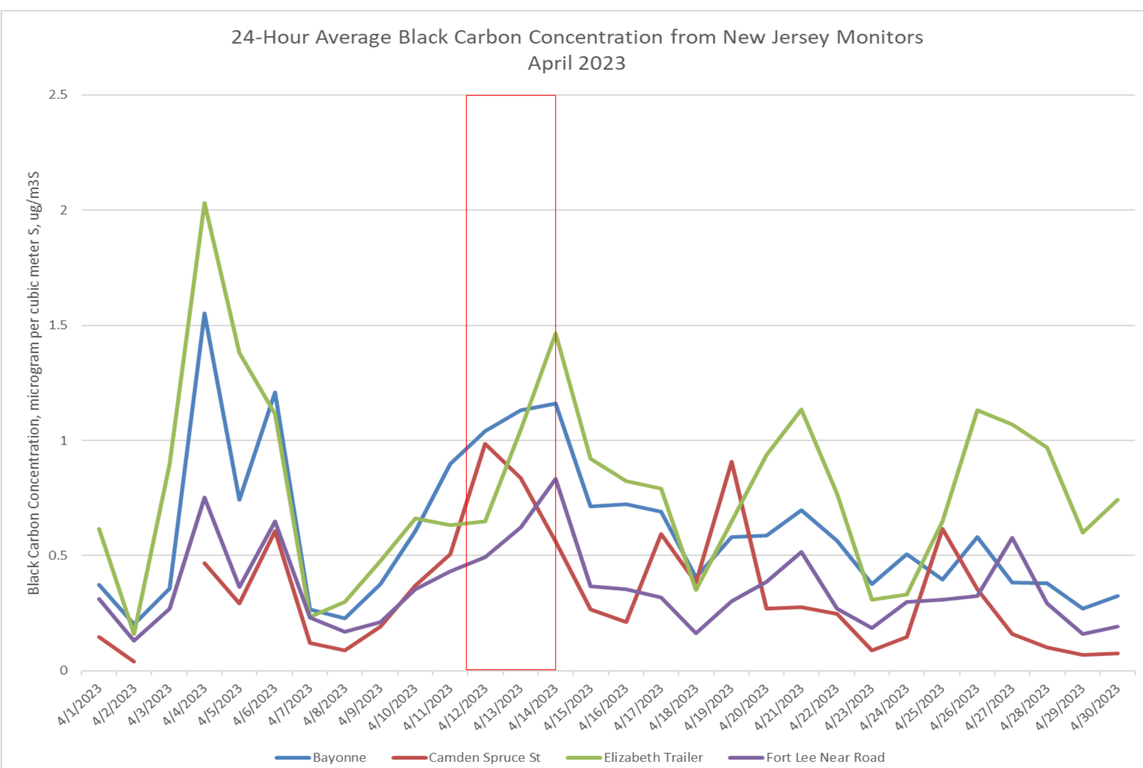


Figure 43: Daily Average Black Carbon Concentration at New Jersey Monitors, May 30 – July 3, 2023



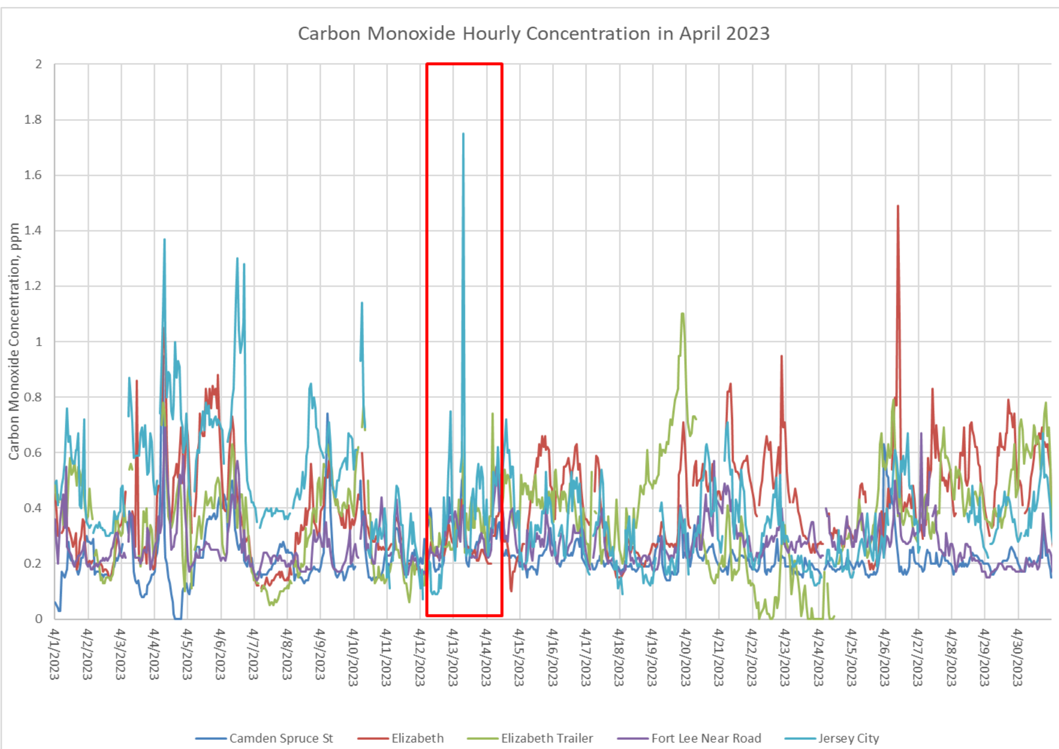
4.2 Carbon Monoxide (CO)

Several research studies have investigated the impact of wildfires in Canada's boreal forests on trace gases and particles. One study determined that an intense wildfire event that occurred in northwestern Canada in June 1995 resulted in increased concentrations of carbon monoxide (CO) and ozone (O_3) concentrations in the midwestern and eastern United States. Therefore, a significant increase in carbon monoxide, in addition to other pollutants in the ambient air may signal a wildfire event.[43] New Jersey measures near-real time CO levels in the ambient air at five monitoring stations throughout the state.[44]

Figure 44 displays the hourly concentration of CO in April 2023, while Figure 45 displays the 24-hour average CO concentration of carbon monoxide in April 2023. Elevated CO levels are noticeable around April 13, as indicated within the red box.

In April 2023, the hourly average CO concentration at the Camden Spruce St monitor was 0.22 ppm. On April 13, the daily average concentration of CO reached 0.31 ppm, while the maximum hourly concentration on the same day peaked at 0.52 ppm at 7:00 AM. Comparing the April 13 concentration to both the April hourly average and the seasonal hourly average, it is evident that the CO levels on April 13 exceeded the norm. Similar trends were observed in most monitors, indicating elevated CO levels on April 13, 2023.

Figure 44: Hourly Carbon Monoxide Concentrations at New Jersey Monitors in April 2023



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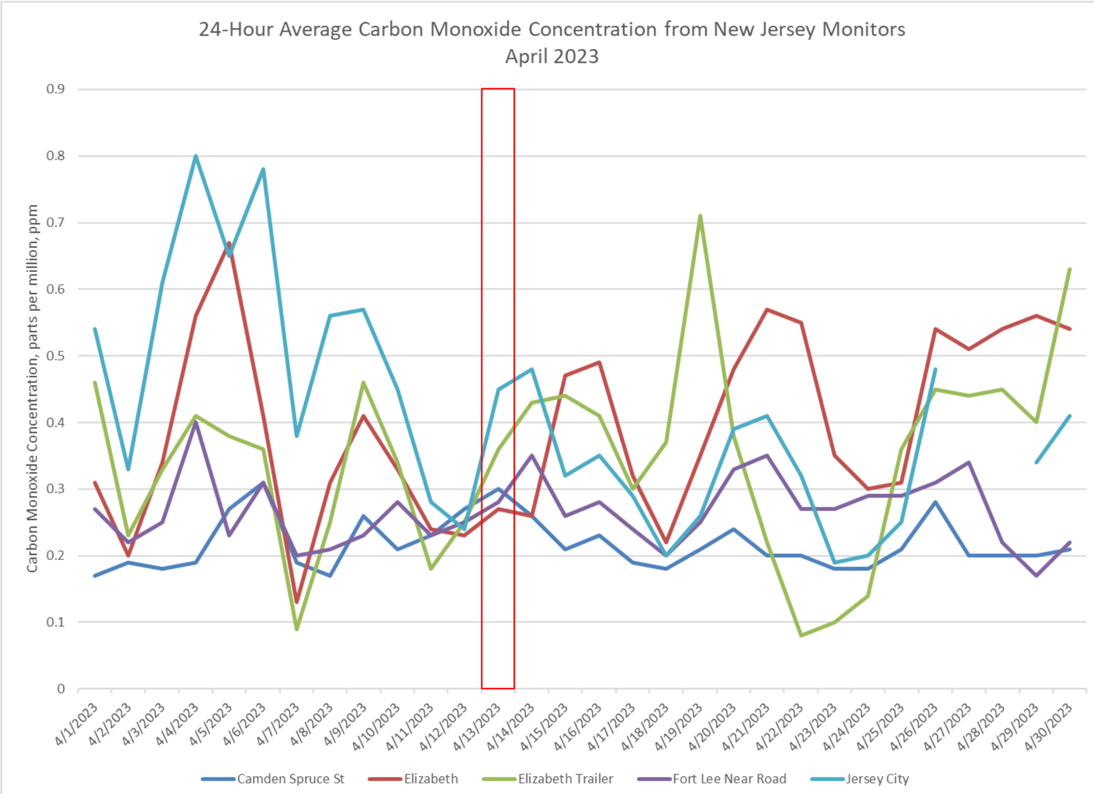
[43] Yang, Z., Demoz, B., Delgado, R., Sullivan, J., Tangborn, A., & Lee P. (2022). Influence of the transported Canadian wildfire smoke on the ozone and particle pollution over the Mid-Atlantic United States. *Atmospheric Environment, 273*. Retrieved February 7, 2024, DOI: https://doi.org/10.1016/j.atmosenv.2022.118940

[44] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

Figure 45: Daily Average Carbon Monoxide Concentrations at New Jersey Monitors from in April 2023



4.3 Nitrogen Dioxide (NO_2)

Nitrogen oxides (NOx) are emitted from wildfires and are precursors to ozone formation; therefore, analyzing NOx trends can provide additional evidence in demonstrating that the ozone exceedances on April 13 qualify as exceptional events. Two of the most common NOx compounds are nitrogen oxide (NO) and nitrogen dioxide (NO_2). NO oxidizes into NO_2 in the atmosphere. According to the USEPA, NO_2 often serves as an indicator for NOx levels.[45] New Jersey measures near-real time NO_2 levels in the ambient air at five monitoring stations throughout the state.[46]

Figure 46 displays the hourly NO_2 concentrations measured at the New Jersey Rutgers University monitor in April 2023. Figure 47 displays the corresponding daily average NO_2 concentrations in April 2023. There were elevated levels of NO_2 throughout the month of April indicating presence of smoke from the fires. In the days leading up to April 13, noticeable spikes of NO_2 concentrations are observed, as highlighted within the red boxes. The elevated NO_2 levels observed at these monitors serve as evidence of smoke impact on New Jersey's air quality.

[45] USEPA. (2023, July 25). *Basic Information about NO_2*. Retrieved February 7, 2024, from https://www.epa.gov/no2-pollution/basic-information-about-no2

[46] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

Figure 46: Hourly Concentration of NO_2 at the Rutgers University monitor in April 2023

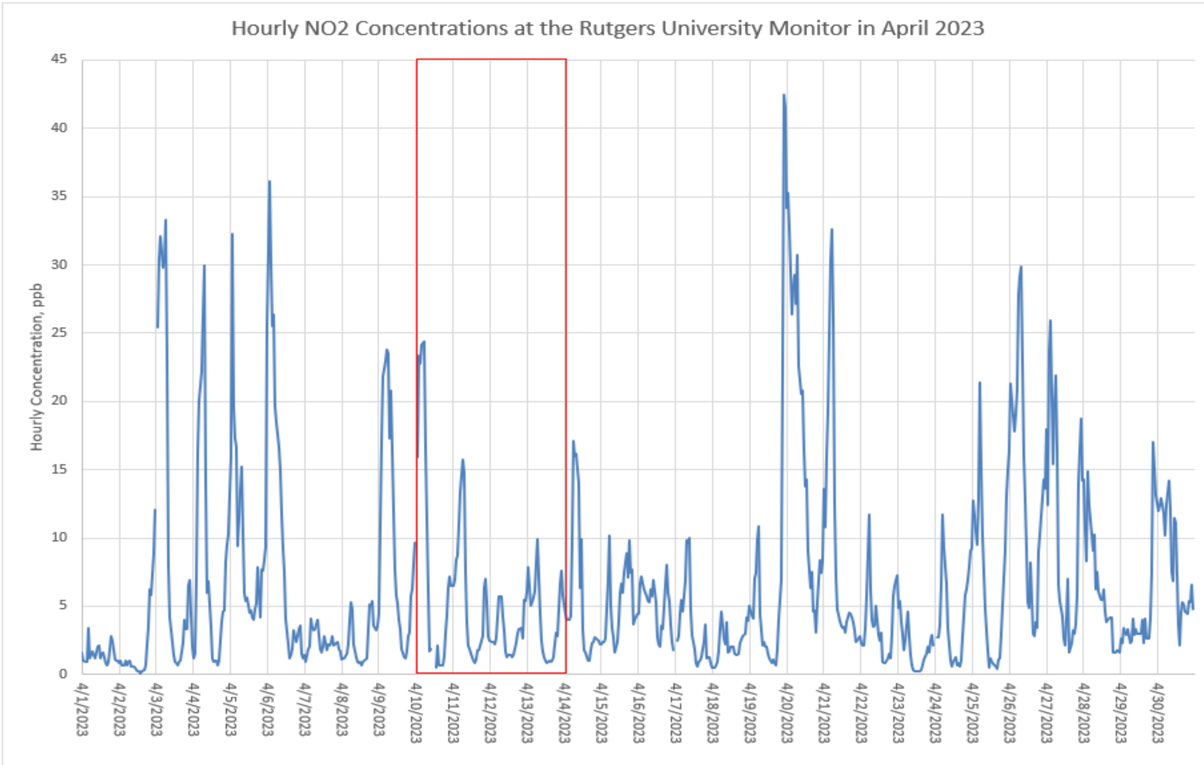
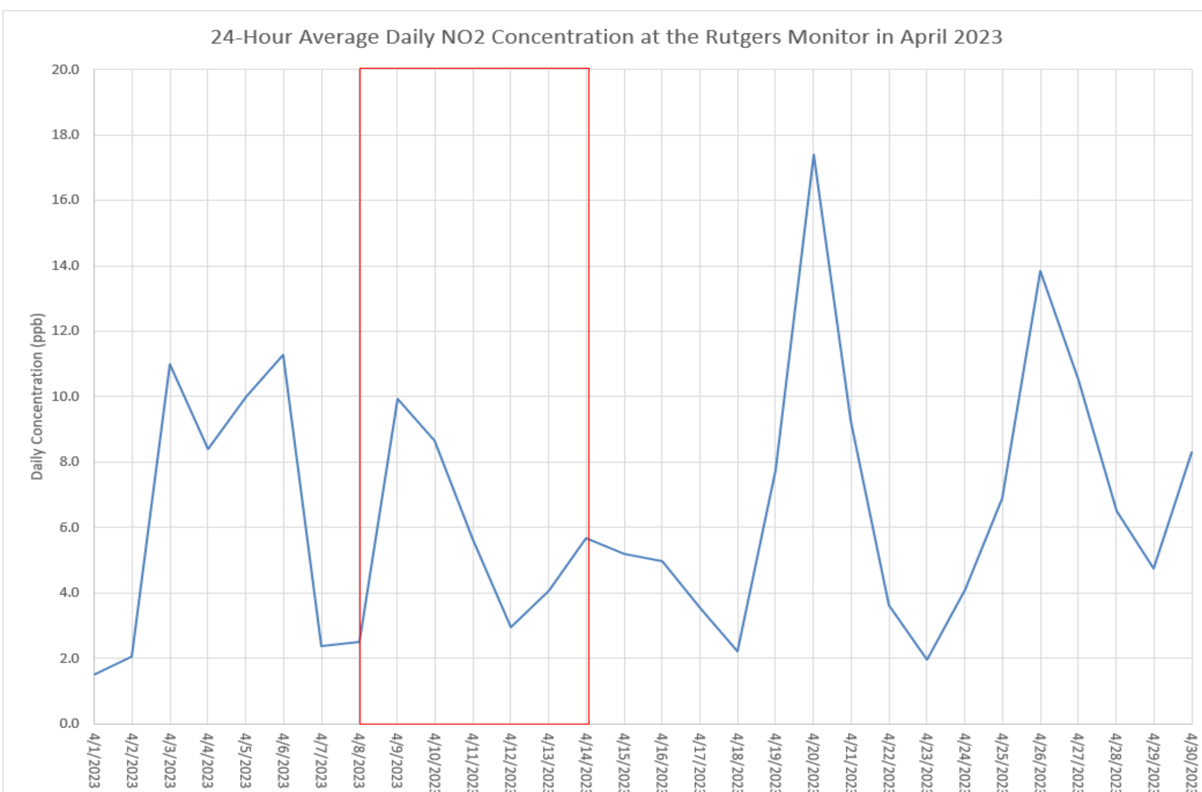


Figure 47: Daily Average Concentration of NO_2 at the Rutgers monitor in April 2023



4.4 Evidence of Changes in Spatial/Temporal Patterns of Ozone and NOx

This section presents satellite evidence of smoke and ozone precursors to demonstrate changes in the spatial and temporal patterns of ozone and NOx and the impacts on New Jersey monitors.

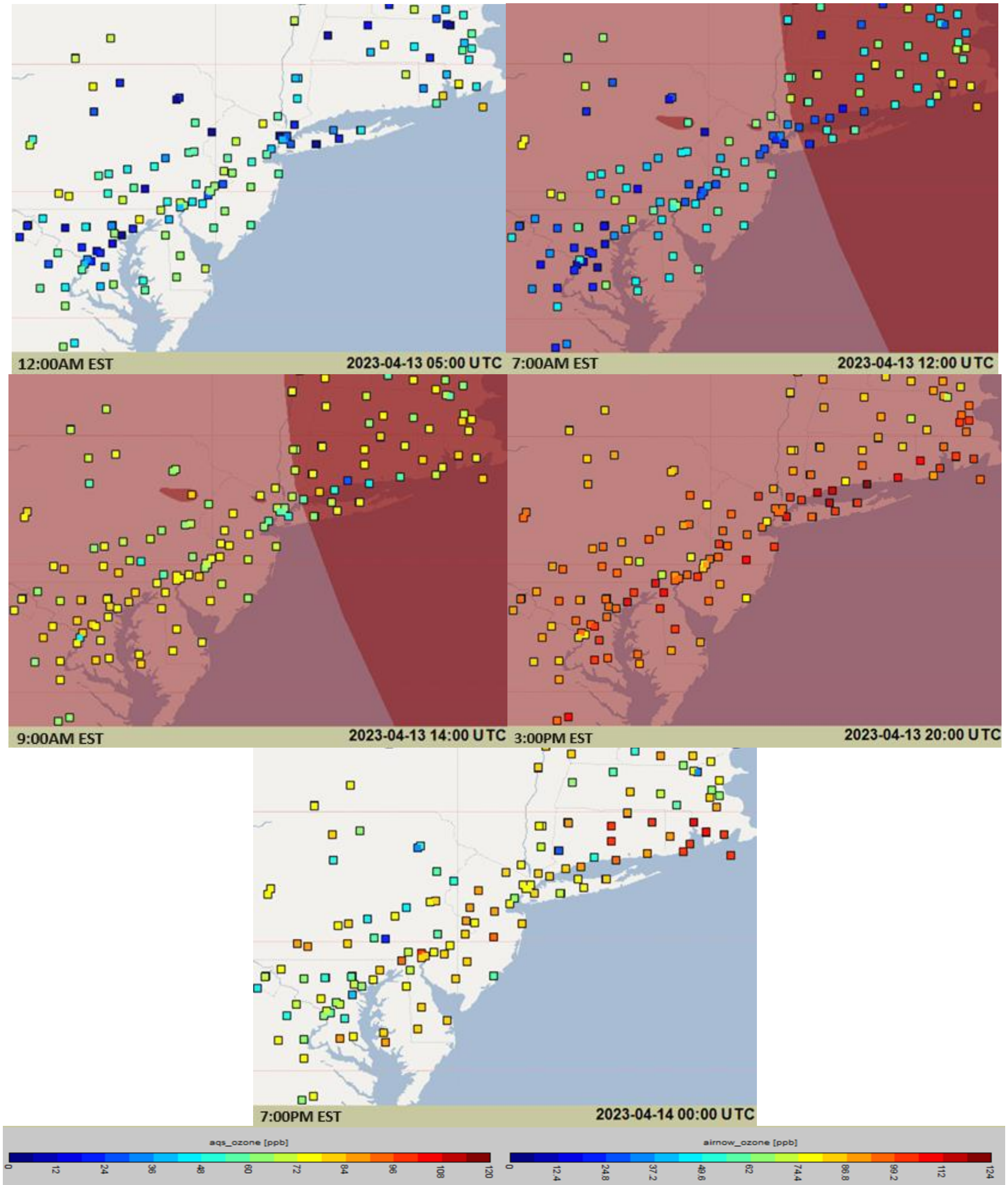
Videos of ozone and smoke patterns were generated using the Remote Sensing Information Gateway (RSIG) application, RSIG3D, and screenshots from the videos are presented below.[47] The videos present hourly monitoring data for nitrogen dioxide and ozone from USEPA AirNow and Air Quality System (AQS) data inventories. Smoke information was obtained from the National Aeronautics and Space Administration (NASA) Hazard Mapping System (HMS) Fire and Smoke Product data inventory. In Figure 60, the location of the smoke plume is indicated by dark red contours. The hourly data is reported in Coordinated Universal Time (UTC), which is five hours ahead of the local Eastern Standard Time (EST), therefore the data continues until 05:00UTC the next day. EST will be used for this analysis. As indicated by the scale in Figure 48 and Figure 49, red represents higher ozone values and blue represents lower ozone values, at the monitors.

4.4.1 Analysis of Changes in Spatial/Temporal Patterns of Ozone Using RSIG3D.

Figure 48 presents screenshots from a video (see Attachment 2) generated using RSIG3D. The video presents the ozone monitoring data with a smoke overlay for April 13, 2023. Abnormally elevated ozone levels were observed throughout New Jersey on this day. At the beginning of April 13, the ozone levels were low. However, after 7:00AM EST, ozone levels at the monitors began to rise. As seen in Figure 48, the overlay at 9:00AM EST shows that the smoke levels began to increase, and several monitors began to violate the 70 ppb 2015 8-Hour ozone NAAQS. Ozone concentration levels continued to rise in the hours that followed, and a denser smoke cloud can be seen in the HMS data during the subsequent timestamps. Between 3:00 PM and 6:00 PM, a line of monitors with extremely elevated ozone levels can be seen across surrounding states; NY, NJ, PA, DE, and MD. Ozone levels only began to decrease around 6:00PM, with some monitors still showing elevated levels, as observed at 7:00 PM in Figure 48. The ozone concentration at the monitors returned to lower levels after 10:00 PM.

[47] USEPA. (2024). *Remote Sensing Information Gateway (RSIG)* (Version 20231206). Retrieved January 25, 2024, from https://www.epa.gov/hesc/remote-sensing-information-gateway

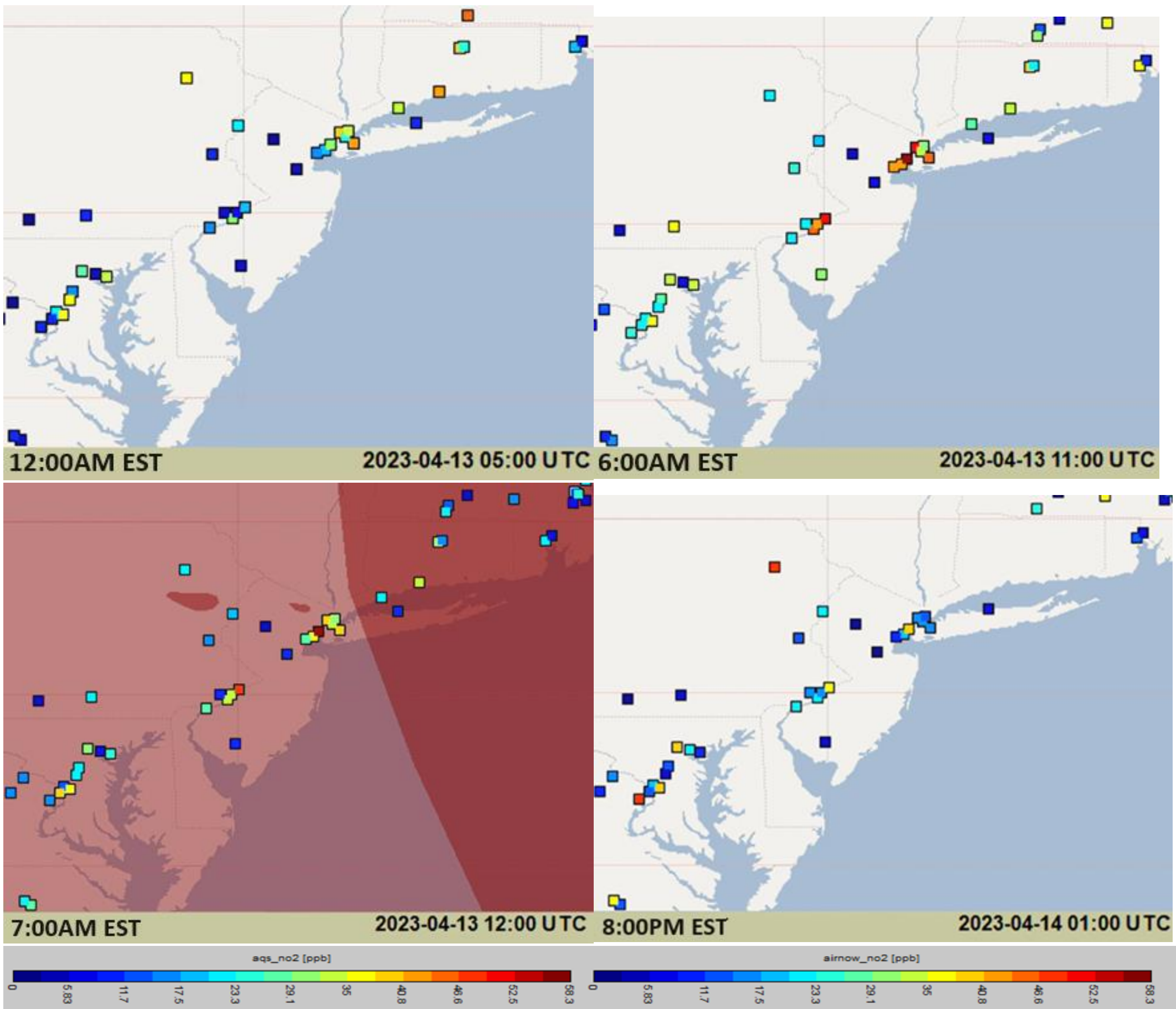
Figure 48: Ozone Monitoring and HMS Smoke Patterns on April 13, 2023



4.7.2 Analysis of Changes in Spatial/Temporal Patterns of Nitrogen Dioxide (NO_2) Using RSIG3D

Figure 49 presents screenshots from a video generated using RSIG3D. The video presents the nitrogen dioxide monitoring data with a smoke overlay for April 13, 2023. The nitrogen dioxide levels began increasing around 12:00AM EST, and reached a peak around 5:00AM and 6:00AM EST. See Figure 49. At 7:00AM, the level decreased, remaining low until 6:00PM. Subsequently, the southern NJ monitors showed slightly elevated levels again. One monitor showed elevated values at 8:00PM and slightly elevated levels continued to be seen until the day ended.

Figure 49: Nitrogen Dioxide Monitoring and HMS Smoke Patterns on April 13, 2023



III. Analyses Comparing the Claimed Event-Influenced Concentrations to Concentrations at the Same Monitoring Site at Other Times

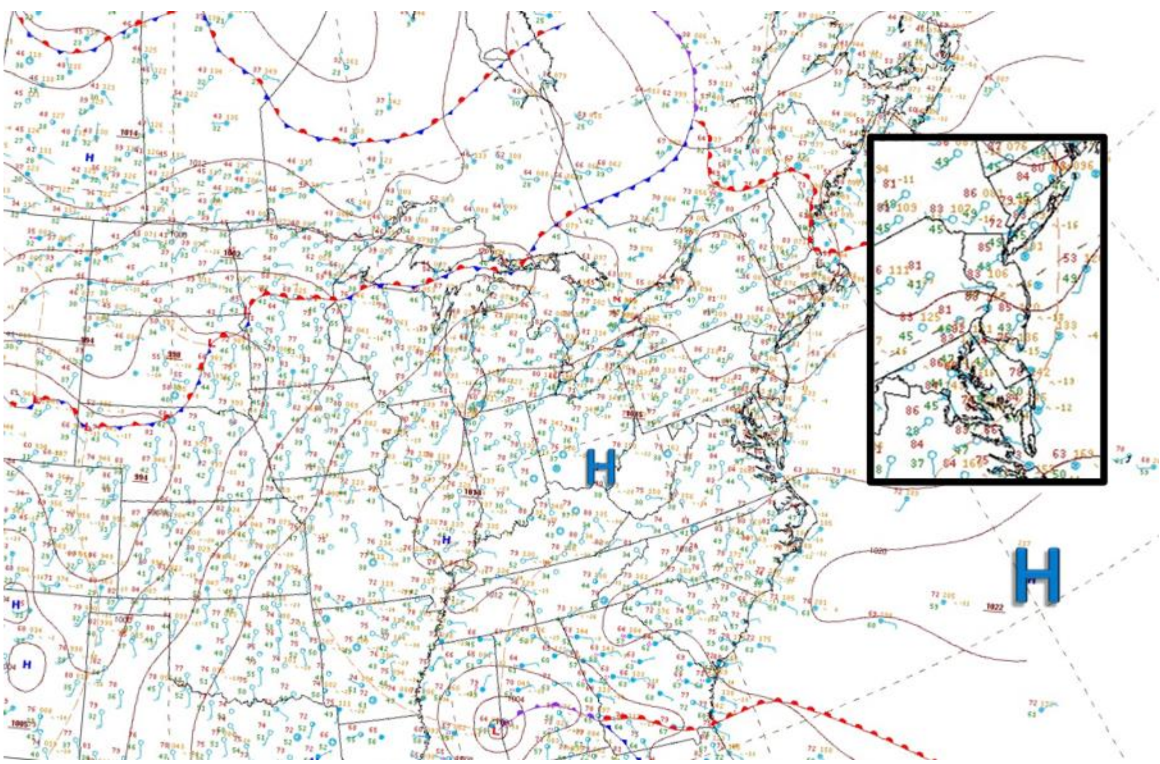
A similar day analysis identifies specific meteorological conditions observed on the exceptional event day (in this case April 13, 2023) and compares those conditions to other days with the same conditions in past history but did not yield unusually elevated ozone concentrations. Therefore, days with similar meteorology when no smoke is present should not produce ozone exceedances of the same magnitude. No data from the year 2020 was used in the similar day analysis due to the unusual anthropogenic emissions conditions caused by the pandemic.

The parameters/criteria that were used for the reference day meteorology in this analysis include the following:

- Surface analysis & upper air (850mb) showing high pressure over southeastern US;
- High temperature at KPHL 86° F or higher;[46]
- 0.00" precipitation;
- General surface wind direction out of the southwest/west-southwest;
- No ozone exceedances (or 1 questionable, isolated exceedance);
- Length of day;

Figure 50 presents surface analysis for the reference day, April 13, 2023.

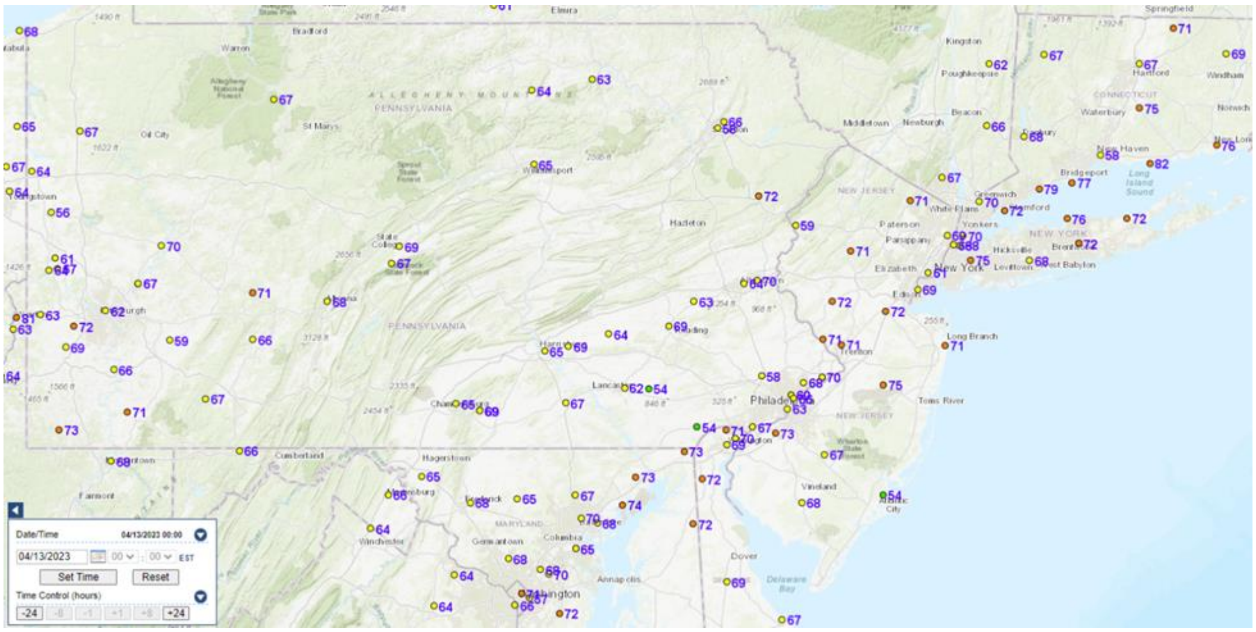
Figure 50: Reference Day Surface Analysis – April 13, 2023, 12UTC



Note: Surface high pressure marked with blue "H" located in southeastern United States. Surface temperatures indicated by red numbers showing nearby range from 83-88 degrees F. Mostly sunny skies indicated by blue wind barbs with hollow circles.

Figure 51 presents the maximum 8-hour ozone concentration on the reference day, April 13, 2023.

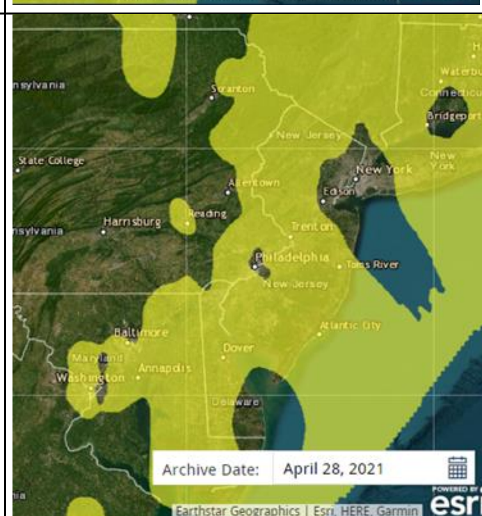
Figure 51: Reference Day 8hr Max Ozone Concentrations on April 13, 2023



Based on the surface analysis and ozone concentrations represented in Figure 50 and Figure 51, Table 7 presents dates that were chosen as similar days for April 13, 2023 because they were characterized by similar meteorological conditions. As noted in Table 7, while the meteorological conditions were similar, the ozone levels on these days were not elevated listed as seen on April 13, 2023. Therefore, the widespread ozone exceedance concentrations on April 13, 2023 can be attributed to an exceptional event due to wildfire smoke.

Table 7: Similar Day Comparison of Max Ozone Concentration, Max Temperature, and AQI Map for April 13, 2023

Note: Ozone (ppb) represents the monitor that recorded the highest observed ozone concentration on the specified day in the New Jersey portion of the Southern NJ-PA-DE-MD nonattainment area. Temperature represents the highest recorded temperature on specified date at KPHL.

Date	Ozone (ppb)	Temp (F)	AQI Map
Reference Day April 13, 2023	75 – Colliers Mills	86	
April 28, 2021	65 – Colliers Mills	87	

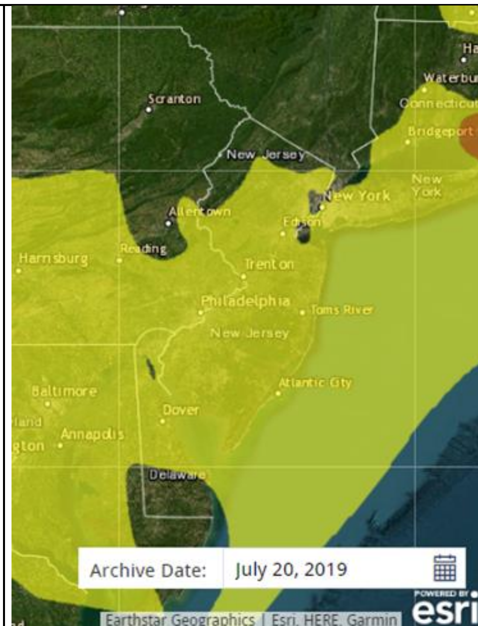
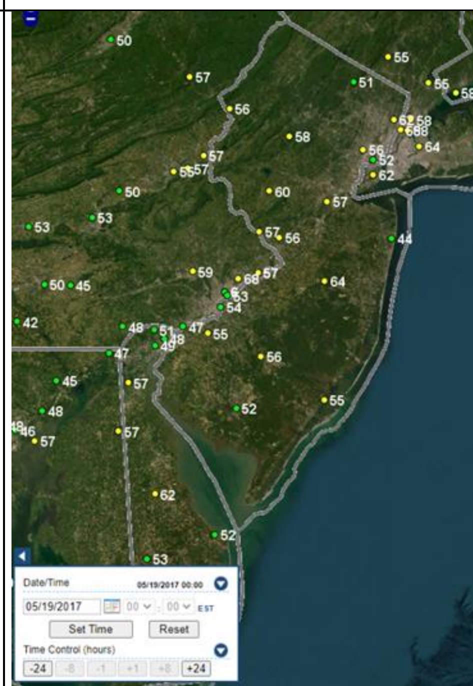
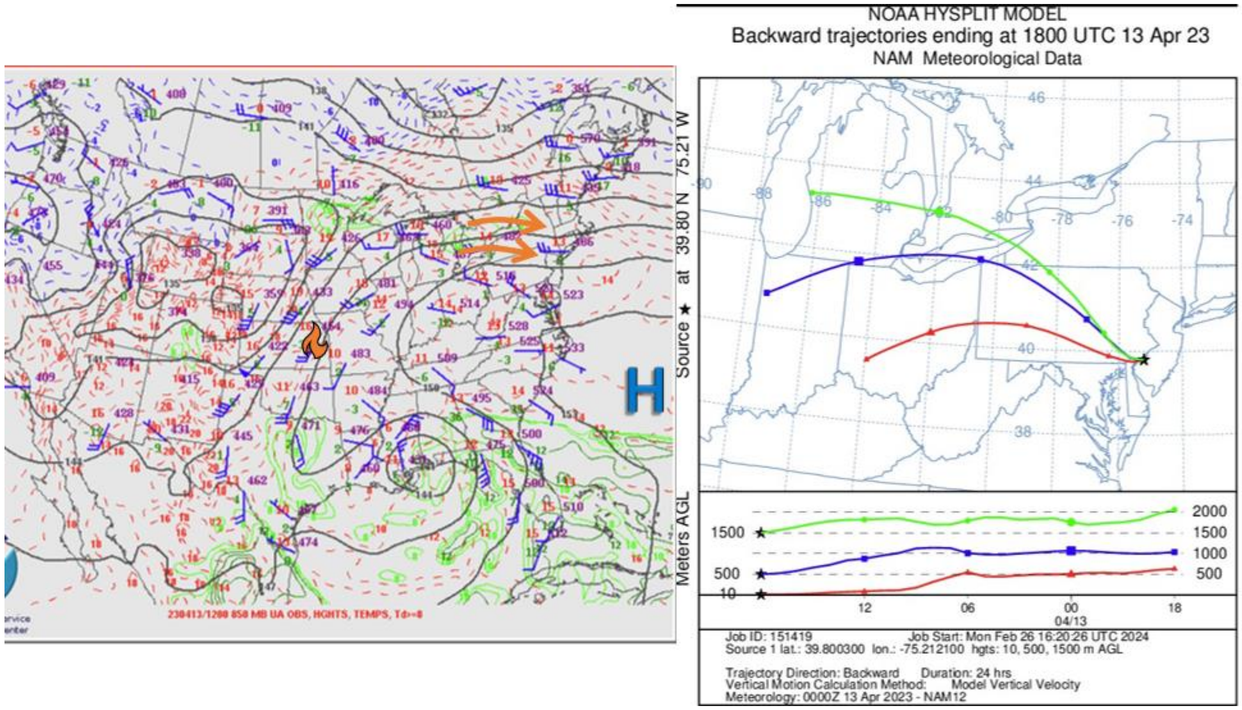
July 20, 2019	62 – Camden Spruce Street	97	
May 19, 2017	64 – Colliers Mills	93	

Figure 52 shows the 850mb map and backward trajectories for the reference day, April 13, 2023. The features of importance for the similar day comparison are high pressure located in the southeastern United States with the center of high pressure off the coast and a matching backward trajectory with average wind direction at KPHL out of the west-southwest/southwest.

Figure 52: 850mb Map and 24hr Backward Trajectories for Reference Day: April 13, 2023



Based on the above criteria for the reference day, the following figures (Figure 53 - 55) show a comparison of the matching meteorological criteria for the similar day analysis.

Figure 53: 850mb Map and 24hr Backward Trajectories for April 28, 2021

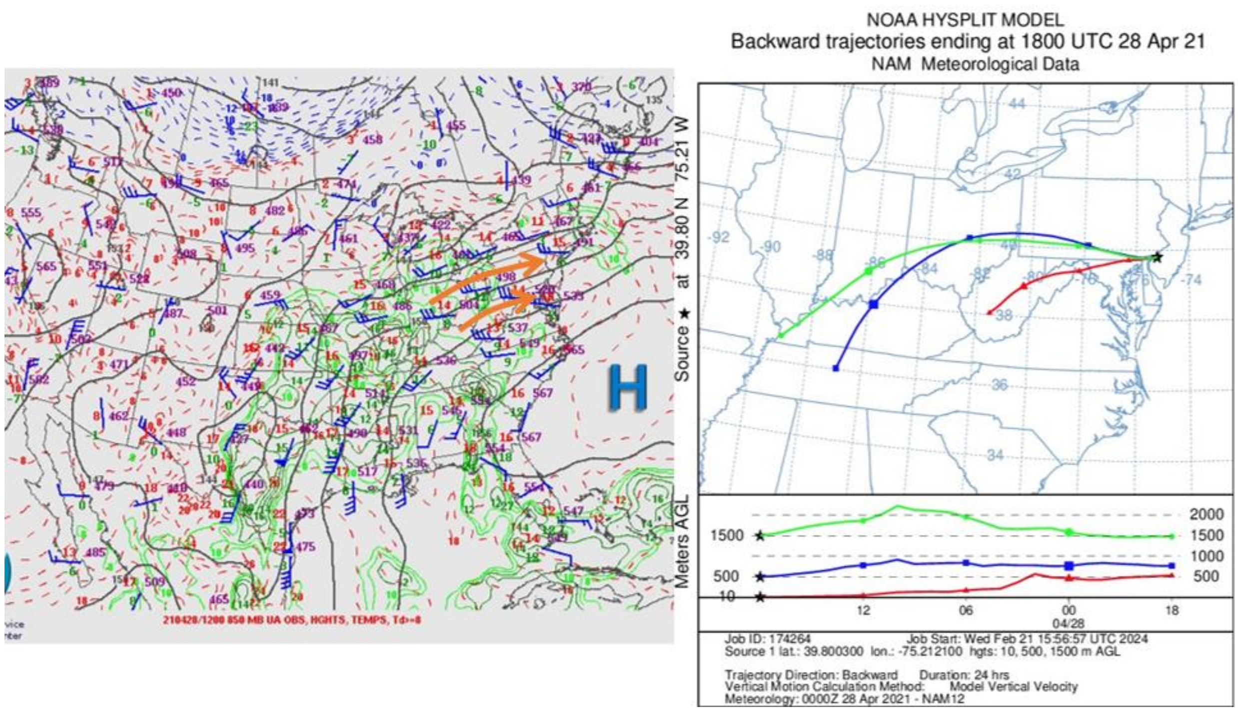


Figure 54: 850mb Map and 24hr Backward Trajectories for July 20, 2019

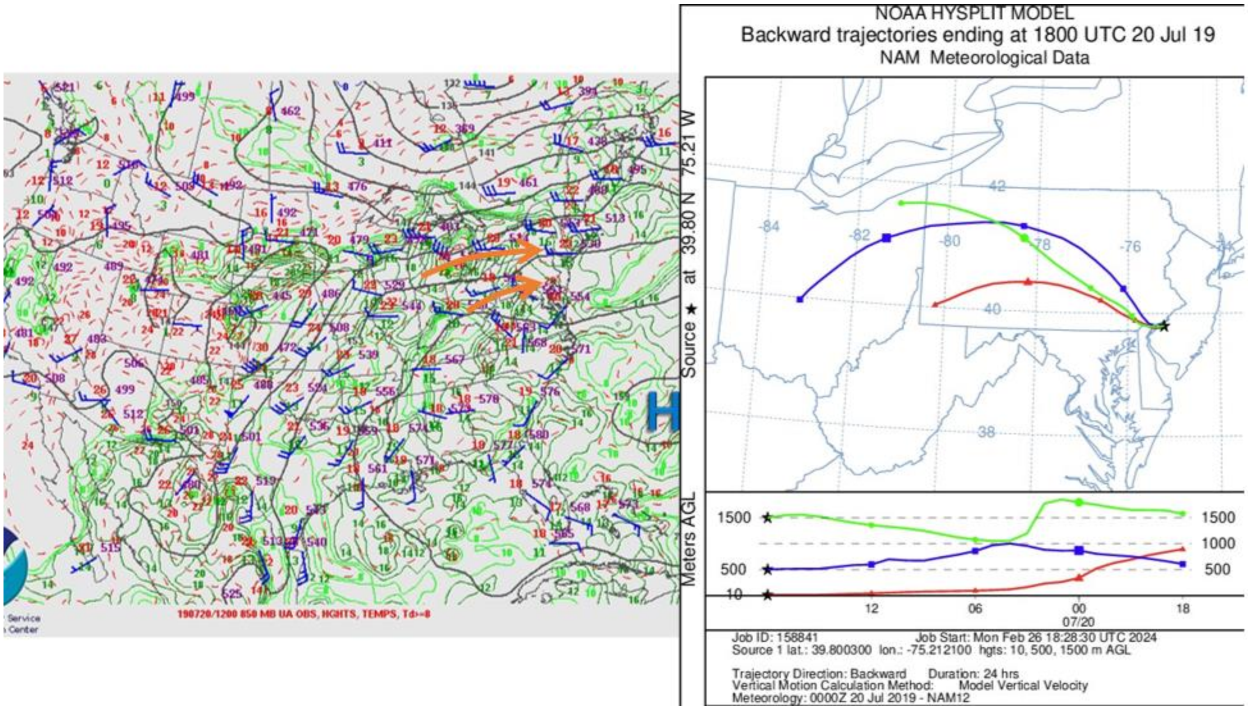
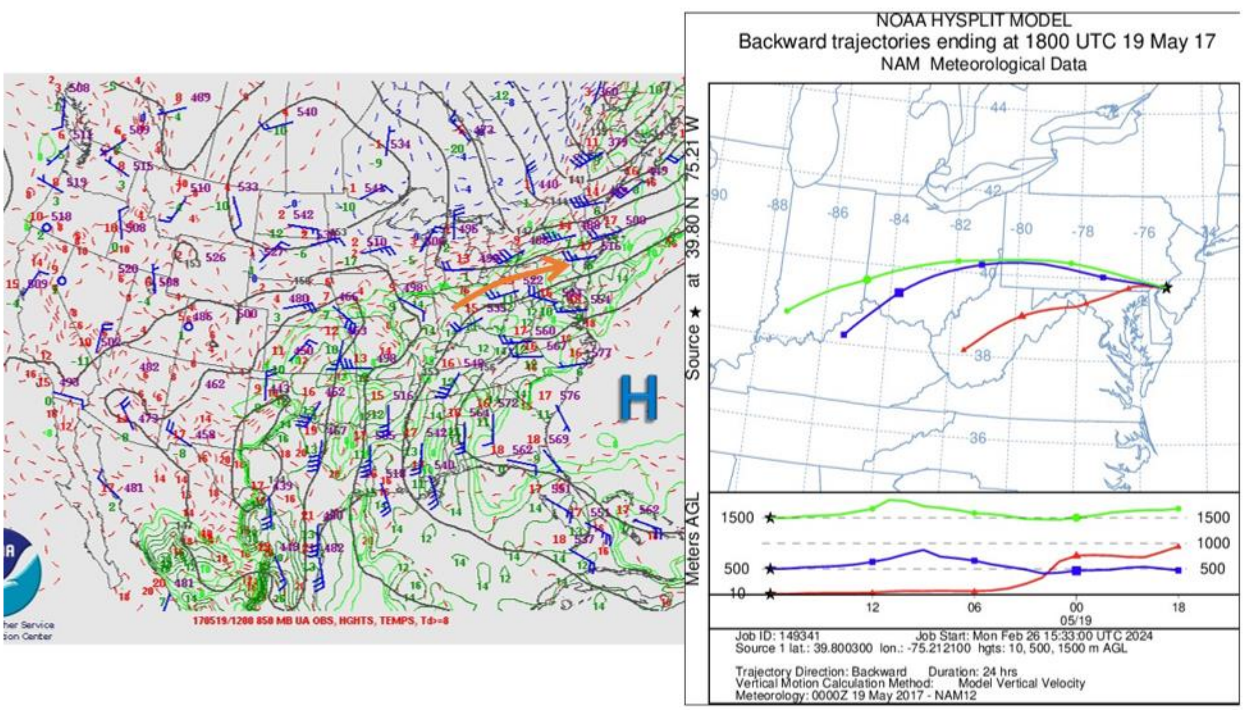


Figure 55: 850mb Map and 24hr Backward Trajectories for May 19, 2017



IV. A Demonstration that the Exceptional Event was Both Not Reasonably Controllable and Not Reasonably Preventable

According to the Clean Air Act and the Exceptional Events Rule, an exceptional event must be "not reasonably controllable or preventable."[48,49] In its July 2018 "Update to Frequently Asked Questions" for the 2016 Revisions to the Exceptional Events Rule the USEPA states, "it is presumptively assumed that if evidence supports that a wildfire occurred on wildland, such a wildfire event will satisfy both factors of the "not reasonably controllable or preventable' criterion, provided the Administrator determines that there is no compelling evidence to the contrary in the record."[50] The USEPA Exceptional Event Guidance also states that wildfire events on wildland are not generally reasonable to control or prevent.[51]

According to 40 CFR 50.14(b)(8)(vii) and EPA Guidance, Air agencies do not need to provide a case-specific justification to support the "not reasonably controllable or preventable" criterion for emissions-generating activity that occurs outside of the State's jurisdictional boundaries within which the concentration at issue was monitored.[52,53]

As previously stated in this document and reported in news articles, the Flint Hills, Kansas, fires pertinent to this demonstration, were prescribed burns that got out of control and developed into a wildfire.[54,55] These fires occurred outside of New Jersey, and can be considered not reasonably controllable or preventable by New Jersey. The Flint Hills fires also occurred on wildland, and NJDEP is not aware of any evidence clearly demonstrating that prevention or control efforts beyond those that were made would be reasonable. Therefore, emissions from these fires were not reasonably controllable or preventable and meet the criterion for an exceptional event.

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[48] 42 U.S.C. 7401 et seq.
[49] 40 CFR 50.14
[50] USEPA. (2018, July). *2016 Revisions to the Exceptional Events Rule: Update to Frequently Asked* Questions.
[51] 42 U.S.C. 7619(b)(1)(iii), *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentration*s. EPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. Page 30: https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf
[52] 2019 EE Guidance: Prescribed Fire on Wildland that May Influence Ozone and PM Concentrations
[53] 40 CFR 50.14(b)(8)(vii) eCFR : 40 CFR 50.14 -- Treatment of air quality monitoring data influenced by exceptional events.
[54] "Burn Scars Across Eastern Kansas", MODIS, April 12, 2023, https://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2023-04-14, Date Accessed: January 25, 2024
[55] "Two out-of-control Fires Burn Thousands of Acres in Riley County" Riley County Kansas, April 10, 2023, https://www.rileycountyks.gov/CivicAlerts.aspx?AID=1582, Date Accessed: January 25, 2024

V. Caused by Human Activity that is Unlikely to Recur at a Particular Location or a Natural Event

According to the CAA and the Exceptional Events Rule, an exceptional event must be "an event caused by human activity that is unlikely to recur at a particular location or a natural event"[56,57] The Exceptional Events Rule's definition of wildfire is "… any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event." [58,59]

According to EPA Guidance, EPA will not treat a prescribed fire as a natural event under the Exceptional Events Rule, unless the prescribed develops into a wildfire. The Flint Hills fires began as prescribed fires, but escalated into wildfires, thus falling under the category of wildfires. [60,61] These fires occurred on wildland, making them a natural event. Sections I and II of this demonstration provide detailed descriptions and visual representations, demonstrating that these fires meet the criteria for being considered a "natural event". As such, NJDEP has demonstrated that these events qualify as natural occurrences and may be considered for treatment as exceptional events.

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[56] 42 U.S.C. 7401 et seq.

[57] 40 CFR 50.14

[58] 42 U.S.C. 7619(b)(1)(iii), *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. EPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. Page 30: https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[59] 40 CFR 50.1(n)

[60] "Burn Scars Across Eastern Kansas", MODIS, April 12, 2023, https://modis.gsfc.nasa.gov/gallery/individual.php?db_date=2023-04-14, Date Accessed: January 25, 2024

[61] "Two out-of-control Fires Burn Thousands of Acres in Riley County" Riley County Kansas, April 10, 2023, https://www.rileycountyks.gov/CivicAlerts.aspx?AID=1582, Date Accessed: January 25, 2024

Exceptional Event Demonstration Analysis for Ozone During June 2, 2023

I. A Narrative Conceptual Model and a Discussion of the Event that Led to Exceedances at New Jersey Monitors

1. A Description of New Jersey's Ozone Nonattainment Areas

New Jersey is associated with two multi-state nonattainment areas: the New York-Northern New Jersey-Long Island Nonattainment area (hereafter referred to as the Northern New Jersey-New York-Connecticut or Northern NJ-NY-CT Nonattainment area) and the Philadelphia-Wilmington-Atlantic City Nonattainment area (hereafter referred to as the Southern New Jersey-Pennsylvania-Delaware-Maryland or Southern NJ-PA-DE-MD Nonattainment Area). The Northern NJ-NY-CT Nonattainment area includes counties in the states of New York and Connecticut and the New Jersey counties of: Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union, and Warren. The Southern NJ-PA-DE-MD Nonattainment area includes counties in the states of Pennsylvania, Delaware, and Maryland and the New Jersey counties of: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Ocean, and Salem. The entire State of New Jersey is classified as Moderate nonattainment for the ozone health standard of 70 parts per billion (ppb) with an attainment deadline of August 2024.

2. Non-Event Ozone Formation in the New Jersey Nonattainment Areas

New Jersey typically experiences high ambient air ozone levels in the summer months. This section of the document discusses the normal patterns of ozone formation in New Jersey's air to characterize how the June 2nd exceptional event caused by various wildfires differs from the usual weather patterns and locations of emissions that cause New Jersey to exceed the National Ambient Air Quality Standard (NAAQS) for ozone.

The evolution of elevated ozone episodes in the eastern U.S. often begins with the movement of a large air mass from the Midwest to the middle or southern Atlantic states, where it assimilates into and becomes an extension of the Atlantic (Bermuda) high pressure system.[62] During its movement east, the air mass accumulates air pollutants emitted by large coal-fired power plants and other sources located outside the Ozone Transport Region (OTR). As the air mass passes over the eastern U.S., sources within the OTR contribute to the air pollution. These expansive weather systems are conducive to the formation of ozone by creating a vast area of clear skies and high temperatures. These two prerequisites for elevated ozone formation are further compounded by a circulation pattern favorable for pollution transport over large distances. In the worst cases, the high-pressure systems stall over the eastern U.S. for days, creating ozone episodes of strong intensity and long duration.

The transport patterns (high pressure) that are conducive to ozone formation often carry ozone/pollutants within them, which can come from locations of farther distance. High pressure systems have a gentle sinking motion (subsidence) that causes air to sink and enhances stagnation of pollutants at the surface. As a result, air traveling more slowly and being trapped at the surface allows the pollutants to accumulate. Under a strong area of high pressure, the mechanisms that usually disperse

[62] NJDEP. (2007). *State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard 8-Hour Ozone Attainment Demonstration Final, Chapter 2: Nature of the ozone air quality problem in the northeast – the conceptual model*. https://dep.nj.gov/wp-content/uploads/airplanning/1997-8-hour-ozone-2007/final_completesip.pdf

pollutants are not present, which leads to a shorter boundary layer giving the pollutants less "volume" to disperse among compared to if the boundary layer was higher/taller. Also, winds that typically disperse pollutants over large areas are not present, so all of the pollution generated/transported becomes trapped in very low levels.

One transport mechanism that can play a key role in moving pollution long distances is the nocturnal, low-level jet stream. The jet is a regional scale phenomenon of higher wind speeds that often forms during ozone events a few hundred meters above the ground. It can convey air pollution several hundreds of miles overnight from the southwest to the northeast, directly in line with the major population centers of the Northeast Corridor stretching from Washington, D.C. to Boston, Massachusetts. The nocturnal, low-level jet extends the entire length of the corridor from Virginia to Maine and has been observed as far south as Georgia. It can thus be a transport mechanism for bringing ozone and other air pollutants into the OTR from outside the region, as well as to move locally formed air pollution from one part of the OTR to another. Other transport mechanisms occur over smaller scales, including land, sea, mountain, and valley breezes that can selectively affect relatively local areas.[63]

The different transport regimes into and within the OTR provide a conceptual picture of unhealthy ozone air quality days. Normally air cools as elevation increases above ground level. However, a nocturnal temperature inversion can occur after sunset if the ground cools faster than the air above it. In this instance, air temperature increases with elevation, which creates a stable boundary layer that prevents the vertical movement of air and thus traps pollutants near the ground. The stable boundary layer extends from the ground to only a few hundred meters in altitude. The air movement within the stable boundary layer is also minimal due to friction from the ground, and ground-level structures. Above this stable boundary layer, a nocturnal low-level jet can form with higher velocity winds due to the absence of frictional forces. Ozone contained in the low-level jet is unable to mix down to the ground because of the presence of a temperature inversion and is thus not subject to removal on surfaces or chemical destruction. Ozone in high concentrations can be entrained in the nocturnal low-level jet and transported several hundred kilometers downwind overnight. The next morning, as the sun heats the Earth's surface, the nocturnal boundary layer begins to break up, and the ozone transported overnight mixes down to the surface where concentrations rise rapidly, partly from mixing and partly from ozone generated locally. By the afternoon, abundant sunshine combined with warm temperatures promotes additional photochemical production of ozone from local emissions. As a result, ozone concentrations reach their maximum levels through the combined effects of local and transported pollution.

During unhealthy ozone exceedance episodes associated with high pressure systems, these multiple transport features are embedded within a large ozone reservoir arriving from source regions to the south and west of the OTR. Thus, ozone exceedance episodes can contain elements of long-range air pollution transport from outside the OTR, regional scale transport within the OTR from channeled flows in nocturnal low-level jets, and local transport along coastal shores due to bay, lake, and sea breezes. These typical patterns that usually result in unhealthful ozone levels were not present in New Jersey on June 2nd, 2023, when air flowed from a direction not normally associated with high ozone levels in New Jersey as explained later in this document.

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[63] Downs, T., Fields, R., Hudson, R., Kheirbek, I., Kleiman, G., Miller, P., & Weiss, L. (2006). *The Nature of the Ozone Air Quality Problem in the Ozone Transport Region: A Conceptual Description*. NESCAUM. Retrieved January 22, 2024, fromhttps://www.nescaum.org/documents/2010_o3_conceptual_model_final_revised_20100810.pdf

Ozone formation within the OTR is primarily due to nitrogen oxides (NOx), but volatile organic compounds (VOCs) are also important because they influence how efficiently ozone is produced by NOx, particularly within urban centers. Recent studies suggest that aged wildfire smoke, containing VOCs, transported into urban areas like New Jersey where an abundant supply of NOx exists, will lead to the creation of higher ozone levels because of the extra VOC from the wood smoke.[64] This is discussed in more detail in the Conceptual Model of Ozone Formation from Wildfires section of this document.

3. Wildfire Description

Multiple wildfires in northwestern Canada set ablaze beginning on May 6, 2023, and stretched from British Columbia, Alberta, and into Saskatchewan through June 2, 2023. The swath of wildfires consumed 3,459,475 acres in total.[65]

Early spring in northwestern Canada typically brings elevated fire risk where dry forest undergrowth is exposed after the snow melts. In May 2023, this fire prone area coincided with unusually hot and windy weather resulting in fires ignited by lightning or human activity that charred more than 1 million hectares (400 square miles) as of May 24th and lofted smoke high into the atmosphere.[66]

On several occasions, the unusually hot and intense fires generated strong updrafts that sent towering clouds of smoke into the stratosphere where stronger, higher-level winds dispersed it (Figure 56 below). Michael Fromm, a meteorologist from the U.S. Naval Research Lab stated, "We have seen smoke from this region behave like this in the past, but the amount of smoke is unusual for this time of year".[67]

[64] Val Martin, M., Honrath, R.E., Owen, R.C., Pfister, G., Fialho, P., & Barata, F. (2006). Significant enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires. *Journal of Geophysical Research: Atmospheres, 111*(D23). DOI: 10.1029/2006JD007530
[65] Canadian Wildland Fire Information System. (n.d.). Government of Canada. https://cwfis.cfs.nrcan.gc.ca/home
[66] NASA Earth Observatory. (2023, May 5-22). *A Smoky May for North America.* Retrieved December 7, 2023, from https://earthobservatory.nasa.gov/images/151384/a-smoky-may-for-north-america
[67] Ibid.

Figure 56: NASA Earth Observatory Image – GEOS-5 – May 20, 2023[68]

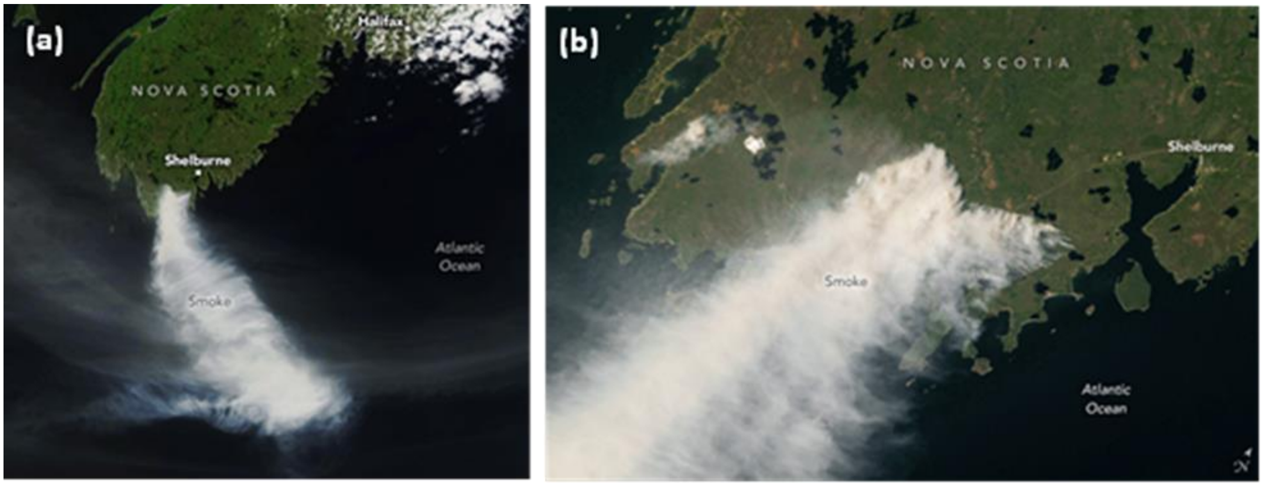
In the last few days of May 2023, unusually large fires ignited in Nova Scotia forcing the evacuation of thousands of people and resulting in the largest recorded wildfire in its history.[69] Smoke billowed from a fire near Shelburne on May 29, and by May 31, after several days of burning, the fire had scorched 17,000 hectares (ha) (66 square miles) near the southern tip of Nova Scotia (Figure 57 and Figure 58)[70].

[68] "A Smoky May for North America", NASA Earth Observatory, May 5-22, 2023. https://earthobservatory.nasa.gov/images/151384/a-smoky-may-for-north-america (Accessed 12/7/2023)

[69] Nova Scotia Wildfires Grow, Prompt Air Quality Warning as far South as Virginia. (2023, June 1). *AP News*. Retrieved December 7, 2023, from https://apnews.com/article/canada-wildfires-halifax-firefighters-us-south-africa-20f340036282d892aaa5528f1e48e618

[70] NASA Earth Observatory. (2023, May 29). *Raging Fires in Nova Scotia*. Retrieved December 7, 2023, from https://earthobservatory.nasa.gov/images/151407/raging-fires-in-nova-scotia

Figure 57 (a) and (b): Satellite & Astronaut Footage from May 29, 2023



(a)NASA Earth Observatory image by Wanmei Liang, using MODIS data from NASA EOSDIS LANCE and GIBS/Worldview.
(b) Astronaut photograph ISS069-E-15007 was acquired on May 29, 2023, with a Nikon D4 digital camera using an 400 millimeter lens and is provided by the ISS Crew Earth Observations Facility and the Earth Science and Remote Sensing Unit, Johnson Space Center. The image was taken by a member of the Expedition 69 crew. The image has been cropped and enhanced to improve contrast, and lens artifacts have been removed.

Figure 58: Picture of Wildfire Smoke Shelburne County, Nova Scotia – May 28, 2023[71]

[71] Comeau, T. (2023, May 28). *Shelburne County wildfire: The fire effort, evacuations, closed highway sections as fire burns out of control. Saltwire*. https://www.saltwire.com/atlantic-canada/news/shelburne-county-wildfire-the-fire-effort-evacuations-closed-highway-sections-as-fire-burns-out-of-control-100857985/

In addition, a smaller fire broke out near Halifax that consumed 837 hectares. Fires had been ongoing throughout Canada for weeks while several regions had an abnormally dry spring. Nova Scotia alone received about half of the usual amount of rainfall in April leading to extremely dry conditions accompanied by windy weather.

Overall, across Canada, it was observed that “Fire activity in Canada has been unusually destructive in 2023. Two million hectares (800 square miles) had burned by the end of May, which is 13 times the 10-year average for that time of year”, see Table 8 below.[72]

Table 8: National Wildland Fire Situation Report as of – May 31, 2023[73]

	2023 Fires as of May 31, 2023 (to date)	10-yr average (to date)
Number Fires	1,826	1,588
Area Burned (ha)	2,728,769	229,880

In addition to the two larger fires (western Canada and Nova Scotia), there were fires in New Jersey occurring between May 29th and June 2nd as well. The Allen Road Fire, which started on May 31 and was extinguished June 2, burned 2,215 acres (896 hectares) over that time with 1,772 acres (717 hectares) burnt on June 1 alone. Emissions from May 31 and June 1 influenced New Jersey air quality on June 1 and June 2, at minimum. This fire had the most prodigious smoke plume of the New Jersey fires, causing PM2.5 exceedances at Delaware monitors on May 31. Another fire was visible on June 1, via satellite over Fort Dix in southern New Jersey. No burn area was reported for this fire, but estimates based on satellite hot spot detection suggest around 77 acres (31 hectares) were burnt. Lastly, the Flat Iron fire on June 2, southeast of Philadelphia, burnt 86 acres (34 hectares).[74] This document focuses more heavily on the Canadian wildfires rather than the New Jersey fires discussed above because in some instances, the smoke plume generated from the fires more directly impacted locations downwind of the fires (to the southwest).

4. Conceptual Model of Ozone Formation from Wildfires (Interaction of Emissions and Chemistry of Event) and Ozone Chemistry that Characterized the Episode Including the Meteorological Conditions and Transport Patterns

Smoke from wildfires has been known to cause elevated ozone levels downwind and expanding observational evidence has demonstrated a clear connection between vegetation fires and photochemical ozone formation within their plumes.[75] Long-range transport of boreal wildfire emissions

[72] NASA Earth Observatory. (2023, May 29). *Raging Fires in Nova Scotia*. Retrieved December 7, 2023, from https://earthobservatory.nasa.gov/images/151407/raging-fires-in-nova-scotia

[73] Canadian Wildland Fire Information System. (n.d.). *Archived Reports*. Government of Canada. https://cwfis.cfs.nrcan.gc.ca/report/archives?year=2023&month=05&day=31&process=Submit

[74] MDE. (2023). *Exceptional Event Demonstration and Analysis of the West-Central and Nova Scotia, Canada and New Jersey Wildfires’ Impact on Maryland’s Ozone Air Quality on June 2, 2023*. https://mde.maryland.gov/programs/air/AirQualityMonitoring/Documents/ExceptionalEvents/MDE_Ozone_EE_Demo_2023_June_2.pdf

[75] Andreae, M.O. (1983). Soot carbon and excess fine potassium: Long range transport of combustion-derived products. *Science, 220*(4602), 1148-1151. DOI: 10.1126/science.220.4602.1148

can result in greater levels of carbon monoxide (CO), organic and black carbon (BC) aerosol, NOx, PM2.5, and aerosol mass downwind of the fire location. Also, greater amounts of CO in the plume can also enhance ozone formation.[76]

A study of the impacts from a 2002 Quebec, Canada wildfire event on the northeastern U.S. reported that ozone levels within the plume are also much greater, reaching 75 parts-per-billion by volume (ppbv) in one instance. [77]

Smoke from wildfires also appears to have a greater effect on enhancing ozone formation in urban areas compared to rural areas. One previous study of Canadian wildfires (not related to this exceptional event) found that in urban areas, or any region modified by nearby NOx sources, ozone levels were more sensitive to long-range fires compared to less populated or polluted regions.[78]

In this study, researchers proved that:

> "Both observations and model results show enhanced O_3 from air transported from the Northwest Territory. The model results imply that, during the period of strongest fire influence, a 10 to 30 ppbv enhancement of O_3 throughout a large region of the central and eastern United States was due to these fires."

4.1 Conceptual Model Overview

The end of May and early June 2023 were characterized by a strong ridge over central Canada allowing unusually hot temperatures to occur in the Northern Plains/Great Lakes while a lack of precipitation was observed in the eastern US. In northwestern Canada, this naturally fire-prone period coincided with unusually hot and windy weather as the strong ridge stretched far northward into western Canada. As a result, what normally would have been a short-lived fire was supercharged into large blazes that burned for several weeks leading up to the event on June 2nd. During this time, smoke from the wildfire outbreak was injected high into the atmosphere where upper-level winds dispersed it across the US. Meanwhile, a southward dip in the jet stream across eastern North America helped direct the smoke toward the northeast in the days/weeks leading up to this high ozone exceedance event. As high pressure in the northeast lingered into the Great Lakes region, a pathway between airmasses allowed smoke to make a southward descent through New England into the Mid-Atlantic. At this time, lower altitude smoke from fires burning in Nova Scotia and New Jersey was also transported into the Mid-Atlantic region via southwesterly winds rotating around widespread high pressure. On June 2nd, a surface trough developed between air masses allowing any smoke occurring at higher altitudes to mix down to ground level. It was this combination of smoke occurring aloft and at the surface that allowed for excess

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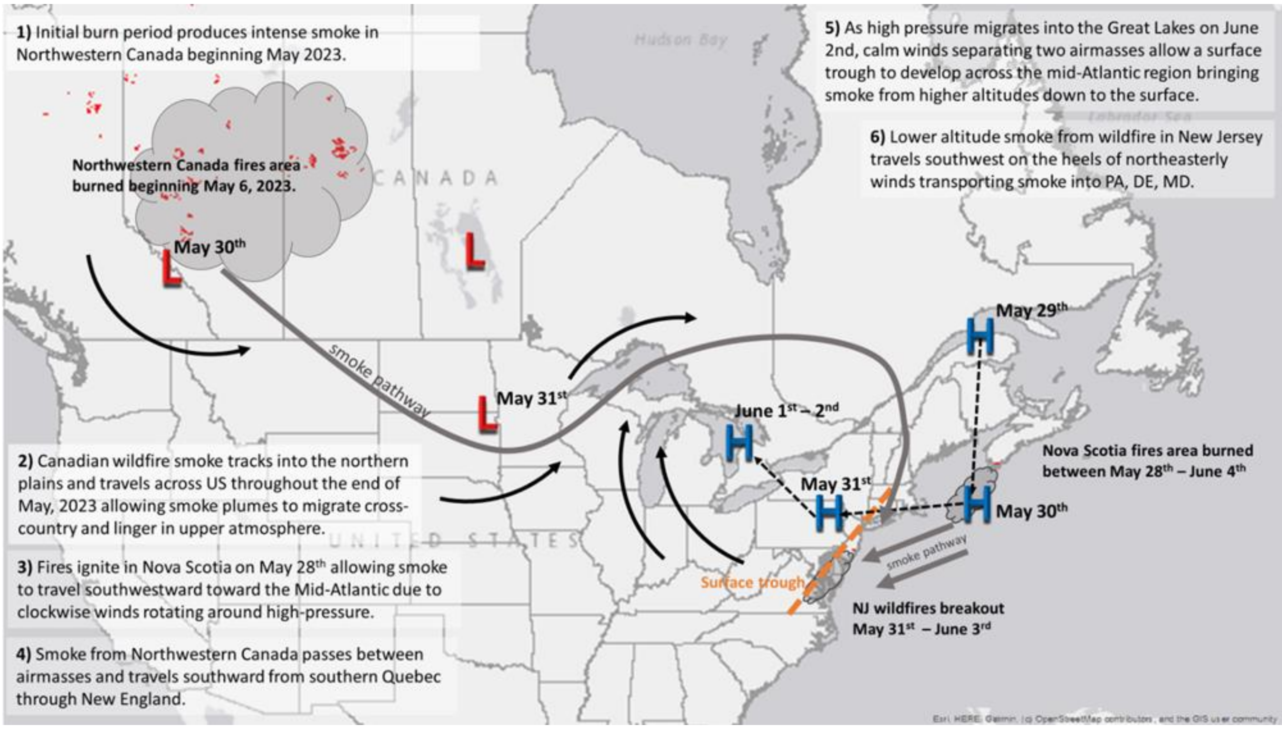
[76] Val Martin, M., Honrath, R.E., Owen, R.C., Pfister, G., Fialho, P., & Barata, F. (2006). Significant enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires. *Journal of Geophysical Research: Atmospheres, 111*(D23). DOI: 10.1029/2006JD007530

[77] DeBell, L.J., Talbot, R.W., Dibb, J.E., Munger, J.W., Fischer, E.V., & Frolking, S.E.. (2004). A major regional air pollution event in northeastern United States caused by extensive forest fires in Quebec, Canada. *Journal of Geophysical Research: Atmospheres, 109*(D19). DOI: 10.1029/2004JD004840

[78] McKeen, S.A., Wotawa, G., Parrish, D.D., Holloway, J.S., Buhr, M.P., Hübler, G., Fehsenfeld, F.C., & Meagher, J.F.. (2002). Ozone production from Canadian Wildfires during June and July of 1995. *Journal of Geophysical Research: Atmospheres, 107*(D14). DOI: 10.1029/2001JD000697

wildfire smoke in the air to impact ozone concentrations on this day. A simplified illustration of the weather pattern is shown in Figure 59.

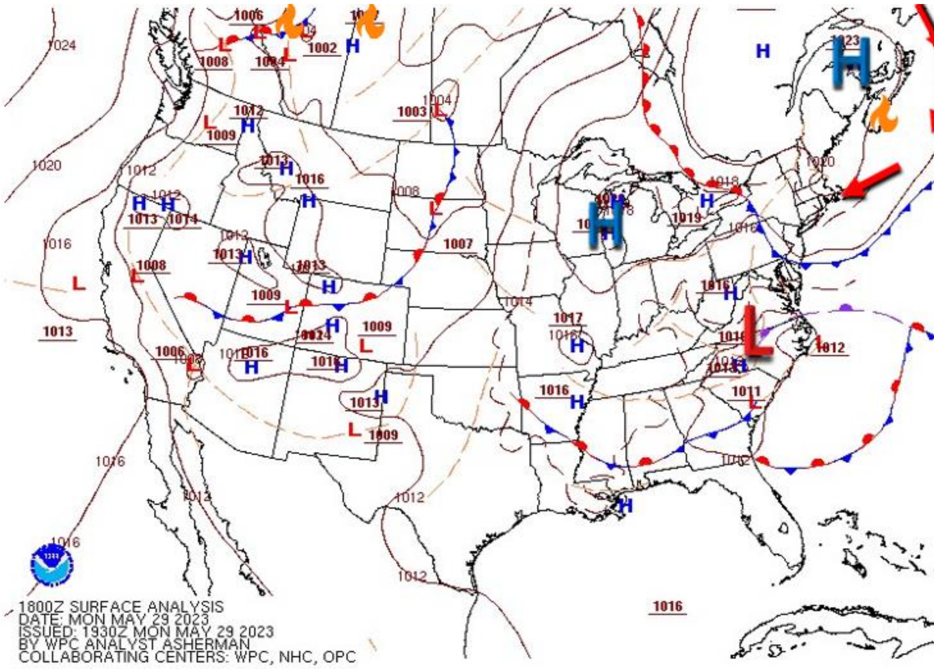
Figure 59: Simplified, Illustrated Conceptual Model Diagram of June 2, 2023, Wildfire Event



4.2 Surface Analysis – Transport & Wind Pattern

As stated in Figure 59 above, an intense burn started on May 6, 2023 in northwestern Canada allowing an expansive plume of smoke to travel across the country affecting ambient air quality levels in its path for several weeks. Beginning on May 29th, an area of low pressure located in the southeastern US provided partly sunny skies/patchy cloudiness/ and unsettled weather to the southern NJ nonattainment area. To the northeast, a strong area of high pressure (see Figure 60) was located near Nova Scotia and was advancing southward allowing a cold front draped across New Jersey to sink southward as the day progressed. Behind the cold front, clear skies, light winds, and temperatures reaching the mid-70s were noted, while breezy winds along the Nova Scotian coastline may have aided in transporting diffuse smoke during the early stages of the Nova Scotia fires toward the US East Coast. At this time, air was likely funneled or dispersed into New England and the Mid-Atlantic via northeast winds moving in a clockwise rotation around this area of high pressure.

Figure 60: Surface Analysis for May 29, 2023, 18UTC



The previously mentioned area of high pressure located near Nova Scotia continued to advance southward on Tuesday, May 30th (Figure 61) bringing with it sunny skies, light winds, and seasonal temperatures in the mid-70 to the remaining parts of the area. Meanwhile, a plume of dense smoke noted on satellite imagery (Figure 62) from fires burning in portions of northwestern Canada started to migrate southeastward from Saskatchewan and into northern portions of the Dakotas on the heels of an occluded front (purple line with halfmoons). At this time, this feature likely acted as a vehicle for wildfire smoke to penetrate southward while a surface trough was noted connecting multiple areas of low pressure across the Canadian provinces. This feature likely allowed smoke from fires a pathway to migrate closer to the surface.

Figure 61: Surface Analysis for May 30, 2023, 18UTC

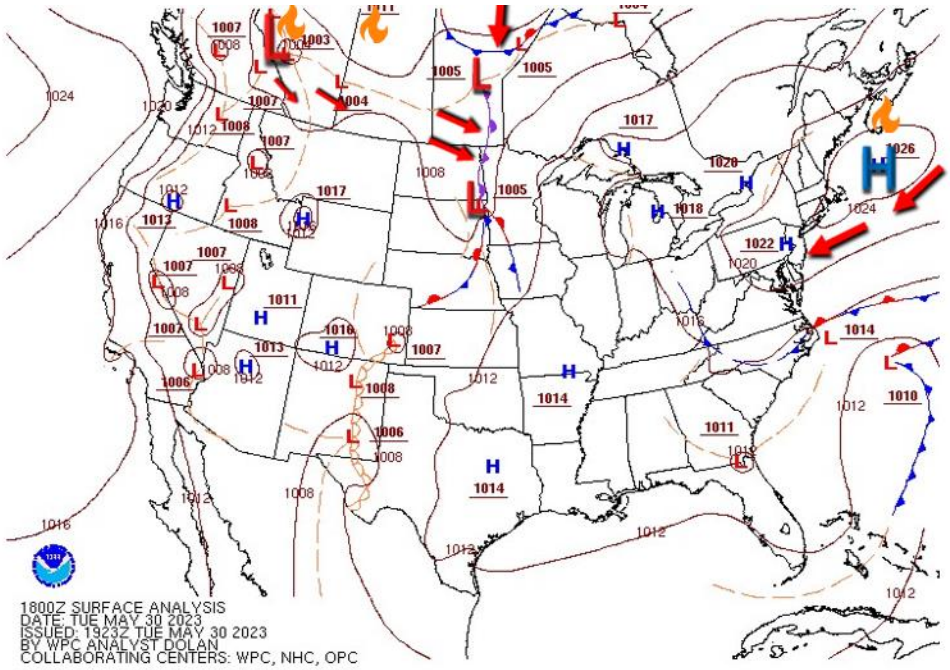
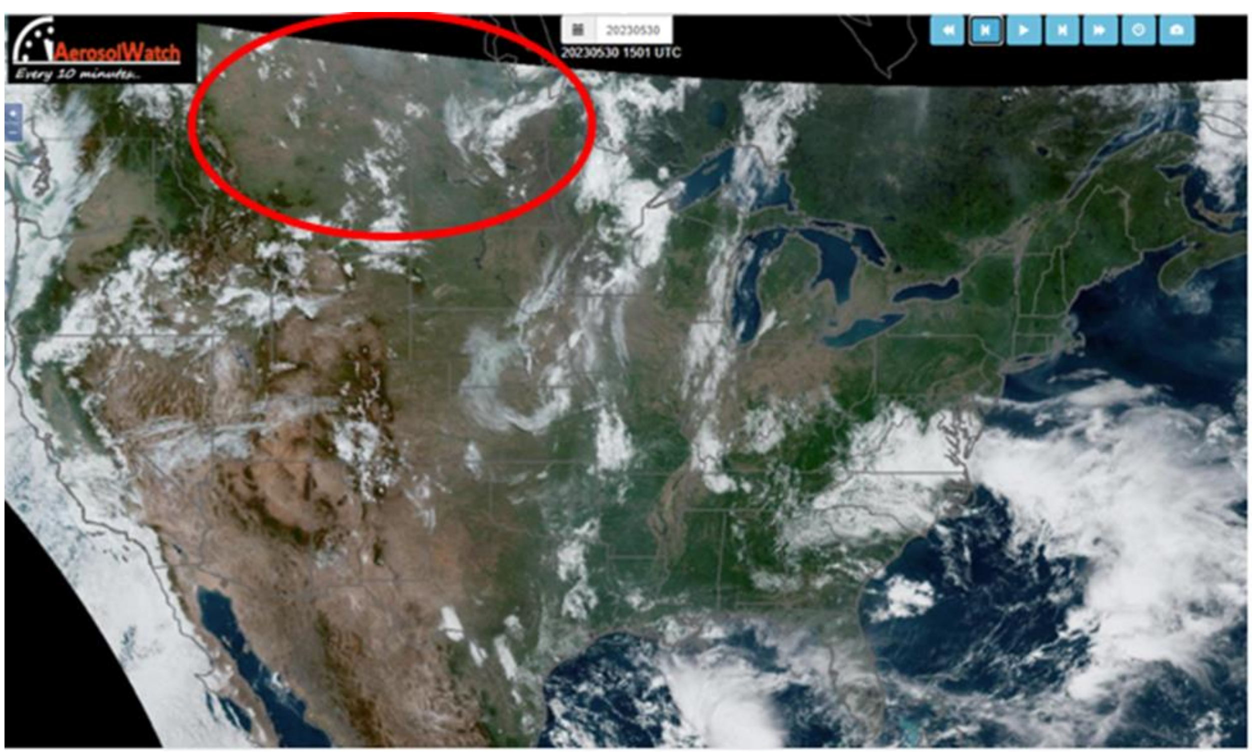


Figure 62: Aerosol Watch Satellite Imagery – May 30, 2023, 15UTC



As wildfire smoke from northwestern Canadian fires tracked eastward across the United States, it briefly lingered between two air masses near the northern Plains on Wednesday, May 31st (circled in red; Figure 63 and Figure 64) where winds were very light leading to more gradual smoke progression. Upon reaching the Plains, this smoke was transported northeastward around the northwestern periphery of high pressure where it was met with favorable conditions for ozone formation including light winds and warm temperatures reaching the upper 80s in the Plains and Great Lakes regions. While smoke from northwestern Canadian fires continued to migrate eastward, fires in Nova Scotia continued to burn while high pressure remained anchored over the northeast US. As a result, very light winds under the center of high pressure in the New Jersey, Pennsylvania, and Maryland area, allowed Nova Scotian wildfire smoke to linger where winds were calm and light. In addition, a small wildfire broke out over southern New Jersey impacting monitors southwest of the fire. Widespread moderate ozone concentrations across the Mid-Atlantic were observed on this day despite temperatures only reaching the upper 70s – low 80s.

Figure 63: Surface Analysis for May 31, 2023, 18UTC

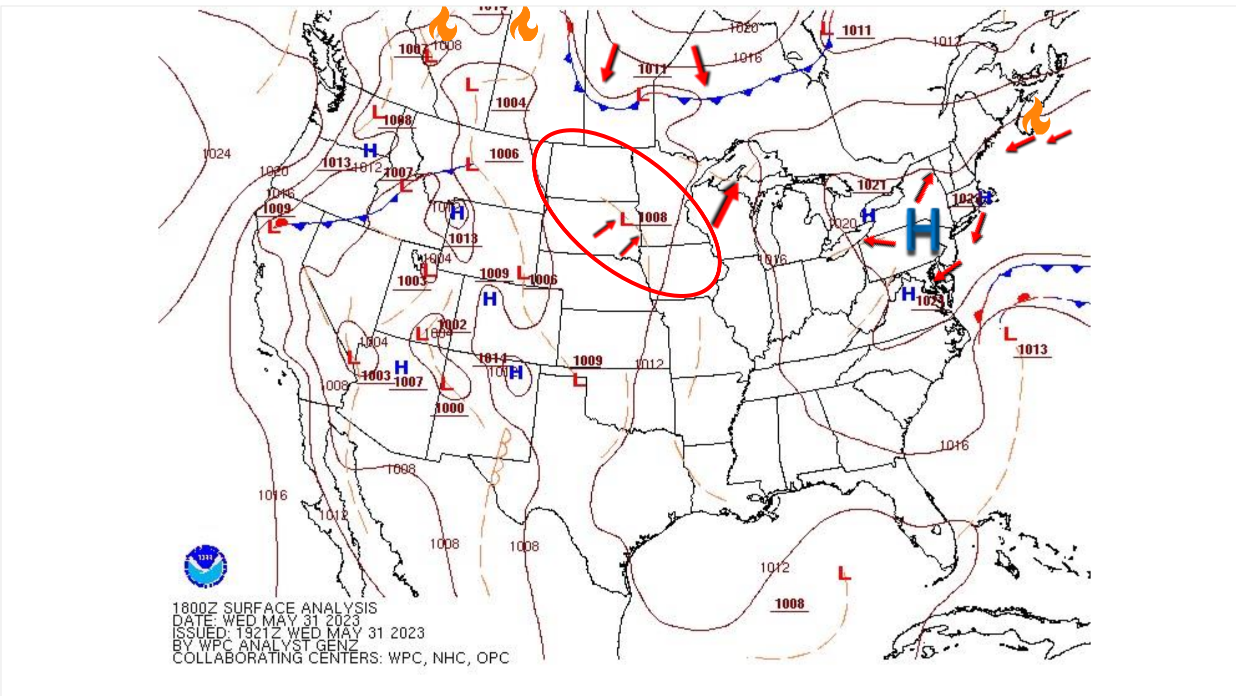
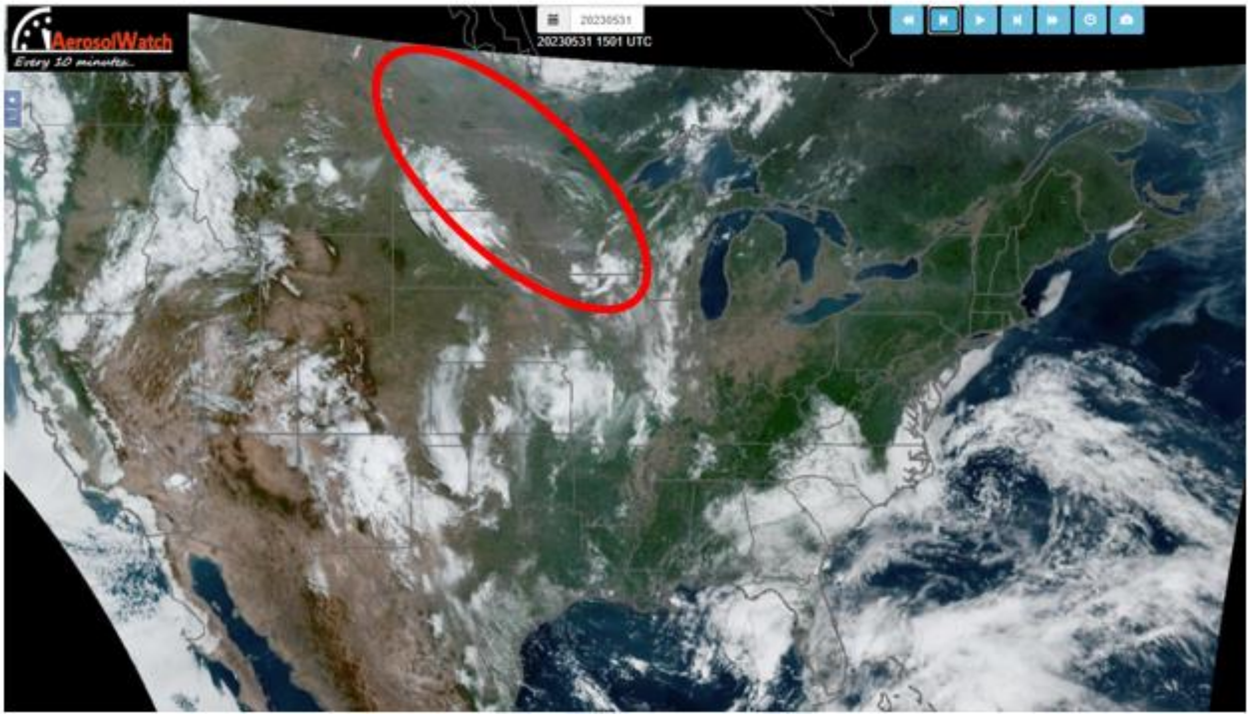


Figure 64: Aerosol Watch Satellite Imagery – May 31, 2023, 15UTC



By Thursday, June 1st, the day before the event, smoke from Nova Scotian fires continued to linger around the Mid-Atlantic region (Figure 65) while the wildfire in southern New Jersey continued to burn and travel downwind through southern New Jersey, and into Delaware and Maryland on the heels of light northeasterly surface winds. Meanwhile, diffuse smoke from Northwestern Canadian fires started to wrap around the northeastern periphery of high pressure near southern Ontario and the Great Lakes. Multiple high-pressure centers developed across the eastern US, providing the smoke a pathway between airmasses to migrate southward through New England and the Mid-Atlantic (Figure 66).

Figure 65: Aerosol Watch Satellite Imagery – Early Morning East Coast June 1, 2023, 11UTC

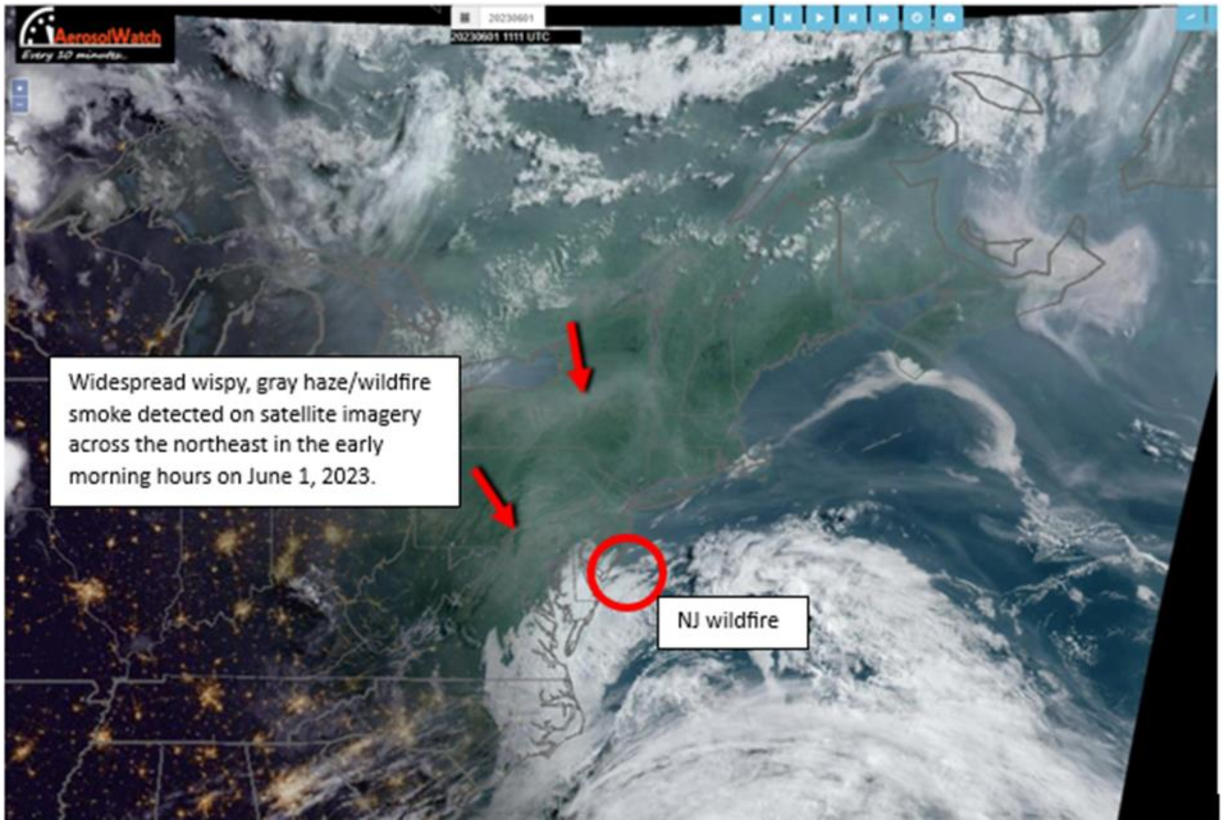
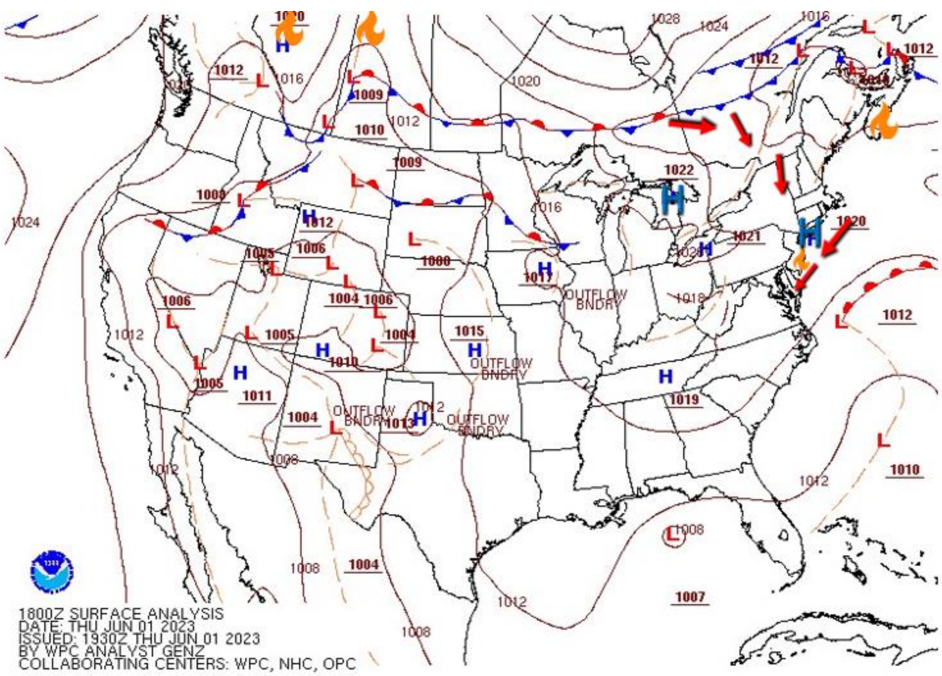


Figure 66: Surface Analysis for June 1, 2023, 18UTC



On June 2nd, widespread ozone exceedances occurred across the Mid-Atlantic due to favorable meteorological conditions in combination with residual wildfire smoke. In the days leading up to this ozone exceedance event, strong high pressure had remained in control of the weather across the Northeast, allowing for light/variable winds, sunny skies, and increasing temperatures soaring into the low 90s on this day. By mid-morning on June 2, a surface trough developed across the nonattainment area (Figure 67) allowing residual wildfire smoke (Figure 68) from northwestern Canada and Nova Scotia to mix down to the surface and increase ozone concentrations. Meanwhile, smoke from a wildfire in southern New Jersey exacerbated these conditions and enhanced the presence of wildfire smoke at ground level. As a result, ozone concentrations were able to spike into the unhealthy and unhealthy for sensitive groups (USG) category at many locations across the nonattainment area on this day.

Figure 67: Surface Analysis for June 2, 2023, 18UTC

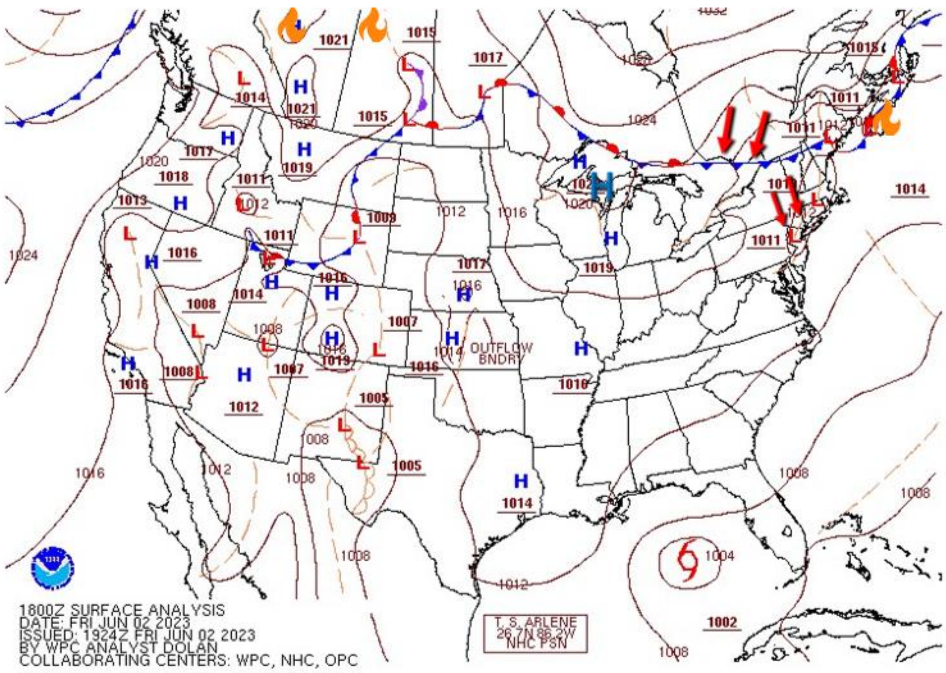
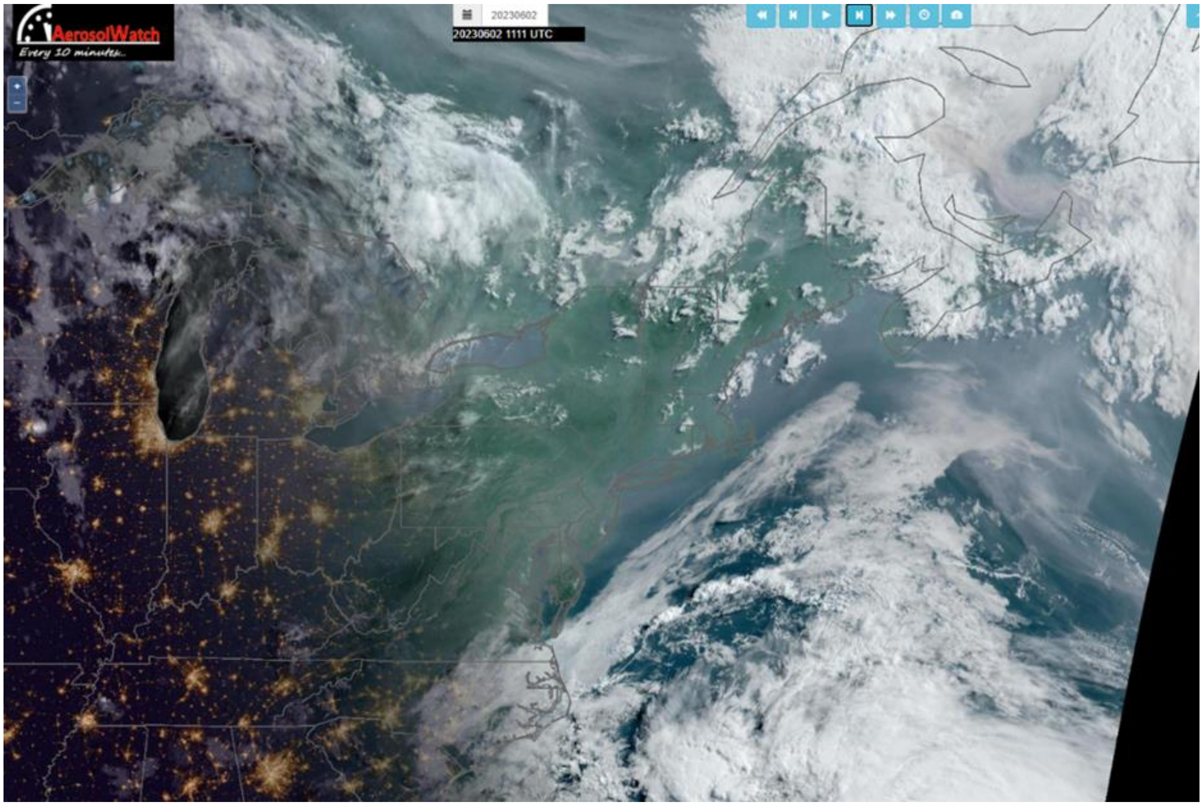


Figure 68: Aerosol Watch Satellite Imagery – Early Morning East Coast June 2, 2023, 11UTC



4.3 Upper Air Analysis

Similar to the previous section, this section will provide an upper air analysis occurring at the 850 millibar (mb) level (approximately 1500 m above sea level). This upper air level sits near the top of the planetary boundary layer (PBL), the atmospheric layer in which ozone pertinent to surface observations and human health develops, and so can serve as a guide for the transport of pollutants. The analysis of this atmospheric level is given for May 29 - June 2, in Figure 69–Figure 73 below.

Wildfire smoke remained trapped within the slowly moving clockwise flow around the center of high pressure in the days leading up to the exceedance event on June 2nd. The previously mentioned cold front approached the Mid-Atlantic from the north on May 29, and was draped across New Jersey. By May 30, the cold front passed through and was able to bring an airmass laden with smoke across the region. This occurred as continued presence of high pressure west of the Mid-Atlantic started to “arc” smoke from within or west of the high pressure through Canada, and then southwards towards the Mid-Atlantic region. The persistent pattern delivered diffuse smoke to New Jersey by May 30, with weak but northeasterly flow with subsidence behind the front bringing the smoke to the surface. Northeast flow continued on May 31 with the center of high pressure strengthening, although not moving (Figure 71).

Between May 29 and May 31, winds between Nova Scotia and New Jersey were favorable for transport of smoke from that region to the Mid-Atlantic. Smoke from the Nova Scotia fires was caught in the transport behind the cold front and northeasterly winds present on May 30 - 31 would have delivered smoke from that fire to New Jersey beginning May 31 to June 1. On June 1, the center of high pressure had strengthened further, but moved westward to over southern Ontario (Figure 72Figure 15). Northeast flow at 850mb continued on June 2, resulting in similar conditions as June 1 with ozone exceedances in the smoky air (Figure 73).[79]

Figure 69: 850mb Upper Air Analysis, May 29, 2023

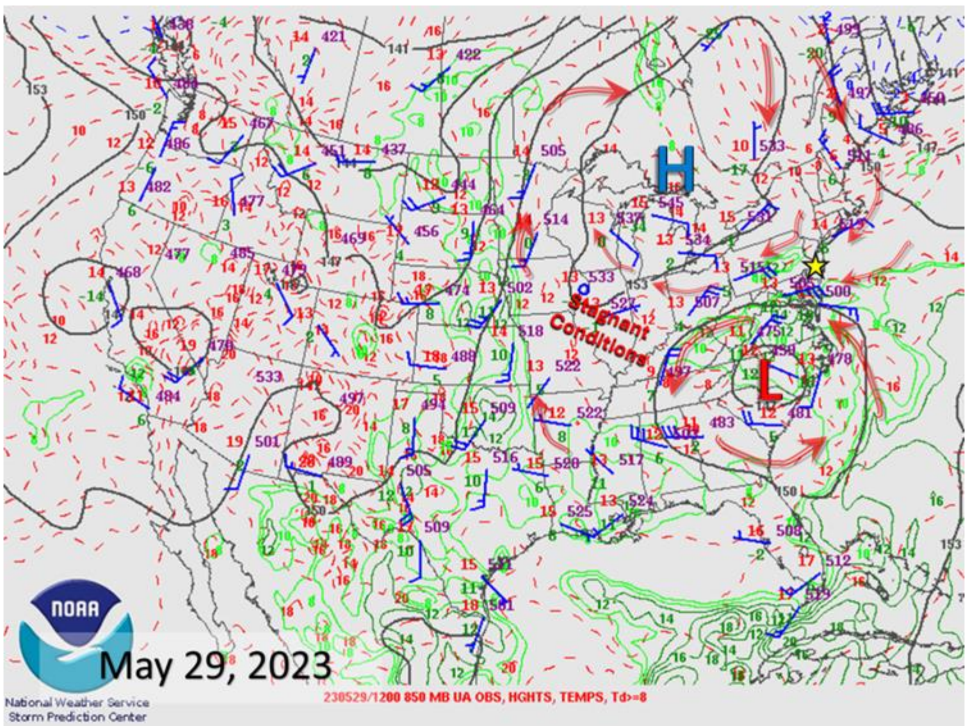


Image courtesy of Maryland Department of the Environment

[79] MDE. (2023). *Exceptional Event Demonstration and Analysis of the West-Central and Nova Scotia, Canada and New Jersey Wildfires' Impact on Maryland's Ozone Air Quality on June 2, 2023*. https://mde.maryland.gov/programs/air/AirQualityMonitoring/Documents/ExceptionalEvents/MDE_Ozone_EE_Demo_2023_June_2.pdf

Figure 70: 850mb Upper Air Analysis, May 30, 2023

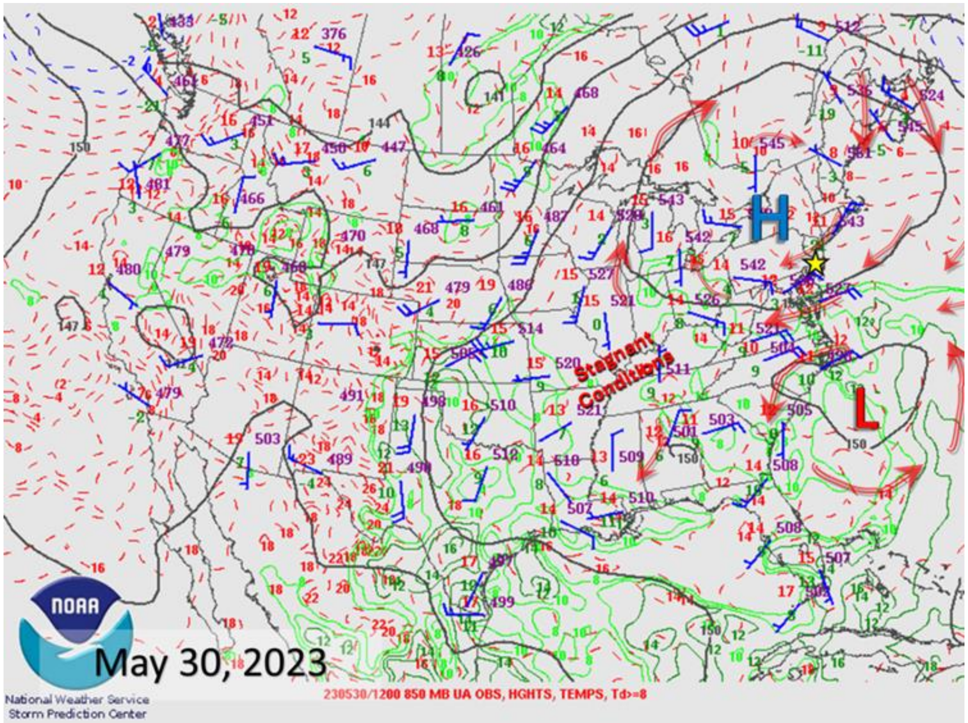


Image courtesy of Maryland Department of the Environment

Figure 71: 850mb Upper Air Analysis, May 31, 2023

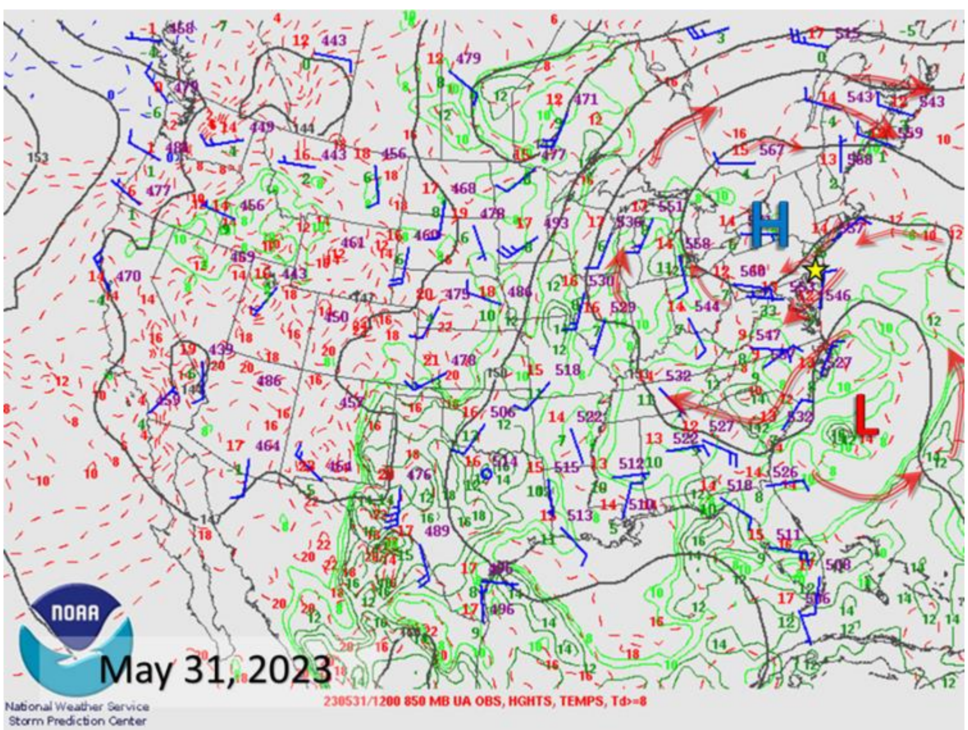


Image courtesy of Maryland Department of the Environment

Figure 72: 850mb Upper Air Analysis, June 1, 2023

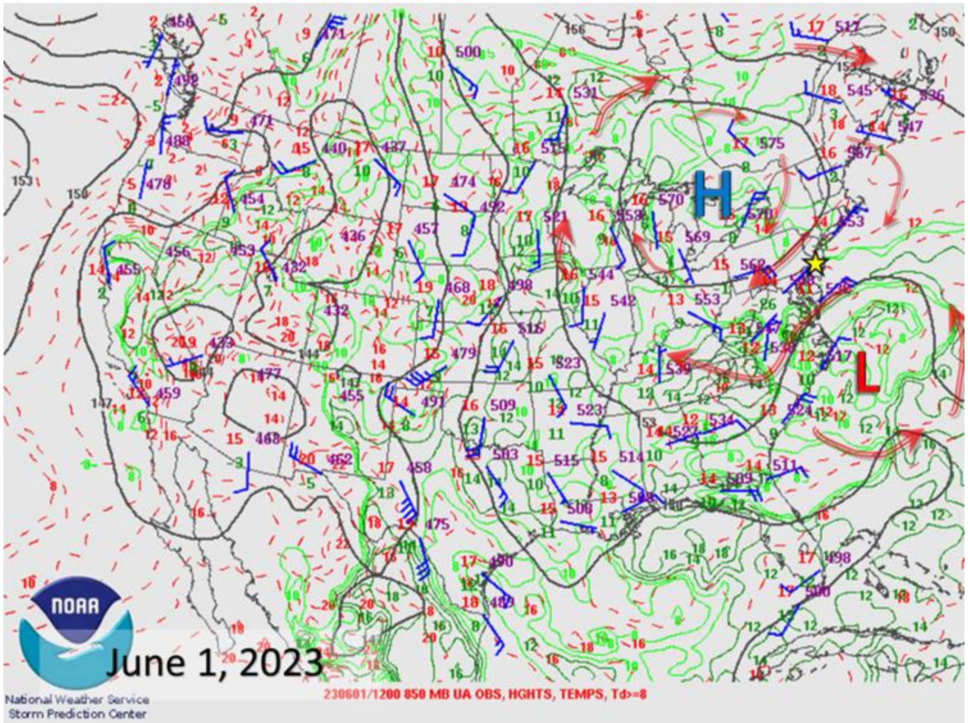


Image courtesy of Maryland Department of the Environment

Figure 73: 850mb Upper Air Analysis, June 2, 2023

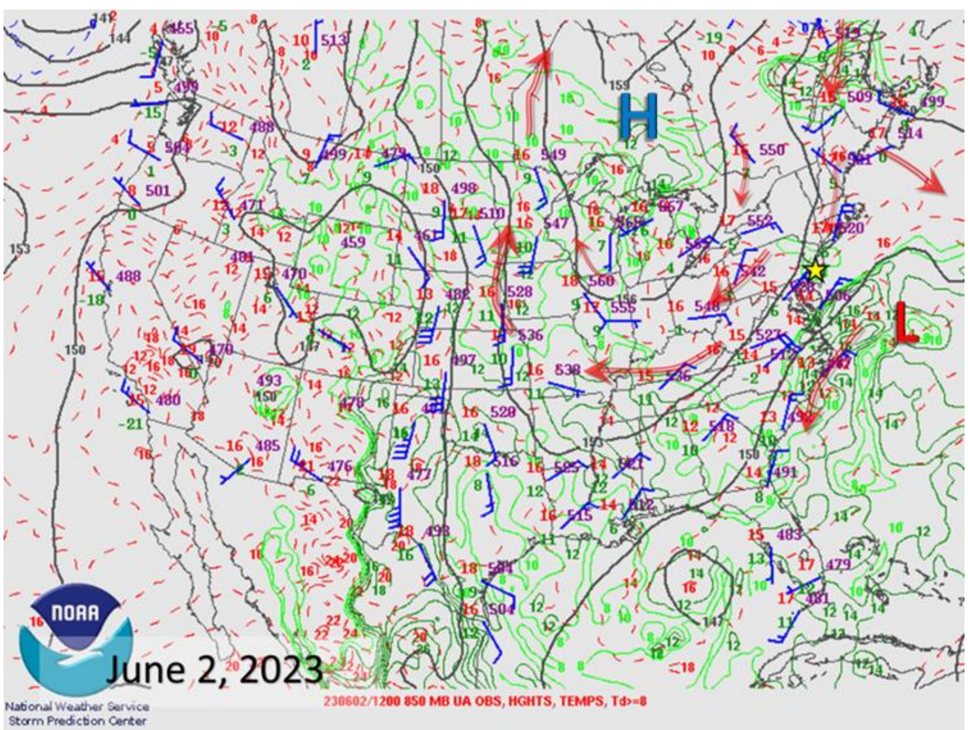


Image courtesy of Maryland Department of the Environment

4.4 Aerosol Optical Depth

Figure 74- Figure 78 show aerosol optical depth (AOD) in the weeks leading up to this high ozone exceedance event on June 2, 2023. AOD is a measure of smoke in the atmosphere that is blocking sunlight. Therefore, it is a helpful indicator of wildfire smoke and how much direct sunlight is prevented from reaching the ground by aerosol particles. "A value of 0.01 corresponds to an extremely clean atmosphere (dark blue) and a value of 0.4 would correspond to a very hazy condition".[80]

In the following images, AOD is indicated by the color scale from cool tones (blue) to warm tones (red), which represents a scale from 0.0 to 1.0. The color black represents no data or where clouds may have been blocking a measurement from being taken. In some cases, the highest values of AOD are also blocked by sunlight and therefore a conclusion cannot be made about the quantity of smoke/particles in that region. In the images, New Jersey is circled in yellow.

Figure 74 shows the initial progression of heavy wildfire smoke beginning on May 21, 2023, through May 24, 2023, migrating across the country. The progression during these initial days shows how the plume splits into two pathways. An optically dense smoke plume of this magnitude can block enough sunlight to limit ozone formation at the surface. However, in Figure 75, which includes Air Quality Index (AQI) levels at the various monitors on the satellite image, the presence of ozone exceedances occurring in the northern plains (as indicated by the orange and red dots relating to Unhealthy for Sensitive Groups and unhealthy AQI levels, respectively) shows that the smoke plume was immediately capable of producing and enhancing levels of ozone along its pathway.[81]

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[80] NOAA. (n.d.). *SURFRAD Aerosol Optical Depth*. Global Monitoring Laboratory: Earth System Research Laboratories. Retrieved December 13, 2023, from https://gml.noaa.gov/grad/surfrad/aod/#:~:text=Aerosol%20optical%20depth%20is%20a,ground%20by%20these%20aerosol%20particles

[81] MDE. (2023). *Exceptional Event Demonstration and Analysis of the West-Central and Nova Scotia, Canada and New Jersey Wildfires' Impact on Maryland's Ozone Air Quality on June 2, 2023*. https://mde.maryland.gov/programs/air/AirQualityMonitoring/Documents/ExceptionalEvents/MDE_Ozone_EE_Demo_2023_June_2.pdf

Figure 74 a-d): Aerosol Optical Depth May 21 – 24, 2023 (left to right, top to bottom)

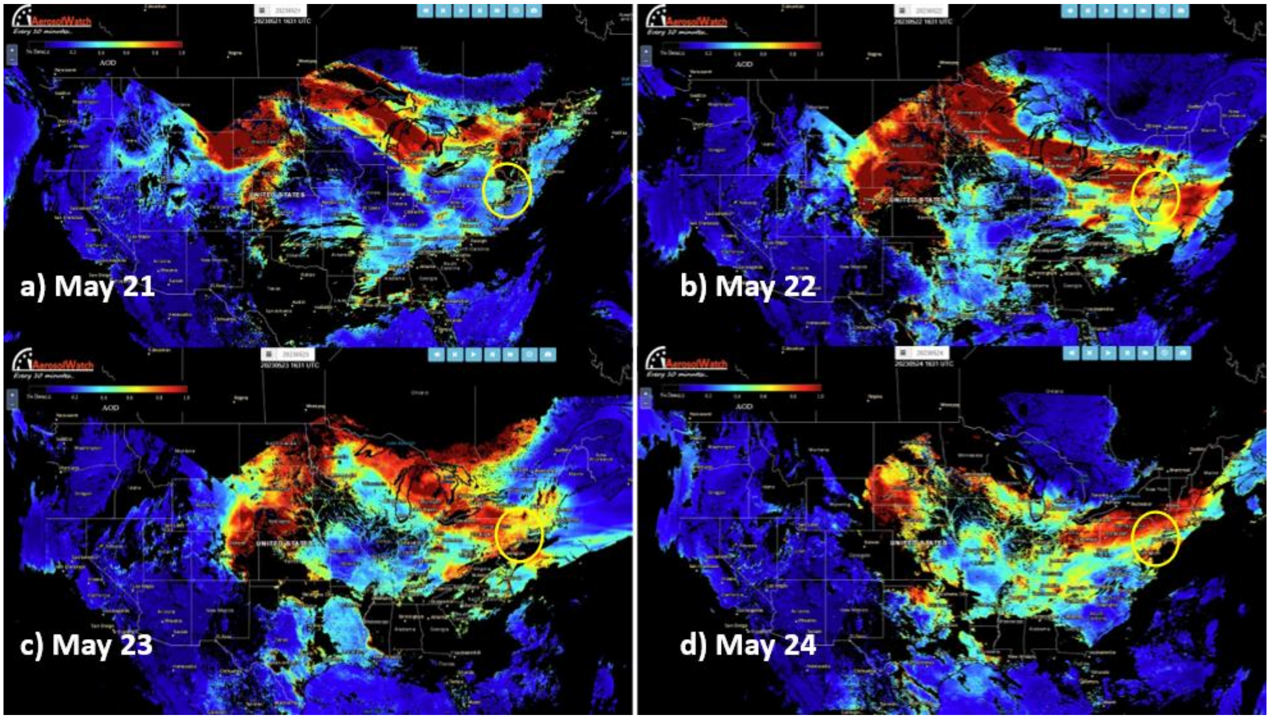


Figure 75: GOES Satellite Imagery of Smoke Plume with Surface Ozone Concentrations on May 21, 2023

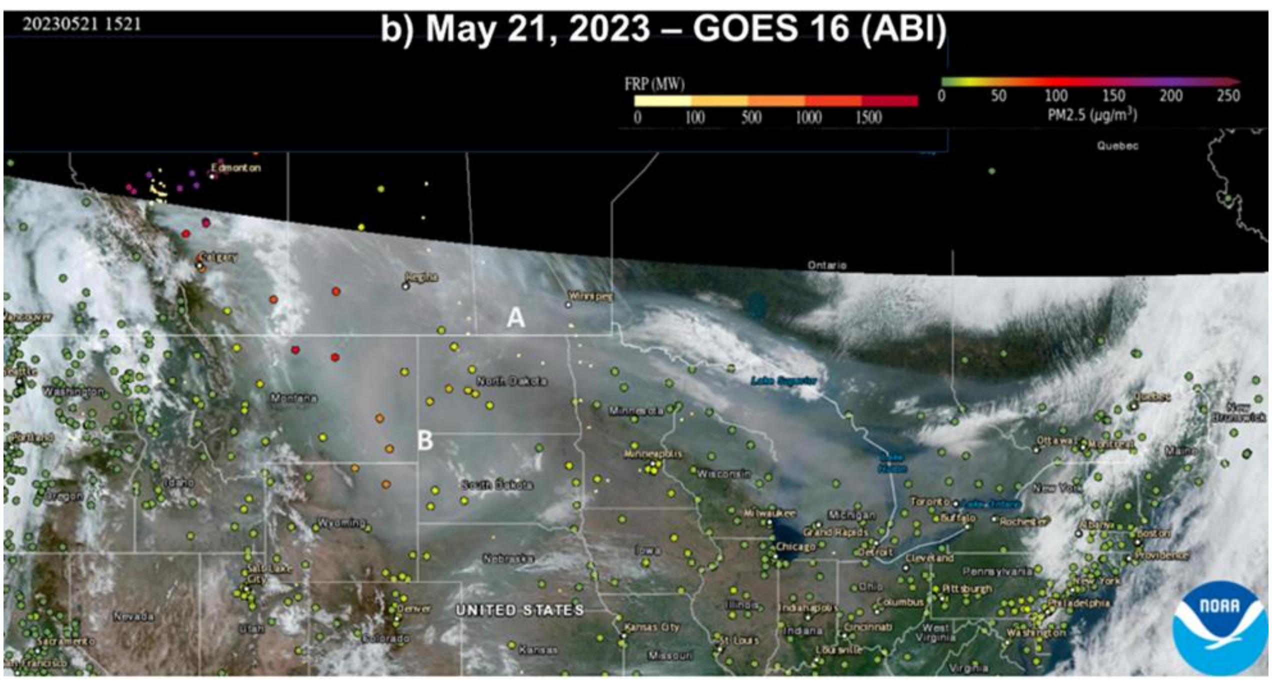
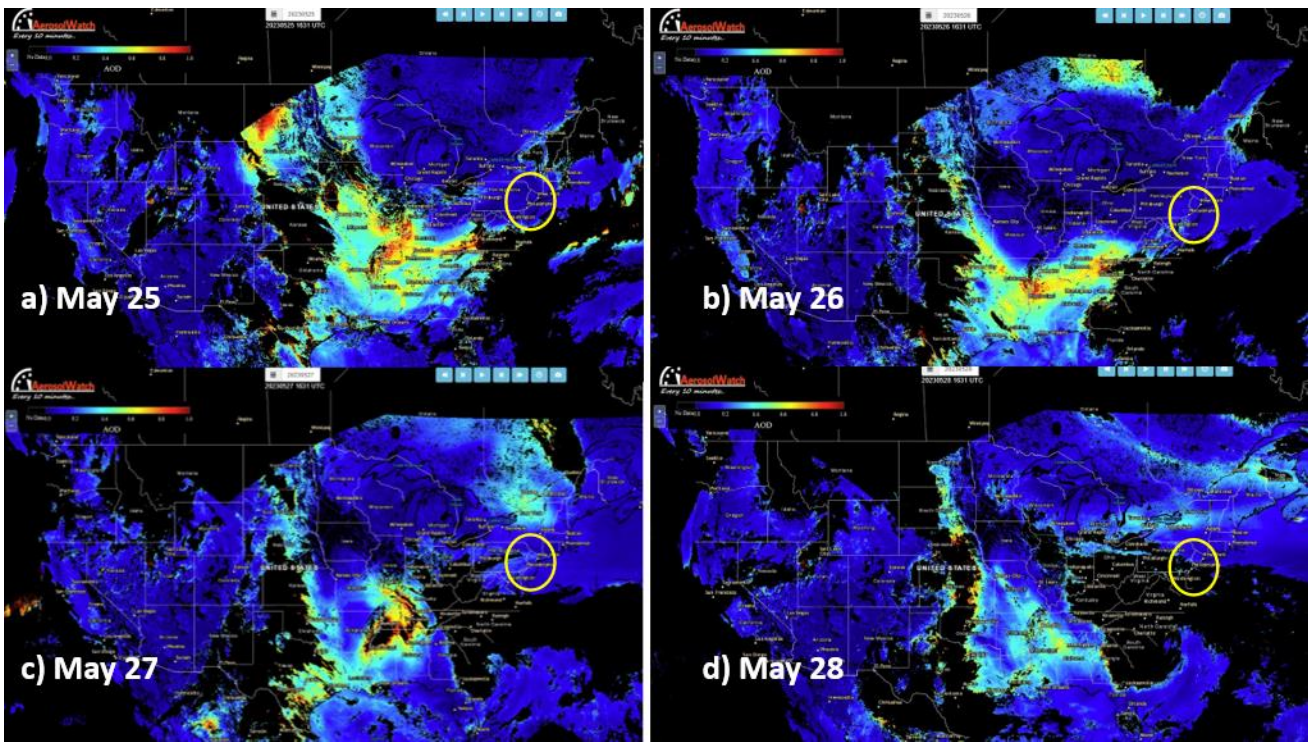


Image source: MDE, June 2, 2023, Exceptional Event Demonstration

By May 25, 2023, the heavy smoke plume dissipated and the wildfire smoke in the atmosphere aged as it interacted with other pollutants. The northern portion of the plume progressed northward into Canada while the southern leg dissipated and migrated southward in the following days to May 28. (See Figure 76 a-d). It should be noted that "the GOES observable domain does not extend beyond southern Canada due to the viewing angle becoming too low and parallax correction too great from the geosynchronous satellite." As a result, the extent of the northern plume into Canada is uncertain but moving in a clockwise rotation around high pressure (which is centered near the Great Lakes region). This is shown in the progression of images from Figure 76 a on May 25 compared to Figure 76 d on May 28.[82]

In the following days, May 26th - 28th, (Figure 76 b-d), the northern extent of the smoke plume continued to wrap around the periphery of high pressure while the southern portion migrated through the central and southern United States. Here, a pattern develops connecting the location of the smoke plume with ozone exceedances occurring at the ground level. This connection will be discussed in further detail in the next section (Daily Ozone AQI Maps). On May 28th (Figure 76 d), smoke from fires burning in Nova Scotia appear on AOD images.

Figure 76 a-d: Aerosol Optical Depth May 25 – 28, 2023



In the days leading up to this high ozone exceedance event, May 29 – June 1 (Figure 77), the aged plume of wildfire smoke from Canada began to make its way into the northeast while nearby fires in Nova Scotia and New Jersey ramped up. On May 31st (Figure 77 c) a buildup of smoke developed across New Jersey (turquoise color) likely from Nova Scotia fires and local fires leading to a slow accumulation of wildfire smoke from multiple sources.

[82] Ibid.

By June 1st the dispersed smoke plume that traveled northward into Canada started to make its way southward through New England (noted by the turquoise color in Figure 77 d. On this day, the impacts of the Nova Scotia fire become more apparent.

Figure 77 a-d: Aerosol Optical Depth May 29, 2023 – June 1, 2023

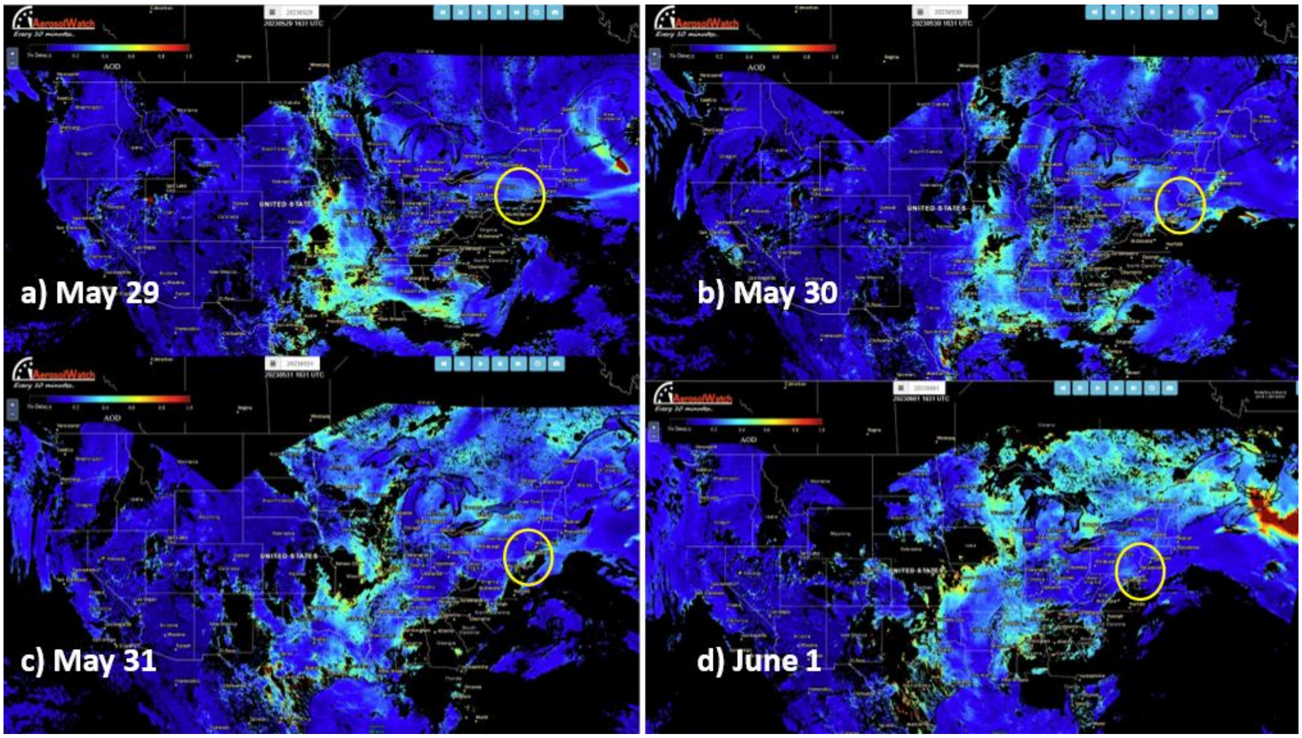
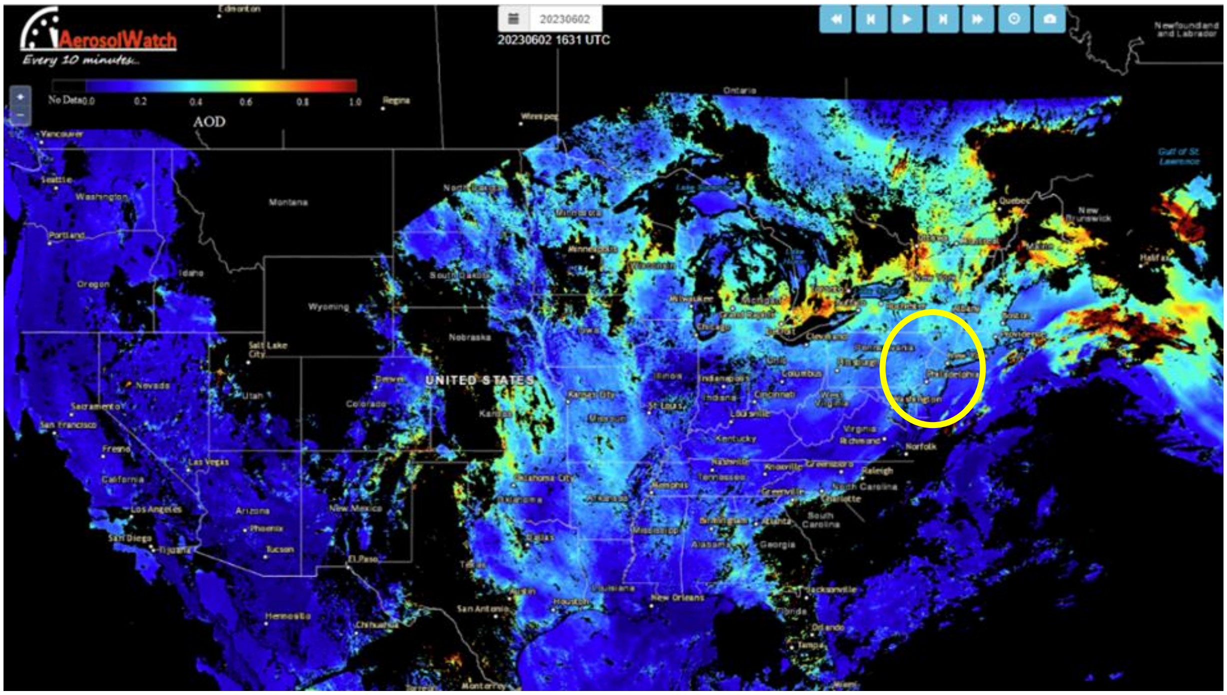


Figure 78 shows the optical depth of the smoke plume as it made its way southward from eastern Canada/New England. At this time, the plume had diffused as it aged while interacting with other pollutants. The combination of the wildfire smoke age, the plume's initial ability to enhance ozone concentrations, and the contribution from multiple wildfire sources all contributed to the ozone exceedances observed on June 2nd, 2023.

Figure 78: Aerosol Optical Depth June 2, 2023



4.5 Daily Ozone AQI Maps

The following images (Figure 79-Figure 83) show Daily Air Quality Index (AQI) levels observed across the continental United States during the days leading up to and including the exceptional event occurring on June 2, 2023. In the images, an exceedance of the ozone standard (70 ppb) is represented by the colors red and orange. The color red signifies Unhealthy ozone levels where the concentrations of ozone (86 – 105 ppb) can begin to have adverse effects on the general population. The color orange shows where ozone concentrations (71 – 85 ppb) reached levels that are Unhealthy for Sensitive Groups (USG), such as asthmatics and the elderly. Yellow represents Moderate ozone (55 – 70 ppb) and air quality is acceptable at this level except for those that are unusually sensitive. Green represents Good ozone levels (0 – 55 ppb) and pose little risk.

In the following five AQI images, surface level ozone concentrations follow the same pattern as shown in the above AOD images. This indicates that ozone AQI was influenced along the wildfire smoke plume pathway as it traveled across the United States, especially in the final five days of transit shown below. On May 29, (Figure 79) widespread moderate and USG ozone levels were located over the Mid-West and portions of the Great Lakes. In the following days, (Figure 80-Figure 82) as the smoke plume wrapped around the periphery of high pressure and made its way into eastern Canada and New England on June 1, ozone concentrations observed in this region were elevated when the smoke plume was present in this location as indicated by increased AOD values and increased AQI concentrations in the same area. By June 2, (Figure 83) AQI concentrations increased into the Unhealthy category.

Figure 79: Daily AQI May 29, 2023

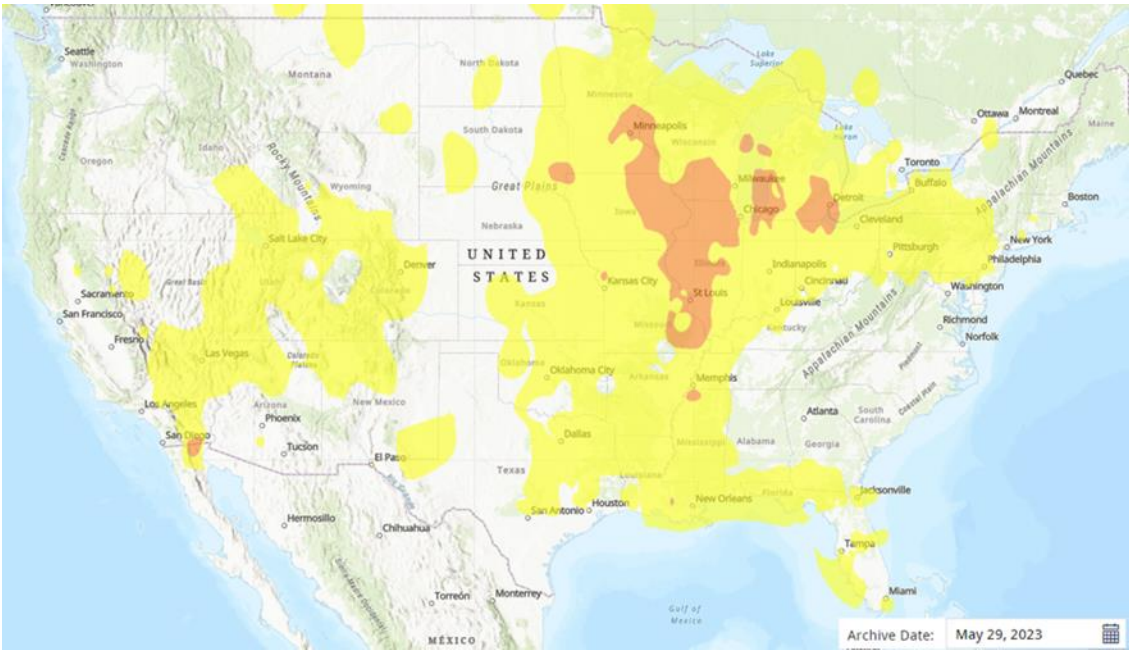


Figure 80: Daily AQI May 30, 2023

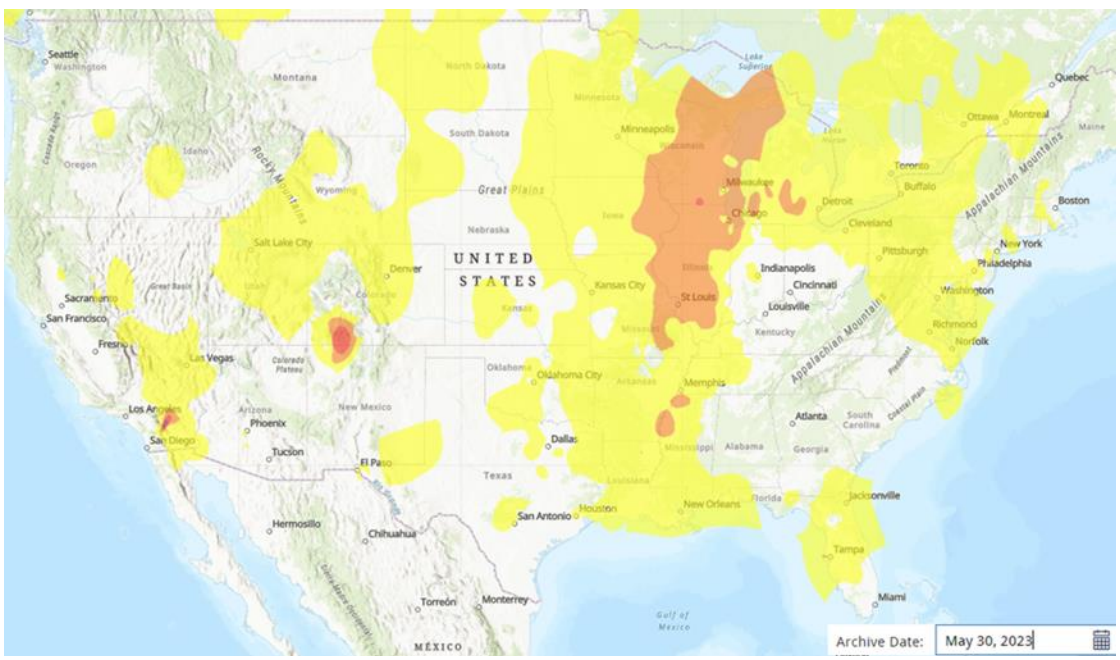


Figure 81: Daily AQI May 31, 2023

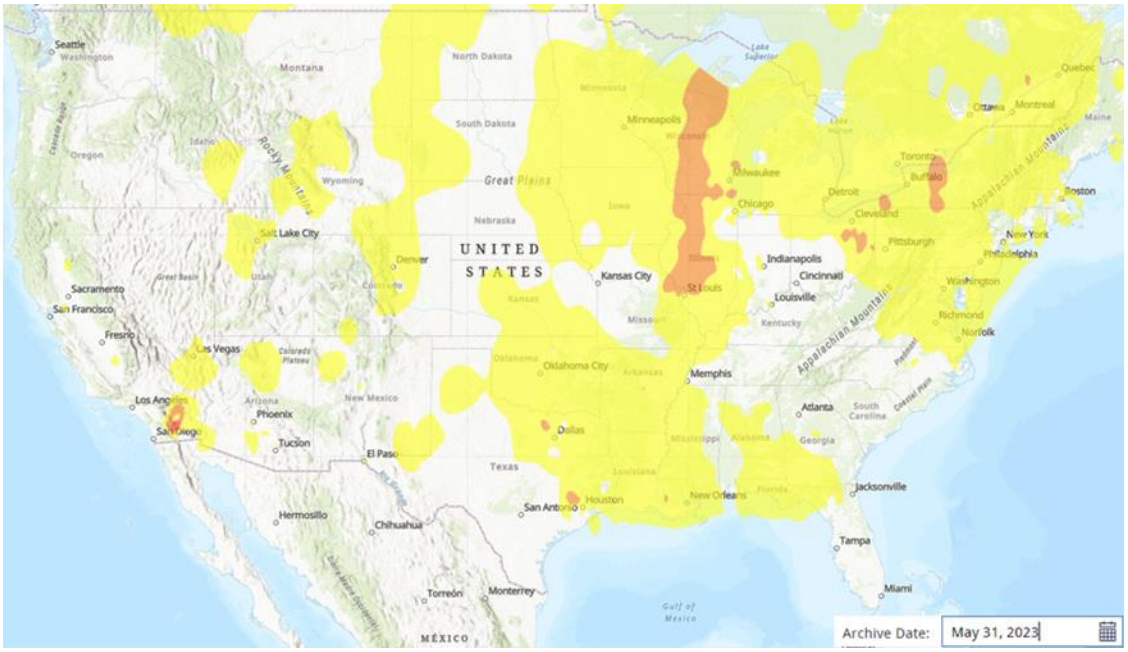


Figure 82: Daily AQI June 1, 2023

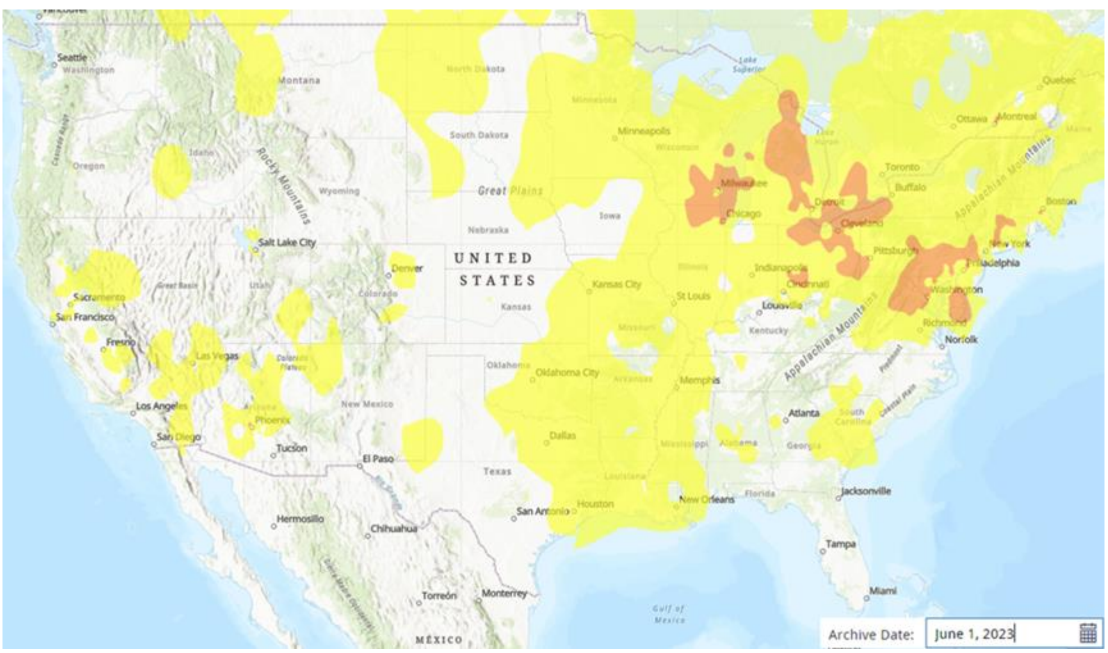
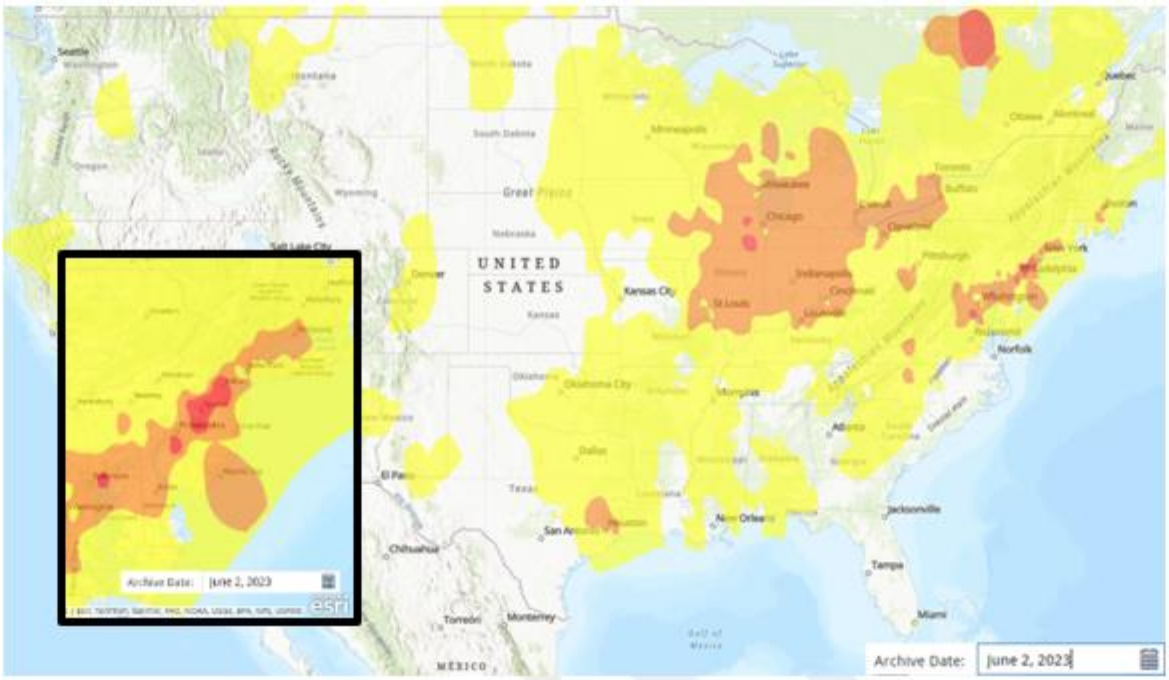


Figure 83: Daily AQI June 2, 2023



II. A Demonstration That the Event Affected Air Quality in Such a Way That There Exists a Clear Causal Relationship Between the Specific Event and the Monitored Exceedance or Violation

The Exceptional Events Rule demonstrations are required to address the technical element and implicit concept of CAA 319(b) that "the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation"[83]. Demonstrations are required to support the clear causal relationship by a comparison of the ozone data requested for exclusion with historical concentrations at the air quality monitor. For a Tier 2 analysis, it needs to be demonstrated that the wildfire event's ozone influences are higher than non-event related concentrations, as well as consider the fire's distance from the affected monitor(s) to indicate a clear causal relationship.[84]

The June 2, 2023, event serves as an example of how smoke can affect air quality in the region. The evidence presented in this report compliments the conceptual model in section 1 and shows that smoke impacted air quality in New Jersey and caused higher-than-normal ozone concentration levels, which resulted in the ozone exceedances on June 2.

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[83] 40 CFR 50.14(c)(3)(iv)(B)-(C).

[84] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

The analyses presented in this section include the requirements of a Tier 2 analysis, as well as a Tier 3 weight of evidence component. The Tier 2 and Tier 3 analyses consist of comparisons to historical concentrations, Q/d analysis, analysis of the 99th percentile or higher of the 5-year distribution of ozone monitoring data, analysis of the four highest ozone concentrations within one year, trajectory analysis, satellite evidence, evidence of spatial/temporal patterns of ozone and/or NOx, changes in supporting ground level measurements, visibility impacts, and similar day analysis. These analyses demonstrate that smoke transport caused elevated levels of ozone which resulted in the exceedances at New Jersey monitors on June 2, 2023.

1. Comparison Between Ozone Data Requested for Exclusion with Historical Concentrations

The comparison of monitored concentrations with historical observations is used to demonstrate a clear causal relationship between ozone concentrations and a fire event. To do so, it is necessary to compare the event-related exceedance with historical concentrations measured at the affected monitor or at other monitors in the area during the same season.[85] According to USEPA Guidance, monitored observations at or above the 99th percentile in the past five years from the event-related ozone concentration can be used to establish statistical evidence that the event was likely influenced by an exceptional event.[86] The NJDEP has officially certified the ozone data presented in this analysis, which includes the 2023 ozone season data.[87]

Scatter plots of the daily maximum 8-hour ozone concentrations at the three New Jersey monitors included in the exclusion request for June 2, 2023, show that all three sites uncharacteristically exceeded the 70 ppb ozone NAAQS, highlighting the exceptional nature of the event. See Figure 84 through Figure 91. The daily maximum concentrations recorded on June 2 at two of the three monitors, Camden Spruce St. (340070002) and Clarksboro (340150002), were the highest concentrations recorded by these stations during the 5-year period. Rider University (340210005) also recorded its highest ozone concentration in the last 5 years and the highest concentration in the New Jersey portion of the nonattainment area in 2023 on June 2, 2023.

Each monitor's ozone data from March 1, 2019, through October 31, 2023, were plotted against that monitor's multi-season 99th percentile. The data for periods outside of the ozone season (November 1 through February 28/29) for the intervening years are not included in the plots. A dotted line indicates the level of the 99th percentile concentration for each plot. Concentrations from June 2, 2023, and the other Exceptional Event dates in 2023, are highlighted in each plot as a red mark.

Table 9 presents the ranking, from 2019 to 2023, of the data requested for exclusion on June 2, 2023, at each monitor.

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[85] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[86] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[87] Certification Letter for 2023 Oozne Monitoring Data (December 18, 2023). See Appendix 3.

Table 9: 2019 to 2023 Ranking of Data Requested for Exclusion on June 2, 2023, at Each Monitor

AQS Code	Site Name	Ozone Concentration (ppb)	Annual Ranking (%)
340070002	Camden Spruce St	81	99.9
340150002	Clarksboro	89	99.9
340290006	Colliers Mills	74	99.4

Figure 84: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Camden Monitor

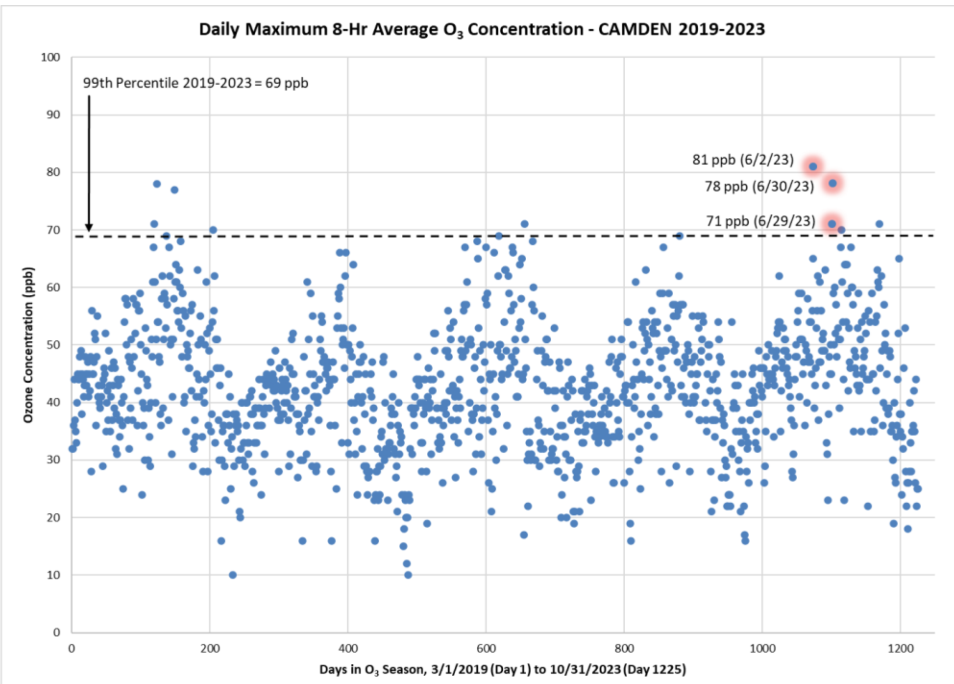


Figure 85: Camden Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

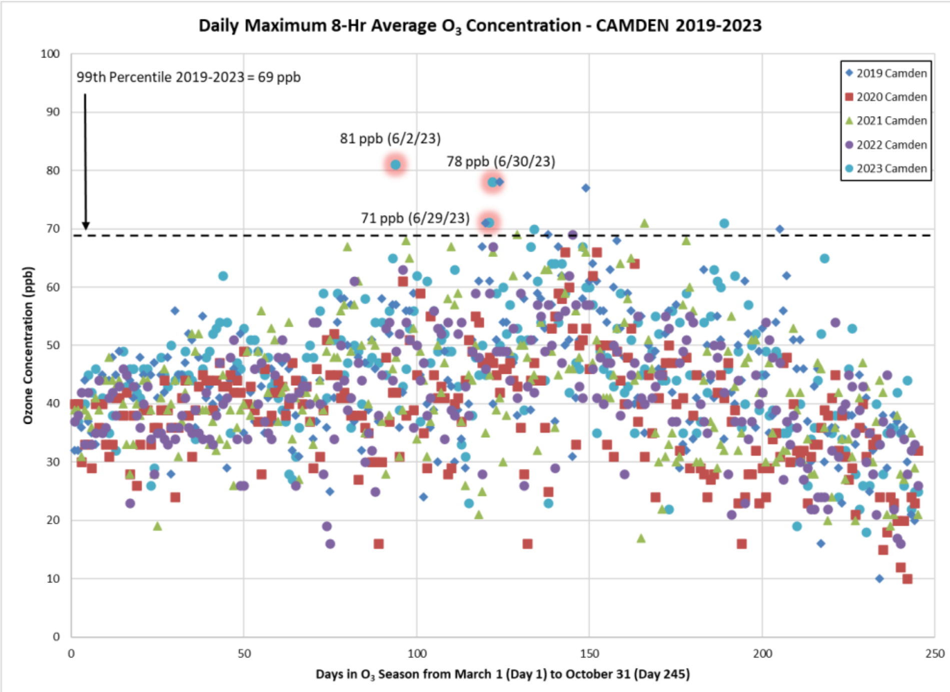


Figure 86: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Clarksboro Monitor

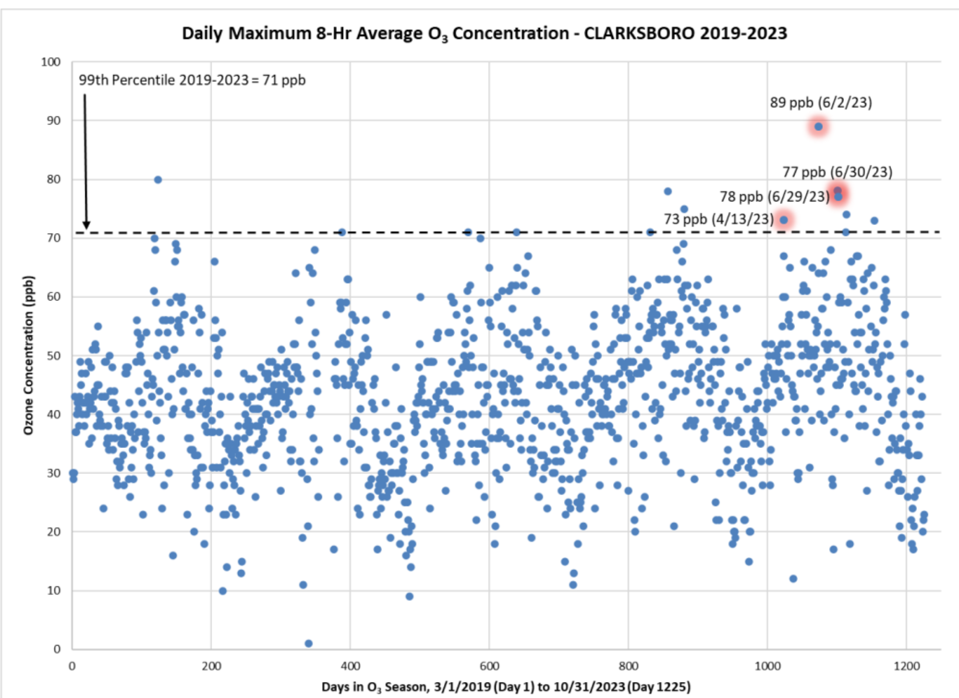


Figure 87: Clarksboro Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

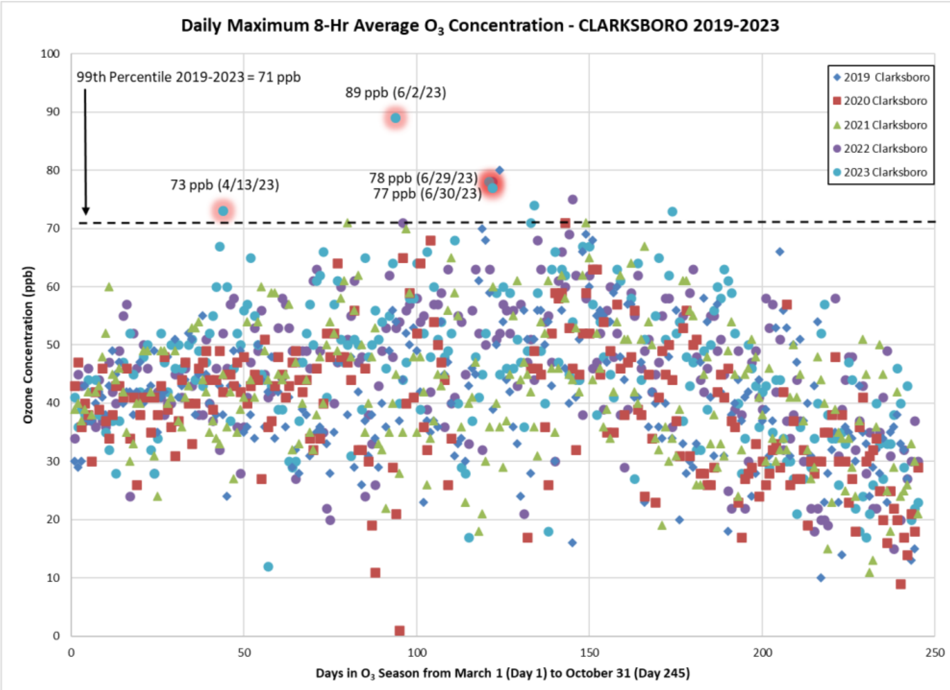


Figure 88: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Colliers Mills Monitor

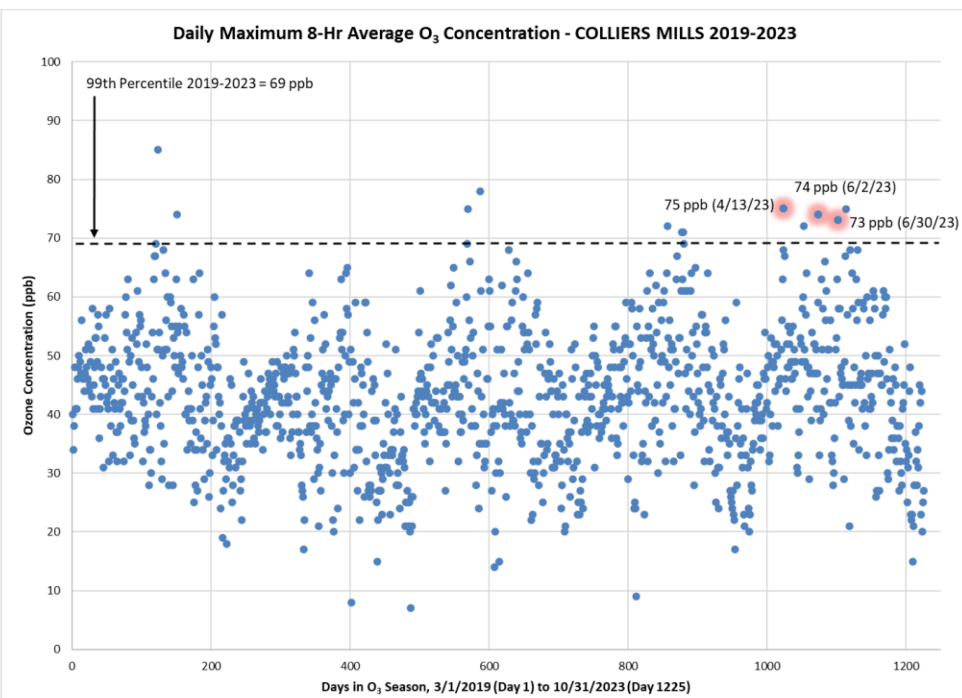


Figure 89: Colliers Mills Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

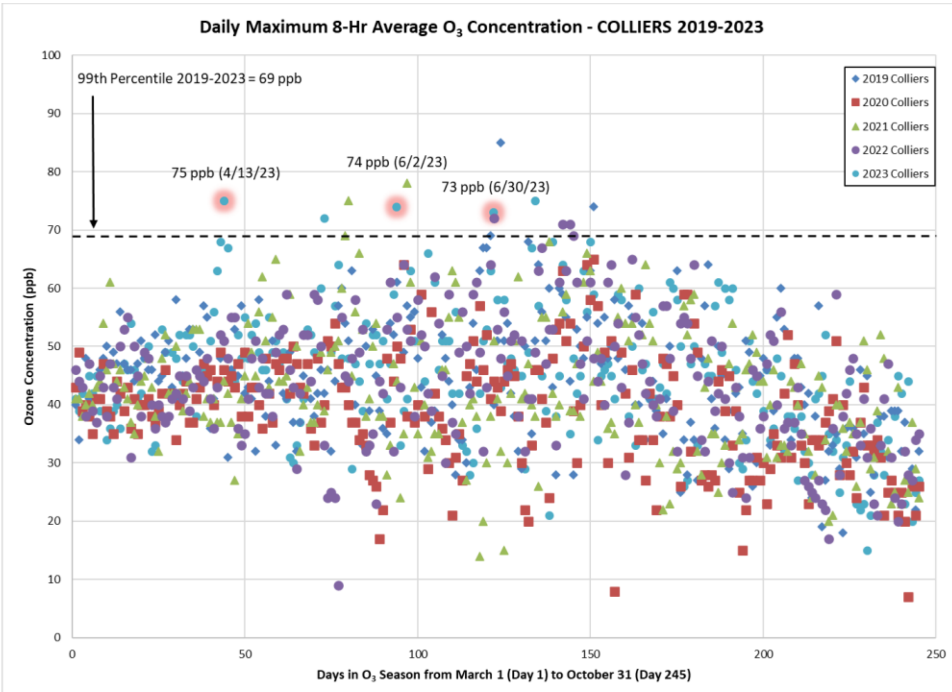


Figure 90: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Rider Monitor

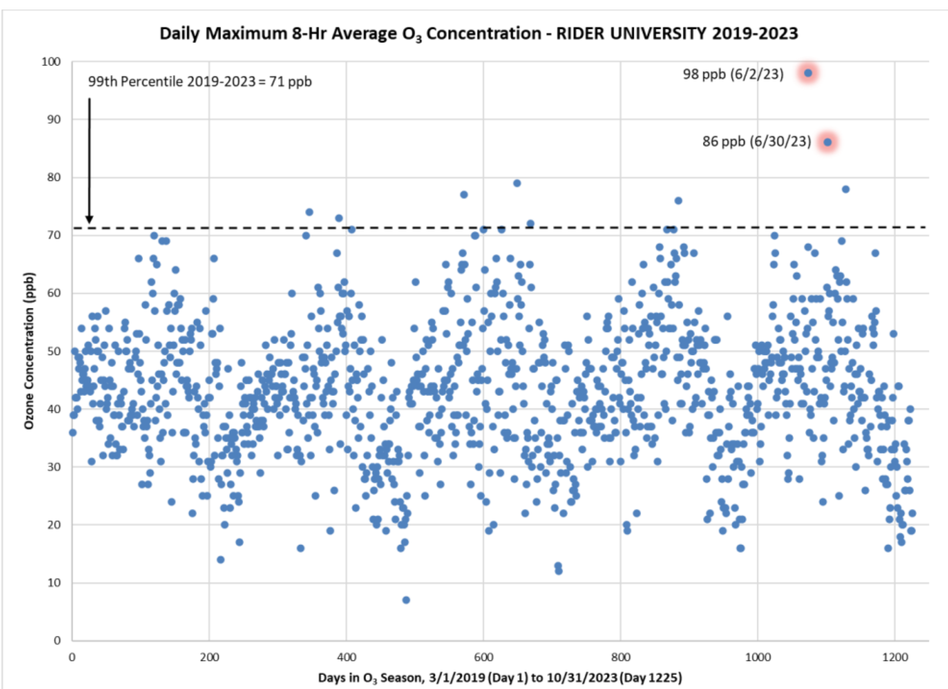
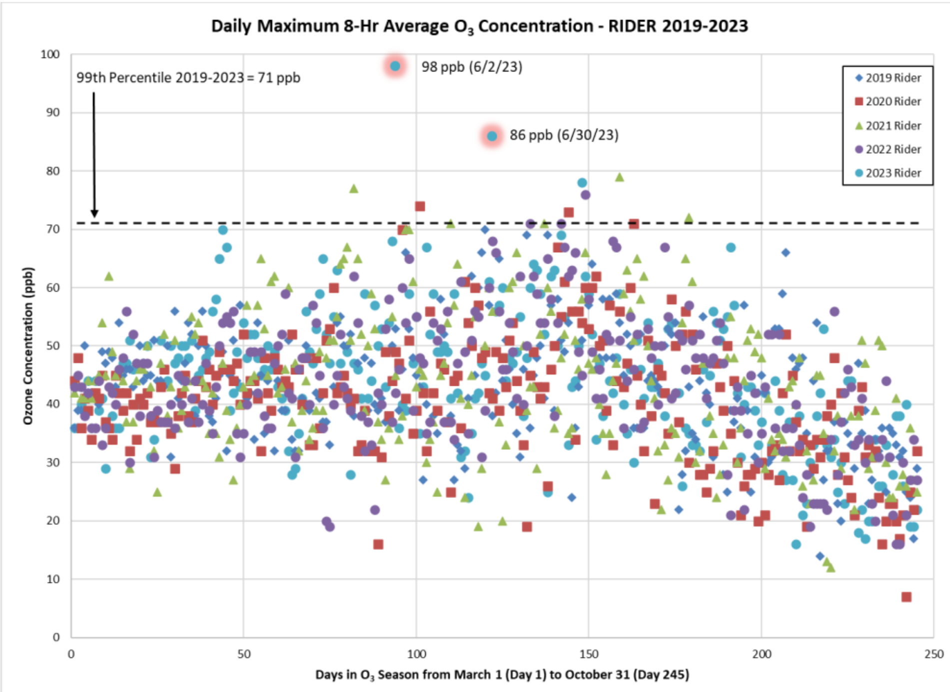


Figure 91: Rider Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations



In accordance with the USEPA Exceptional Events Guidance documents, the 99th percentile was calculated for the monitors in the Southern NJ-PA-DE-MD nonattainment area based on the daily maximum 8-hour ozone values for March through October in the last five years, 2019-2023. The distinctive nature of the 2023 data is evident when comparing them to data from the previous four years, 2019-2022. On June 2, 2023, five of the seven monitors with valid data in the Southern NJ-PA-DE-MD nonattainment area recorded daily maximum concentrations greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period. For one of the remaining two monitors, the daily maximum concentrations recorded on June 2, 2023, was greater than the 98th percentile concentration for the 5-year period. For this reason, the evidence presented in this section indicates a clear causal relationship and satisfies the comparison of the fire-influenced exceedance with historical concentration element of the Exceptional Events demonstration.

New Jersey also considered the ozone concentrations on the days preceding, on, and following the June 2 exceptional event. On Tuesday, June 2, 2023, four out of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area recorded exceedances of the 2015 70 ppb 8-hour ozone NAAQS. One monitoring site also exceeded the 2008 75 ppb 8-hour ozone NAAQS, and two sites exceeded the 1997 84 ppb 8-hour ozone NAAQS. The highest daily maximum 8-hour ozone concentration recorded for the Southern NJ-PA-DE-MD nonattainment area in 2023 was 98 ppb at Rider University.

Table 10 summarizes the daily maximum 8-hour average ozone concentrations recorded in Southern NJ-PA-DE-MD nonattainment area from May 29, 2023, through June 6, 2023, with the exceedances highlighted.

Table 10: Daily Maximum Ozone Levels in the New Jersey Portion of the Philadelphia-Wilmington-Atlantic City, Southern NJ-PA-MD-DE, Nonattainment Area Before and After the June 2, 2023, Exceptional Event

AQS Code	Site Name	5/29	5/30	5/31	6/1	6/2	6/3	6/4	6/5	6/6
340071001	Ancora State Hospital	52	40	44	50	67	37	37	48	58
340010006	Brigantine	39	30	30	30	41	23	28	37	48
340070002	Camden Spruce St	54	45	56	65	81	39	43	46	53
340150002	Clarksboro	54	46	55	64	89	40	44	47	58
340290006	Colliers Mills	51	41	47	59	74	33	39	41	63
340110007	Millville	51	38	40	51	64	33	39	46	58
340210005	Rider University	53	43	54	68	98	36	40	39	59
340219991	Washington Crossing*	54	44	54	NA	NA	22	41	42	60

*Operated by USEPA

exceeds 70 ppb NAAQS of 2015
exceeds 75 ppb NAAQS of 2008
exceeds 84 ppb NAAQS of 1997

2. Evidence that The Event, Monitors, and Exceedance Meet the Key Factors for Tier 2 Clear Causal Analyses

Emissions from the burning of forests and vegetation have been shown to add several pollutants that enhance ozone formation to the ambient air including fine particle matter, non-methane hydrocarbons, black carbon, and carbon monoxide.[88] According to a study by the National Oceanic and Atmospheric Administration (NOAA), the effects of fire emissions on the atmosphere are even larger and far more widespread than previously believed, and substantially contribute to ozone, one of the most common and harmful constituents of air pollution.[89]

2.1 Emissions over Distance (Q/d) Analysis

According to the USEPA guidance, a Q/d analysis is recommended as a rough assessment of the ability of a wildfire to cause increased ozone concentrations.[90] The Q/d analysis is a simple comparison of the ratio of the emissions (Q), the daily tons of VOC and NOx emitted from the fire to distance, (d), in kilometers, from the fire to the point of concern. The guidance indicates that a fire should have a Q/d in excess of 100 tons per day per kilometer of distance (tpd/km) in order to be considered to have a clear causal impact on ozone. This value was developed based on analyses of four fires which occurred in 2011. [91]

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[88] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

[89] NOAA. (2022, January 10). *Smoke from wildfires influences ozone pollution on a global scale.* https://research.noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/

[90] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.USEPA.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[91] Ibid.

2.1.1 Estimate of Emissions, Q

According to the USEPA Guidance, the emissions from wildfires can be estimated using information from Section 13.1, Wildfires and Prescribed Burning, of USEPA's AP-42, Compilation of Air Emission Factors.[92] This section presents emission factors for various pollutants by fire and fuel configurations for the fire from AP-42. The emissions and emission factors are calculated using the following formulas:

$$F_i = P_i * L \quad \text{(Equation 1)}$$

$$E_i = F_i * A \quad \text{(Equation 2)}$$

Combining equations 1 and 2, we have:

$$E_i = P_i * L * A \quad \text{(Equation 3)}$$

where:

F_i = emission factor (mass of pollutant/unit area of forest consumed)

P_i = yield for pollutant "i" (mass of pollutant/unit mass of forest fuel consumed), where:

= 12 kg/Mg (24 lb/ton) for total hydrocarbon (as CH_4)

= 2 kg/Mg (4 lb/ton) for nitrogen oxides (NOx)

L = fuel loading consumed (mass of forest fuel/unit land area burned)

A = land area burned

E_i = total emissions of pollutant "i" (mass pollutant)

The values of P_i above are for total hydrocarbons and for nitrogen oxides. The fuel loading, L, provided in AP-42 for different regions of the United States ranges from 8 to 60 tons per acre.[93] This analysis will present a range of emissions, starting with a conservative estimate based on a low-end emission rate of 10 tons per acre associated with Central Canadian forests, and the results could increase by a factor of 6, if the high end of fuel loading is considered.

According to the Canadian Wildland Fire Information System (CWFIS), wildfires across northwestern Canada consumed 1,400,000 hectares (3,459,475 acres) between May 13 and May 20, 2023.[94] The report also notes a slight pause around May 17 during an otherwise extremely intense eight-day period. (Figure 92). According to CWFIS, on May 16, wildfires burned an extensive area of 311,360 hectares (769,387 acres).[95] This is almost equivalent to the land area of Rhode Island, which is approximately 314,000 hectares.[96] During the burn period of May 13-20, 2023, smoke appeared to have stalled and built up over parts of the area. Additional burning towards the end of the month may have contributed more, however, initial analyses seem to indicate that the smoke may have drifted northward. Smoke at this latitude is harder to track due to limited satellite overpasses (latitude is too far north for geostationary retrievals) and cloud cover during polar orbiting overpasses.

[92] USEPA. (1996). AP42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.1: Wildfires and Prescribed Burning. https://www.epa.gov/sites/default/files/2020-10/documents/13.1_wildfires_and_prescribed_burning.pdf

[93] USEPA. (1996). AP42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.1: Wildfires and Prescribed Burning. https://www.epa.gov/sites/default/files/2020-10/documents/13.1_wildfires_and_prescribed_burning.pdf

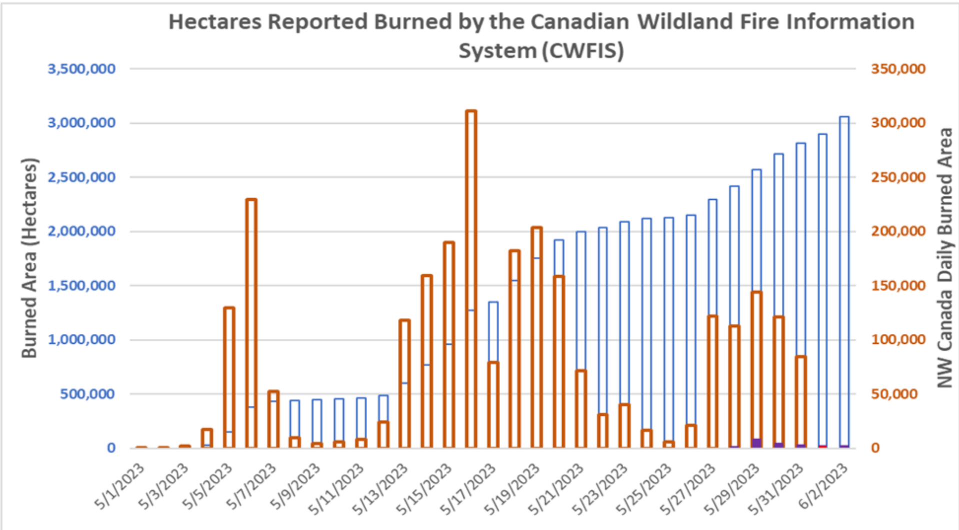
[94] Canadian Wildland Fire Information System. (n.d.). Government of Canada. https://cwfis.cfs.nrcan.gc.ca/home

[95] Ibid.

[96] Rhode Island Government. (n.d.). *Fun facts & trivia*. RI.gov. https://www.ri.gov/facts/trivia.php (A contextual comparison to the State of Rhode Island makes the fires' size more comprehensible).

Figure 92 was plotted using data provided by CWFIS. The blue bars represent the total area burned during the 2023 season, and the orange bars represent the daily area burned in west-central Canada that are pertinent to this demonstration, with the values on the right axis. The purple bars in late May and early June represent the Nova Scotia and/or New Jersey fires.

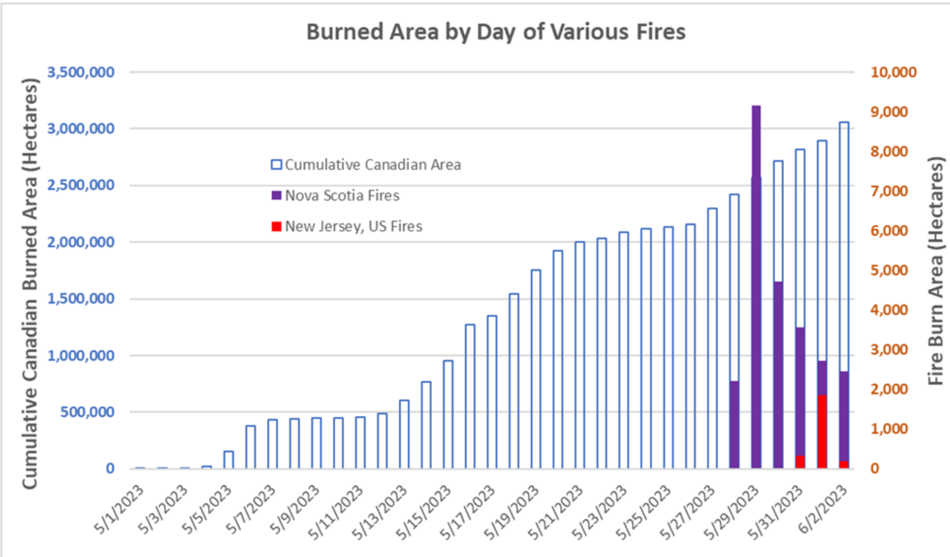
Figure 92: Daily hectares of land burned across Canada May 1 - June 2, 2023



Several additional fires occurred closer to the Mid-Atlantic. As shown in Figure 93, the fires were smaller but due to close proximity to New Jersey, contributed to increased airborne precursors. The first observed fires were the Nova Scotia fires, which occurred between May 28 and June 2, and burned a total land area of 24,840 hectares (61,381 acres) over this period. Most of the burning occurred on May 29 when 9,154 hectares (22,620 acres) burned. The smoke from the fires moved in a south-south westerly direction towards the Mid-Atlantic region between May 29-31, and burning a total land area of 19,670 hectares (48,605 acres) over that period. This resulted in residual smoke across the New Jersey region for the June 2 event.

Figure 93 was also plotted using data provided by CWFIS. The blue bars represent the total area burned during the 2023 season, and purple bars represent the area burned in Nova Scotia, Canada. The red bars represent the daily area burned in New Jersey that are pertinent to this demonstration, with the values on the right axis.

Figure 93: Comparison of Nova Scotia and New Jersey fires in relation to Daily hectares of land burned across Canada May 1 - June 2, 2023



Prior to the June 2 exceedance, several fires occurred in New Jersey that may have contributed to precursor concentrations in the atmosphere from the west-central Canada and Nova Scotia "background" smoke (Figure 93). The Allen Road fire in southern New Jersey burned a total of 2,215 acres between May 31 and June 2, with most of the burn occurring on June 1, when 1,772 acres burned. This smoke came thickly through New Jersey on June 1, leaving another source of residual smoke for June 2. Two other smaller fires were reported or observed across New Jersey: the Fort Dix fire and the Flatiron fire. The Fort Dix fire occurred on the Fort Dix Military Installation, in Pemberton Township, Burlington County, in southern New Jersey on June 1, directly east of Philadelphia. Little information regarding military burns is available, however, estimation based on satellite area-of-detection put the magnitude of the fire around 77 acres. While small, a copious, visible plume was apparent from the fire heading towards the eastern Greater Philadelphia area on June 1 (Figure 94). The Flatiron fire in Medford Township, Burlington County, New Jersey occurred on June 2. This fire was reported at 86 acres and burned only on June 2. A third fire, Box Turtle Wildfire, was reported on May 29 and occurred southeast of Philadelphia in Monroe Township, Gloucester County, New Jersey. This fire consumed 158 acres. Due to cloud cover, little visible evidence can be extracted from this burn, and thus, it has been left out of further analysis here. Still, collectively, despite the smaller fire sizes, the close proximity to the ozone exceedance region suggests an additional contributing direct causal relationship.

Figure 94 illustrates that the Allen Road fire is associated with the thicker plumes of smoke over southern New Jersey, Delaware, and Maryland. The Fort Dix fires in Central New Jersey are also visible amidst the background smoke. The hotspots of fire radiative power (FRP) are collated with the origins of plumes of smoke, which are blowing towards the west/southwest.[97] Smoke is spread out throughout the entire region.

[97] Fire radiative power (FRP) is a reliable measure of fire intensity and location, which is measured by satellite.

Figure 94: June 1, 2023, GOES-16 visible satellite imagery at 2231 UTC (6:31 pm EDT) over the northern Mid-Atlantic

Considering the above, Q/d analyses may be applied to each individual fire. The transport pattern from the south-southwest may have caused each fire to have a compounding contribution to smoke impacts on June 2, with ozone formation already apparent on June 1 amidst many of these fires/smoke sources. Each fire is presented individually below. The individual effects can be considered to be additive.

For the west-central Canada fires, the total hydrocarbon emissions over the entire period can be estimated to be:

$E_{hc} = P_{hc} * L * A$

= 24 lbs of HC / ton of forest fuel consumed * 10 tons fuel / acre * 3,459,475 acres
= 830,274,000 pound of HC or
= **<u>415,137 tons of HC emitted during the period from May 13 – 20, 2023</u>**

If the high end of fuel loading is considered, the total hydrocarbon emissions become:

= 24 lbs of HC / ton of forest fuel consumed * 60 tons fuel / acre * 3,459,475 acres

= 4,981,644,000 pounds of HC or

= **2,490,822 tons of HC emitted during the period from May 13 – 20, 2023**

Similarly for NOx:

$E_{NO_x} = P_{NO_x} * L * A$

= 4 lbs of NOx / ton of forest fuel consumed * 10 tons fuel / acre * 3,459,475 acres

= 138,379,000 pounds of NOx

= **69,190 tons of NOx emitted during the period from May 13 - 20, 2023**

If the maximum fuel load is considered, the total nitrogen oxides emissions become:

= 4 lbs of NOx / ton of forest fuel consumed * 60 tons fuel / acre * 3,459,475 acres

= 830,274,000 pounds of NOx

= **415,137 tons of NOx emitted during the period from May 13 – 20, 2023**

Q is the total daily emission rate in tons per day of reactive hydrocarbons and nitrogen oxides. USEPA recommends in the Exceptional Events Guidance,[98] that only 60% of the hydrocarbons from wildfires should be considered reactive. Therefore, the reactive hydrocarbon emissions become:

Q = rHC + NOx.

rHC = 0.6 * Ehc or

0.6 * 415,137 = **249,082 tons of reactive HC emitted daily during the period from May 13 – 20, 2023**.

If the maximum fuel load is considered, the reactive hydrocarbon emissions become:

0.6 * 2,490,822 = **1,494,493 tons of reactive HC emitted during the period from May 13 – 20, 2023**.

No adjustments are suggested for the NOx emissions to account for reactivity.

Therefore, the total rHC and NOx emissions over the period are **249,082 + 69,190, or 318,272 tons over the eight days, or 1,494,493.2 + 415,137, or 1,909,630 tons over the eight days,** if maximum fuel load is considered**.**

On average this results in a **daily emission rate, or Q, of 39, 784 tons per day or 238,704 tons per day,** if maximum fuel load is considered.

Similar procedures are followed for each successive fire to calculate the emission rate.

2.1.2 Estimate of Distance from the Fire, d.

New Jersey estimated the distance, d, from the approximate centroid of the fire region, which was along the border between Alberta and Saskatchewan, (roughly 55.8835°N, 110.1683°W), to the Clarksboro monitor (39.800339, -75.212119), since this monitor is centrally located within the New Jersey portion of the Southern NJ-PA-MD-DE nonattainment area and experienced ozone violations during the Exceptional Event. Google maps was used to determine the straight-line distance between the approximate fire region centroid, along the border between Alberta and Saskatchewan and the Clarksboro monitor resulting in an approximate value of **2036 miles (3277 kilometers),** for d.[99]

[98] 42 U.S.C. 7619(b)(1)(iii), Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations. USEPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. https://www.USEPA.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[99] Map Developers. (n.d.). *Distance From To - Calculate distance between two addresses, cities, states, zipcodes, or locations*.https://www.mapdevelopers.com/distance_from_to.php?&from=55.8835%C2%B0N%2C%20110.1683%C2%B0W&to=40.283092%2C%20-74.742644

2.1.3 Q/d Estimate

Using the values and days burned determined in the previous section for the west central Canada fires, Q/d is calculated to be 72.8 tpd/km [238,704 tpd divided by 3,277 km](Table 11). If we assume that the single day on May 16 is representative of the smoke arriving in New Jersey from the out-of-control fires, when 311,360 acres burned, New Jersey's Q/d value becomes 52.4. A similar test using May 18-20 gives a Q/d value of 75.7. All Q/d values are below the USEPA recommended level of 100 tpd/km but are within accepted levels in sample cases presented in USEPA guidance as conveying a clear causal relationship.

Table 11: Q/d analysis, Western Canada Fires, May 13-20, 2023

ACRES	Ehc (tons)	Enox (tons)	Q	No. days burning	d	Q/d	DESCRIPTION
1,347,522	**970,216**	**161,703**	**743,832**	**3**	**3277**	**<u>75.7</u>**	**<u>Fuel loading at maximum of 60 tons/acre instead of 10,</u> May 18-20 only**
3,459,475	2,490,822	415,137	1,909,630	8	3,277	72.8	Fuel loading at maximum of 60 tons/acre instead of 10, May 13-20
311,360	224,179	37,363	171,871	1	3277	52.4	Fuel loading at maximum of 60 tons/acre instead of 10, May 16 only
1,347,522	161,703	26,950	123,972	3	3277	12.6	Standard Q/d, May 18-20 only
3,459,475	415,137	69,190	318,272	8	3,277	12.1	Standard Q/d, May 13-20
311,360	37,363	6,227	28,645	1	3277	8.7	Standard Q/d, May 16 only

2.1.4 Additional Q/d from Diverse Fire Sources

There is no known USEPA guidance for combining Q/d for multiple sources as would be appropriate for the June 2 ozone event, when at least four different fires contributed to smoke effects in New Jersey. [100] Therefore, Q/d analyses similar to the one used for the west-central Canadian were assessed for the other contributing fires in this event. The same fuel loading used for the west-central Canadian fires was used for Nova Scotia, while a fuel loading of 11 assigned to Eastern Region was used for the Allen Road,

[100] 42 U.S.C. 7619(b)(1)(iii), Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations. USEPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. https://www.USEPA.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

Fort Dix, and Flat Iron fires.[101] Various scenarios for the fires are presented in Table 12 through Table 15, with distances estimated from each fire to Clarksboro, New Jersey. As potential contributors to New Jersey's ozone exceedance, the Q/d calculated for the burn days that had the most impact from the west-central Canadian, Nova Scotia and Fort Dix fires were summed to reach a cumulative Q/d impact of **89.7 [75.7 + 13.9 + 0.1] tons per day per km**, a value accepted in other sample cases in the USEPA guidance to justify a clear causal relationship.

Table 12: Q/d analysis, Nova Scotia, Canada, Fires, May 29-31, 2023

ACRES	Ehc (tons)	Enox (tons)	Q	No. days burning	d	Q/d	DESCRIPTION
22,620	**16,286**	**2,714**	**12,486**	**1**	**896**	**13.9**	**Fuel loading at maximum of 60 tons/acre instead of 10, May 29 only**
43,127	31,052	5,175	23,806	3	896	8.9	Fuel loading at maximum of 60 tons/acre instead of 10, May 29-31 only
22,620	2,714	452	2,081	1	896	2.3	Standard Q/d, May 29 only
43,127	5,175	863	3,968	3	896	1.5	Standard Q/d, May 29-31 only

Table 13: Q/d analysis, Allen Road Fire, New Jersey, May 31-June 1, 2023

ACRES	Ehc (tons)	Enox (tons)	Q	No. days burning	d	Q/d	DESCRIPTION
1,772	**234**	**39**	**179**	**1**	**68**	**2.6**	**June 1 only**
2,104	278	46	213	2	68	1.6	May 31 – June 1

Table 14: Q/d analysis, Fort Dix Fire, New Jersey, June 1

ACRES	Ehc (tons)	Enox (tons)	Q	No. days burning	d	Q/d	DESCRIPTION
77	**10**	**2**	**8**	**1**	**57**	**0.1**	**June 1**

[101] USEPA. (1996). AP42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.1: Wildfires and Prescribed Burning. https://www.epa.gov/sites/default/files/2020-10/documents/13.1_wildfires_and_prescribed_burning.pdf

Table 15: Q/d analysis, Flat Iron Fire, New Jersey, June 2

ACRES	Ehc (tons)	Enox (tons)	Q	No. days burning	d	Q/d	DESCRIPTION
86	**11**	**2**	**9**	**1**	**35**	**0.2**	**June 2**

2.2 Discussion of 5-years of Ozone Data from 2019-2023- 99th Percentiles

Observations at monitors measuring at or above the 99th percentile in the past five years is considered statistical evidence that the values were likely influenced by an Exceptional Event. The Exceptional Events Guidance documents were used to calculate the 99th percentile for all of the monitors in the New Jersey portion of the Southern NJ-PA-MD-DE nonattainment area for all of the days in March through October over the last five years (2019-2023). These percentiles are presented in scatterplots in Figure 84-Figure 91 and summarized in Section 1.

Table 16 summarizes the daily maximum 8-hour ozone concentrations measured by monitors in the New Jersey portion of the Southern NJ-PA-MD-DE nonattainment area on June 2, 2023, along with each monitor's respective 99th and 98th percentile daily maximum 8-hour ozone concentrations for the 5-year period 2019-2023. The values highlighted in blue are over the 99th percentile for the 5-year period for each monitor, while the value highlighted in pink is over the 98th percentile. The last column highlights the monitors that exceeded their 99th percentile (YES) on June 2, 2023. Blanks indicate that the monitor did not exceed the 99th percentile.

Table 16: 5 years (2019-2023) of Daily Maximum 8-hour Average Ozone Concentrations for New Jersey Exceptional Event Monitors

	Daily Maximum 8-Hour O_3 (ppb)				2019-2023 Daily Max 8-Hr Avg		
	6/1/2023	6/2/2023	6/3/2023	6/4/2023	99th %ile	98th %ile	Exceed 99th %ile (2019-2025) Level on June 2, 2023
Ancora State Hospital	50	67	37	37	66	61	**YES**
Brigantine	30	41	23	28	61	58	
Camden Spruce St	65	81	39	43	69	66	**YES**
Clarksboro	64	89	40	44	71	67	**YES**
Colliers Mills	59	74	33	39	69	67	**YES**
Millville	51	64	33		68	62	
Rider University	68	98	36	40	71	68	**YES**
Washington Crossing	No Data	No Data	22	41	68	66	No Data

> level of 99th Percentile

> level of 98th Percentile

Table 16 shows that on June 2, 2023, five of the seven monitors with valid data in the New Jersey portion of the Southern NJ-PA-MD-DE nonattainment area, including the three monitors seeking an Exceptional Event exclusion, recorded daily maximum concentrations greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period. For one of the remaining two monitors, the daily maximum concentrations recorded on June 2, 2023, was greater than the 98th percentile concentration for the 5-year period. The daily maximum concentrations recorded on June 2, 2023, at Camden Spruce St., Clarksboro, and Rider University were the highest concentrations recorded by these stations during this 5-year period.

2.3 Discussion of Highest Ozone Concentration Within 1 year

According to the USEPA Guidance, if the exceedance due to an Exceptional Event is one of the four highest ozone concentrations within one year, it satisfies key factor 2 for a Tier 2 analysis. Key factor 2 compares event-related ozone concentration with non-event related high ozone concentrations. New Jersey has satisfied this key factor with the 99th percentile analysis, and the highest daily maximum ozone concentrations in 2023 in Table 17 to showcase the severity and widespread nature of June 2 event. This unusual occurrence was also repeated during the April 13, June 29, and June 30 Exceptional Event periods in New Jersey.

Table 17 compares the daily maximum 8-hour ozone concentrations measured during the Exceptional Event days with the five highest concentrations for the year. The overall maximums for 2023 ozone season at the Southern NJ-PA-MD-DE nonattainment area monitors, except Brigantine, occurred on an Exceptional Event Day, indicating the impact of the wildfires on New Jersey monitors. Furthermore, all exceedances on an Exceptional Event Day at all of Southern New Jersey's monitors were among the fourth or fifth highest for the year.

Table 17: Ozone Daily Max Values Compared with Five Highest Daily Maximums in 2023

Site Name	Daily Max 8-Hr Ozone (ppb)				2023 Daily Maximum 8-Hr Ozone Concentrations (ppb)				
	4/13/2023	6/2/2023	6/29/2023	6/30/2023	1st Max	2nd Max	3rd Max	4th Max	5th Max
Ancora State Hospital	66	67	73	67	73	69	67	67	66
Brigantine	54	41	51	59	67	64	59	58	55
Camden Spruce St	62	81	71	78	81	78	71	71	70
Clarksboro	73	89	78	77	89	78	77	74	73
Colliers Mills	75	74	63	73	75	75	74	73	72
Millville	68	64	75	72	75	72	68	68	68
Rider University	70	98	61	86	98	86	78	70	69
Washington Crossing*	71	NA	63	89	89	74	72	71	71

*Site is operated by USEPA

1st Max	2nd Max	3rd Max	4th Max	5th Max	Exceedance Day

During the Exceptional Event periods in 2023, seven out of eight monitors in the New Jersey portion of the Southern NJ-PA-MD-DE nonattainment area recorded their highest daily maximum 8-hour average ozone concentrations. Three of the seven monitors recorded their highest values on June 2. The next most severe ozone event occurred on June 29-30, 2023, where seven monitors exceeded the 70 ppb 2015 8-hour ozone NAAQS, with one exceeding the 84 ppb 1997 8-hour ozone NAAQS. All of the ozone exceedances that occurred during the Exceptional Event periods exceed the 70 ppb 2015 ozone NAAQS and are among the highest 5 daily maximum 8-hour average for each of the monitors.

3. Evidence that Fire Emissions were Transported to New Jersey Monitors

A trajectory analysis can be used to show that the emissions from the fire were transported to the monitors, based on the methodology recommended in USEPA Guidance.[102] New Jersey presents trajectory modeling results in this section to show that emissions from west-central Canadian fires were transported to New Jersey.

3.1 Trajectory Analysis

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was employed to calculate backward trajectories arriving in New Jersey on June 2. The meteorological model that was used to compute the backward trajectories was obtained from the North American Mesoscale Forecast System, 12km, (NAM 12).

Figure 95 shows trajectories at three different wind heights with the endpoint at the Clarksboro monitor on June 2, 2023. The three wind heights above ground level (AGL) that are plotted on Figure 95 are 10m, 500m, and 1500m. Figure 96-Figure 98 show the different wind heights AGL for monitored exceedances throughout the region on the same day. The figures illustrate where the air came from during the 48 hours preceding the 8-hour ozone standard exceedances on June 2, 2023. The Clarksboro monitor is highlighted on Figure 96-Figure 98 with a yellow star.

The 48-hour surface level backward trajectories (Figure 96) show that air at the surface originated off the coast of New Jersey and Long Island and traveled in a general west/southwestward direction indicating the contribution of wildfire smoke from the Nova Scotia fires burning to the east. Through their westward transit, air parcels encountered multiple surface troughs, causing slight shifts in direction and recirculation along the way. Overall, trajectories meandered slowly over regions, which saw widespread levels of moderate and Unsafe for Sensitive Groups (USG) ozone levels in the days leading up to the exceedances, causing a gradual buildup of wildfire smoke in combination with other pollutants.

The 48-hour mid-level backward trajectories (Figure 97) originated over southern Quebec and various portions of New England. Air parcels traveled primarily in a southerly direction through transit, traversing over regions that saw widespread levels of moderate ozone levels in the days leading up to the exceedances. As a result of high pressure, mid-level air experienced a gentle sinking motion and slowed drastically upon arrival, which likely allowed smoke aloft to mix down to lower levels of the atmosphere at their final destinations enhancing ozone concentrations at the surface.

The 48-hour upper-level backward trajectories (Figure 98) originated over the Ontario/New York border and Quebec region and traveled in a clockwise direction under the influence of high pressure. They slowly experienced a slight sinking motion, allowing pollutants to mix down to lower levels. The air then traveled southwest and began rising due to a low-pressure system in the area. Air traversed through

[102] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

regions that experienced widespread moderate and USG ozone levels in the day leading up to the exceedance. All trajectories traveled a long distance before reaching their destinations, allowing for a buildup of ozone precursors from multiple wildfire sources on this day.

Figure 95: HYSPLIT Backward Trajectories on June 2, 2023 - Clarksboro – 10, 500, and 1500m AGL

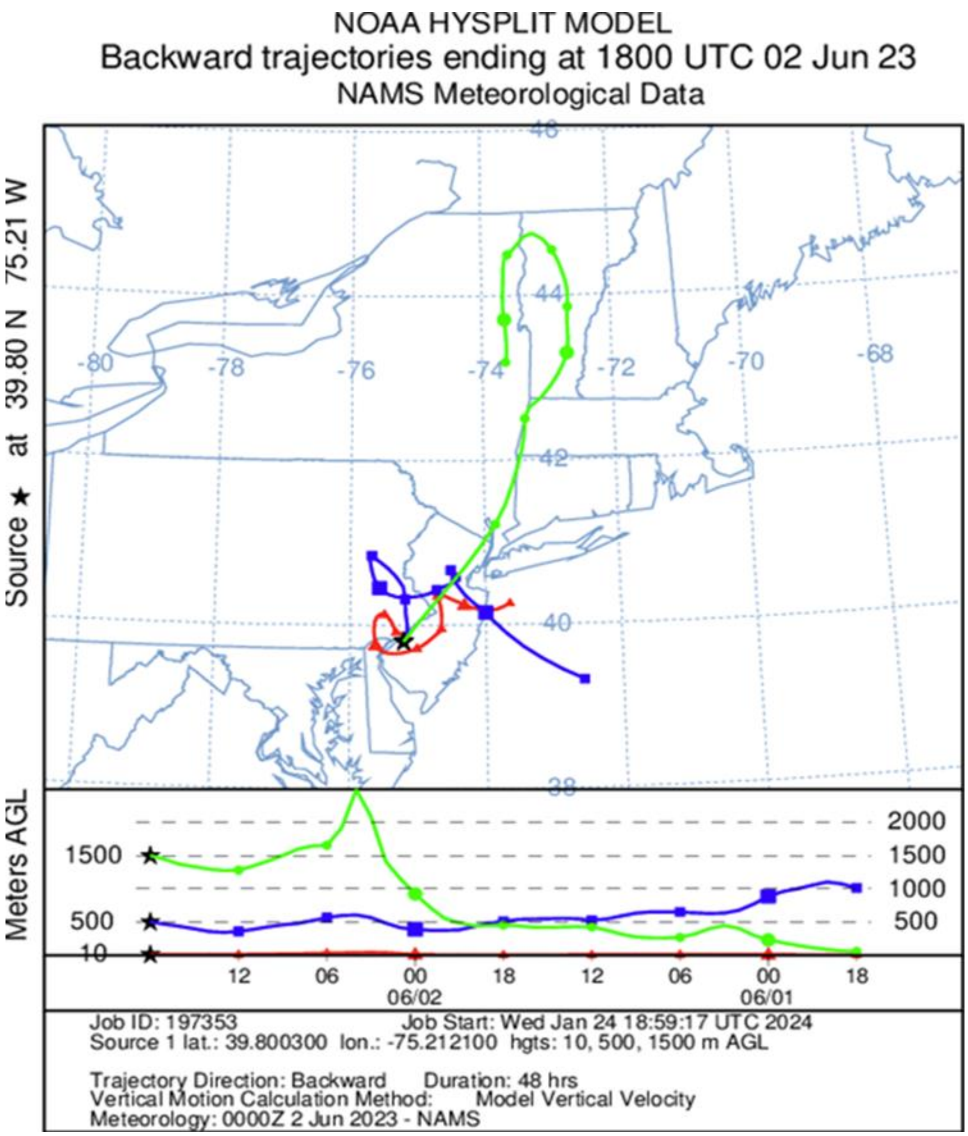


Figure 96: HYSPLIT Backward Trajectories on June 2, 2023, 10m AGL

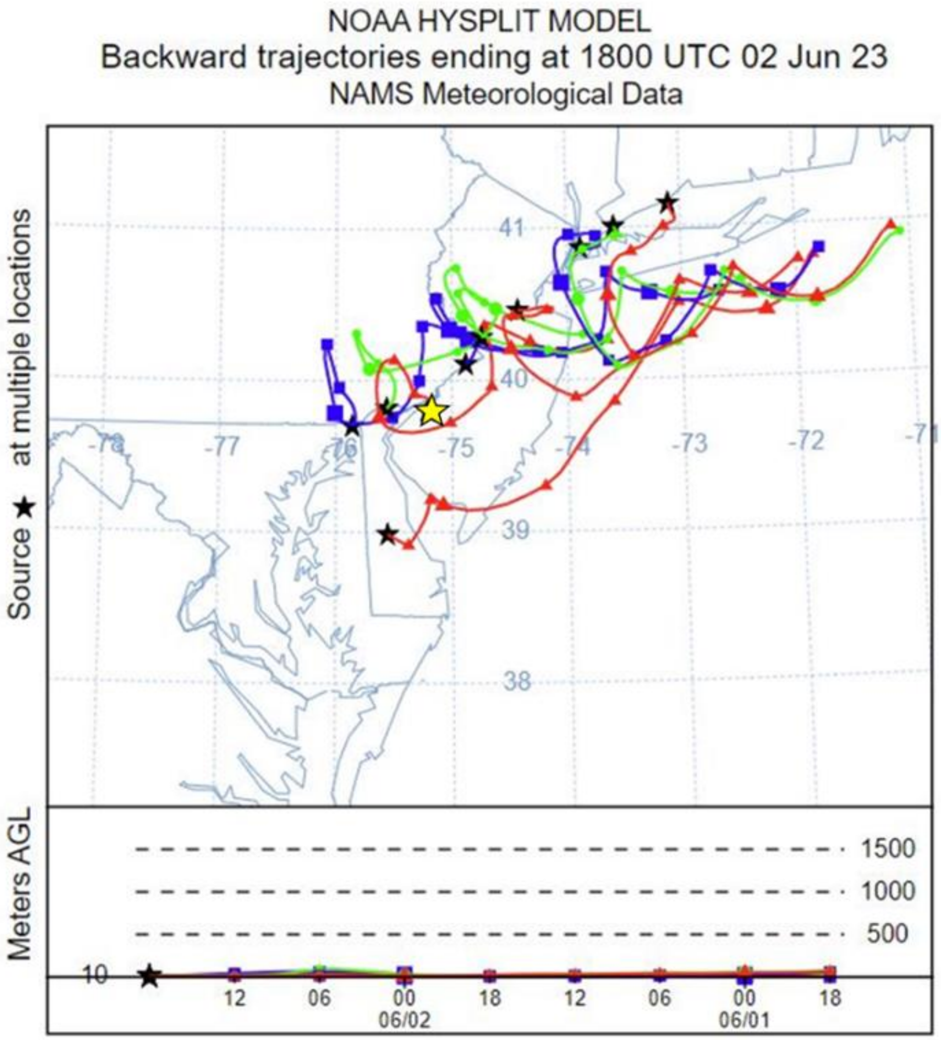


Figure 97: HYSPLIT Backward Trajectories on June 2, 2023, 500m AGL

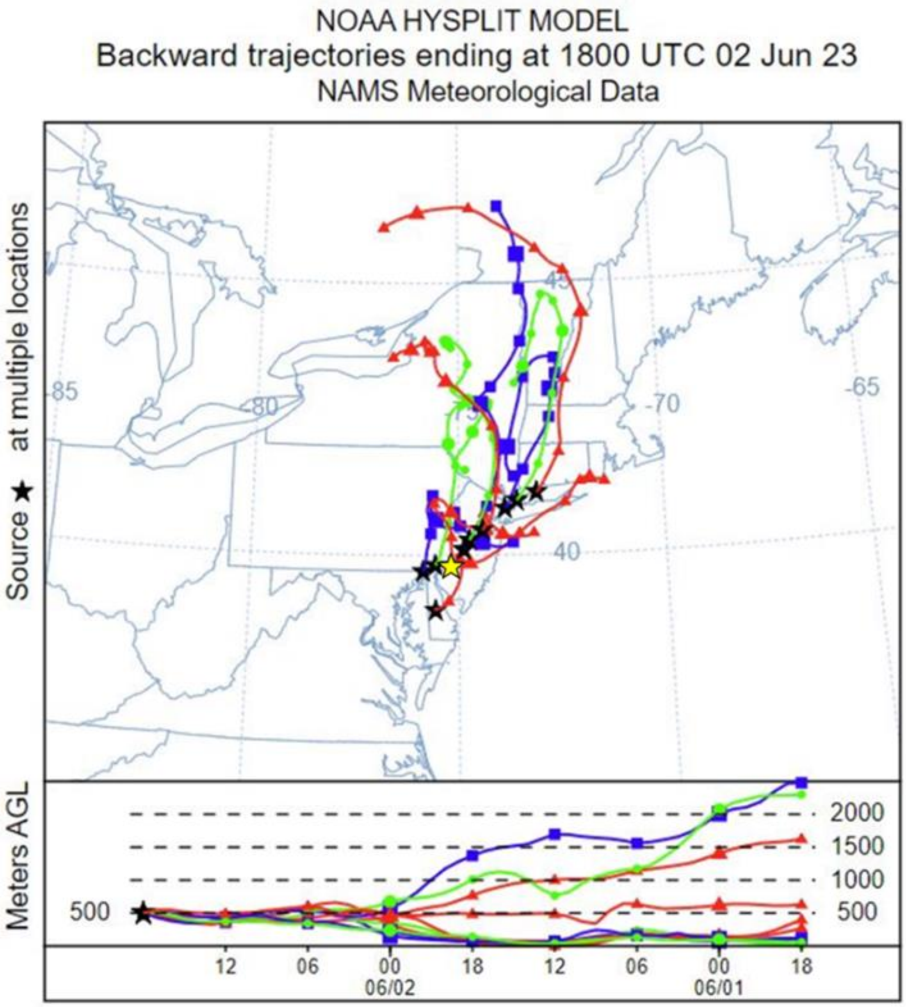
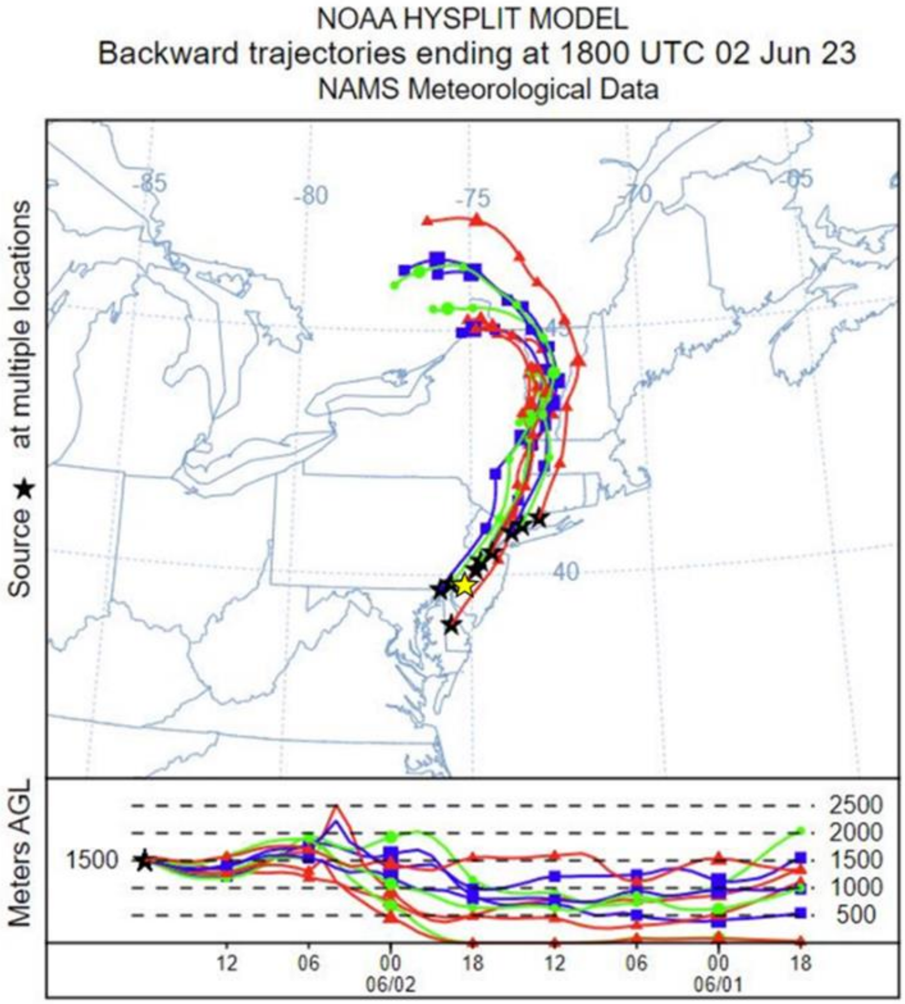


Figure 98: HYSPLIT Backward Trajectories on June 2, 2023, 1500m AGL



4. Evidence that Fire Emissions Affected New Jersey Monitors

This section adds to the weight of evidence that the emissions from the fires affected the monitored ozone concentrations at New Jersey monitors, as recommended by USEPA Guidance.[103]

The primary pollutants emitted from wildland fires include greenhouse gases, non-methane volatile organic compounds (NMVOC), NOx, and aerosol.[104] Wildland fires emit a variety of aerosols, including black carbon, organic carbon, and inorganic compounds.

The New Jersey monitoring network measures both total PM2.5 mass and speciated compounds such as ionic potassium (K^+) and organic carbon, as well as other pollutants such as CO, NOx and VOCs. Analyses

[103] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

[104] Urbanski, S.P., Hao, W.M., & Baker, S. (2008). Chemical Composition of Wildland Fire Emissions. In Bytnerowicz, A, Arbaugh, M.J., Riebau, A.R., & Andersen, C. (Eds.), *Developments in Environmental Science* (Vol. 8, pp. 79-107). Elsevier. Retrieved January 24, 2024, DOI: 10.1016/S1474-8177(08)00004-1, https://www.fs.usda.gov/rm/pubs_other/rmrs_2009_urbanski_s001.pdf

of the various species that can be attributed to fires are presented in the following sections. The analyses show that the ozone exceedance in New Jersey was characterized by enhanced precursors attributable to wildfire species. The 2023 data concerning fine particulate matter, potassium, organic carbon, elemental carbon, black carbon, carbon monoxide, nitrogen dioxide, non-methane hydrocarbon and non-methane volatile organic compounds presented in this analysis is preliminary and awaits certification by NJDEP.

4.1 Fine Particulate Matter (PM2.5)

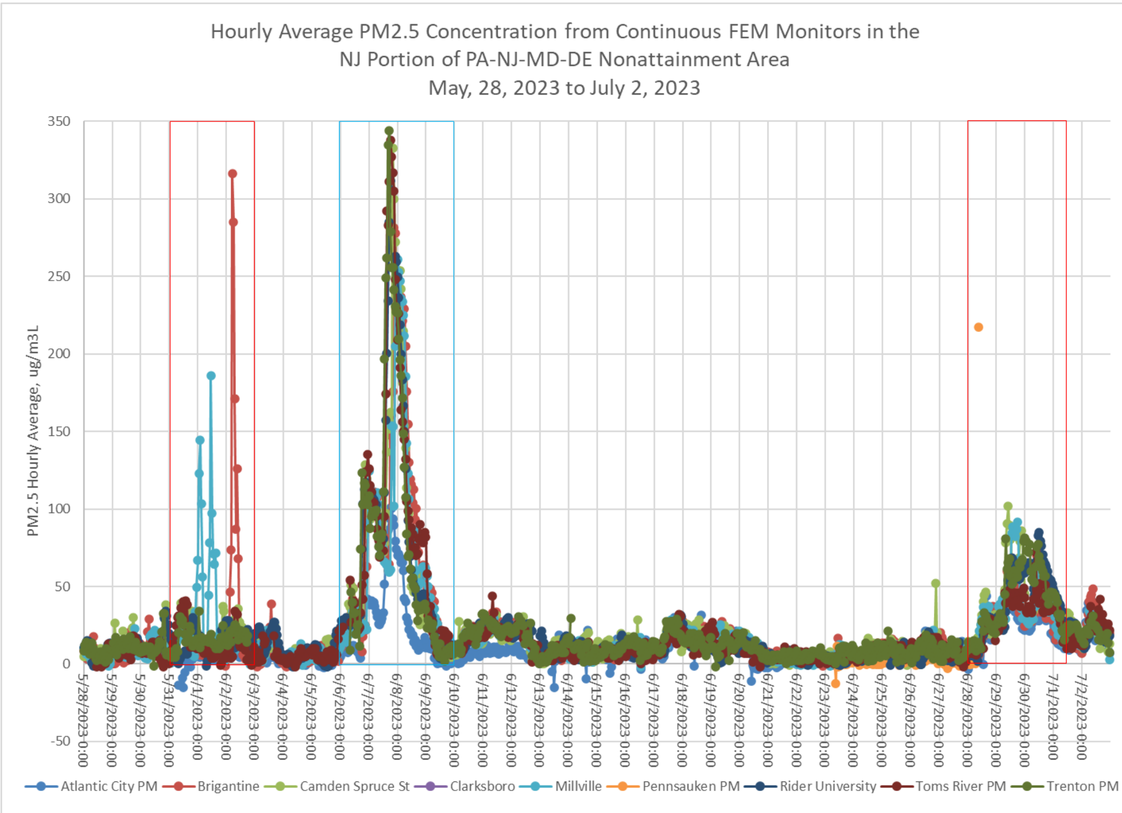
PM2.5 emissions from wildfires can be transported across large distances. PM2.5 is one of the species that accounts for the next largest share of emissions from wildfire after CO_2 and CO.[105] New Jersey monitors PM2.5 levels using filter-based continuous Federal Equivalent Method (FEM) monitors. The National Ambient Air Quality Standard for 24-hour PM2.5 is 35 ug/m^3.

Hourly PM2.5 concentrations from May 28 - July 2, 2023, for monitors in the Southern NJ-PA-DE-MD nonattainment area, are presented in Figure 99. On June 2, PM2.5 levels recorded a peak hourly average of 316 ug/m^3, a value nine times the daily federal standard. June 2 was the second day in the 2023 ozone season that recorded extremely high PM2.5 levels, and this record was the 4^{th} highest for the season. The first three highest records occurred on June 7, 2023. The red and blue boxes in Figure 99 indicate periods of elevated PM2.5 concentrations. These elevated concentrations in the red boxes coincide with the June 2 and June 29-30 Exceptional Event dates. New Jersey is not seeking Exceptional Event exclusions for the time period in the blue box because it does not have regulatory significance related to ozone for New Jersey.

Based on analysis in this demonstration combined with this PM2.5 data analysis, the peak on June 2 is attributed to the local fires that occurred in New Jersey on June 1; the Allen Road, Flat Iron and Fort Dix fires, and smoke transport from the west-central Canadian wildfires. Therefore, the elevated levels of PM2.5 in addition to other factors contributed to the June 2 ozone exceedance in New Jersey.

[105] Ibid.

Figure 99: Hourly Average PM2.5 Concentration from Continuous FEM Monitors in the NJ Portion of Southern NJ-PA-MD-DE Nonattainment Area from May 28, 2023, to July 2, 2023



4.1.1 Potassium and Organic Carbon

Biomass burning is a significant source of particle pollution, which is mainly composed of organic carbon (OC) and black carbon. These particles also contain potassium ions. Wildfire smoke can be traced using ionic potassium (K^+), which is a reliable indicator of wildfire emissions due to its scarcity in anthropogenic sources and its concentration above background levels.[106]

The presence of smoke from wildfires can be determined in the outside air by looking for elevated levels of certain pollutants, called markers, that are key components of wood smoke but are not usually found in outside air except in trace amounts. Primary markers for wood smoke emissions include potassium (K) and levoglucosan.[107] When there are high levels of potassium in the outdoor air, it is usually an indication that wood smoke is present and causing an increase in the outdoor air concentrations of other pollutants

[106] Ma, Y., Weber, R.J., Lee, Y.N., Orsini, D.A., Maxwell-Meier, K., Thornton, D.C., Bandy, A.R., Clarke, A.D., Blake, D.R., Sachse, G.W., Fuelberg, H.E., Kiley, C.M., Woo, J.H., Streets, D.G., & Carmichael, G.R. (2003). Characteristics and influence of biosmoke on the fine-particle ionic composition measured in Asian outflow during the Transport and Chemical Evolution Over the Pacific (TRACE-P) experiment. *Journal of Geophysical Research: Atmospheres, 108*(D21), 37-1 – 37-16. DOI: 10.1029/2002JD003128, https://aerosols.eas.gatech.edu/papers/Ma%20ACE%20Asia%20Biomass%20Smoke.pdf

[107] Gibson, M.D., Haelssig, J., Pierce, J.R., Parrington, M., Franklin, J.E., Hopper, J.T., Li, Z, & Ward, T.J. (2015). A comparison of four receptor models used to quantify the boreal wildfire smoke contribution to surface PM2.5 in Halifax, Nova Scotia during the BORTAS-B experiment. *Atmospheric Chemistry and Physics, 8*(2), 815-827. DOI: 10.5194/acp-15-815-2015

from wood smoke emissions as well. USEPA's PM2.5 Speciation Trends Network analyzes fine particle samples from sampling locations nationwide to monitor the levels of potassium and other parameters. The samplers generally operate on a three-day sampling schedule. However, some samplers operate on a six-day sampling schedule.

New Jersey has PM2.5 Speciation samplers located in the Camden Spruce Street and Rutgers University air monitoring stations. The Rutgers University sampler operates on a three-day sampling schedule, while the Camden Spruce Street sampler operates on a six-day sampling schedule. Figure 100 presents preliminary data obtained from June 2023. The data collected at Rutgers showed the presence of potassium in the air on June 2, indicating smoke. However, there were no data collected at Camden for June 2. For most of June 2023, the air quality was consistently impacted by smoke. Despite this, June 2, 2023, shows elevated concentrations of potassium at the Camden monitor compared to most of the days in June when there were no ozone episodes. Higher PM2.5 concentrations were also observed at some of the Southern NJ-PA -DE-MD nonattainment area monitors on the same day.

The red boxes in Figure 100 indicate the two smoke periods that New Jersey is pursuing as Exceptional Events: June 2 and June 29-30. Although there appears to be a smoke event around June 7-8, New Jersey is not pursuing that episode because it was not identified to have regulatory significance related to ozone air quality for New Jersey. During this time period, organic and elemental carbon concentrations showed similar characteristics as potassium at the Camden and Rutgers monitors, as shown in Figure 101 and Figure 102.

The potassium concentration at the Rutgers and Camden monitors is evidence of smoke impact on New Jersey monitors.

Figure 100: Preliminary Potassium (K) Concentrations Measured from PM2.5 Speciation Sites at Rutgers and Camden, New Jersey Monitors in June 2023

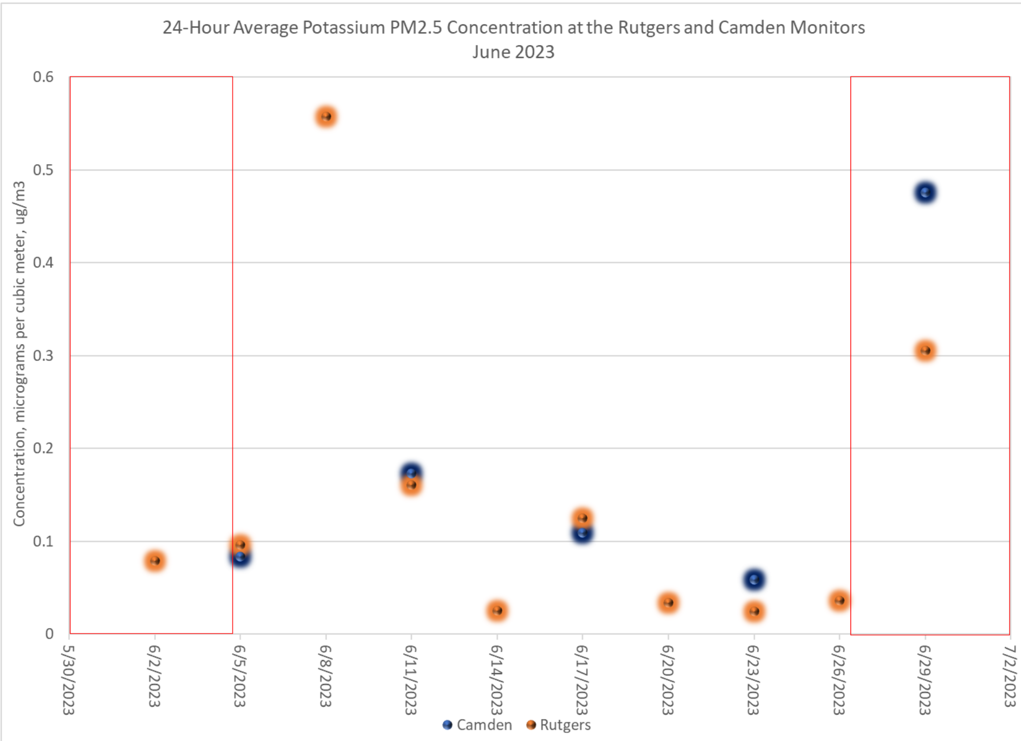


Figure 101: Preliminary Organic Carbon (OC) Concentrations Measured from PM2.5 Speciation Sites at Rutgers and Camden, New Jersey Monitors in June 2023

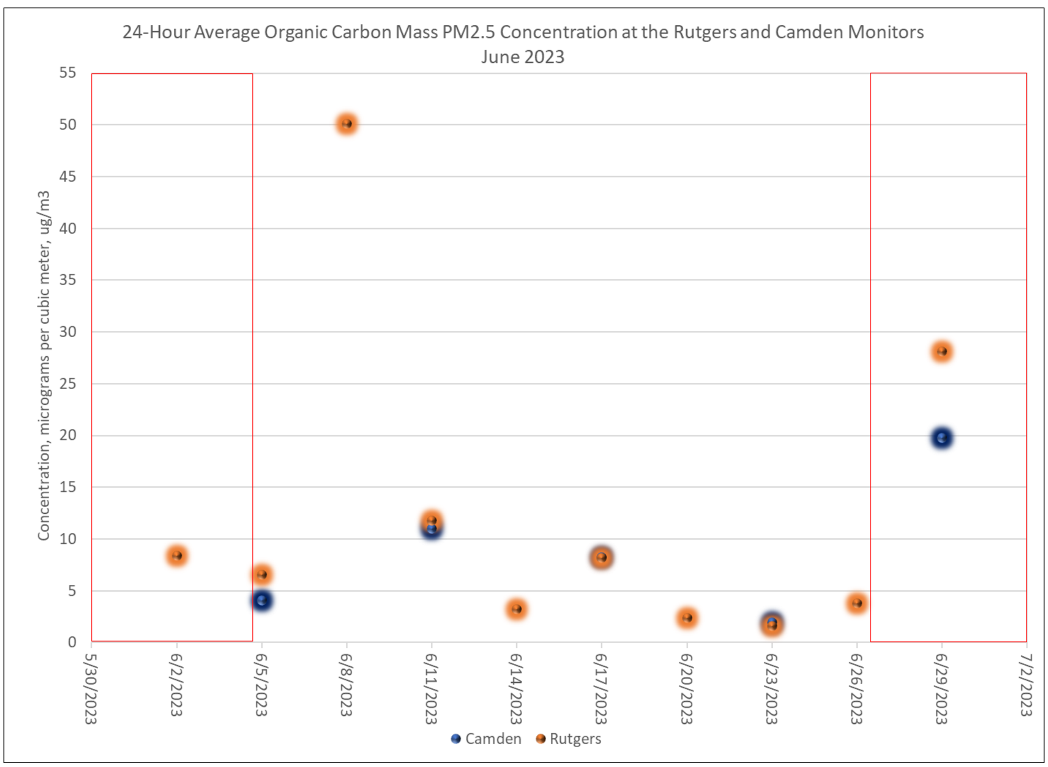
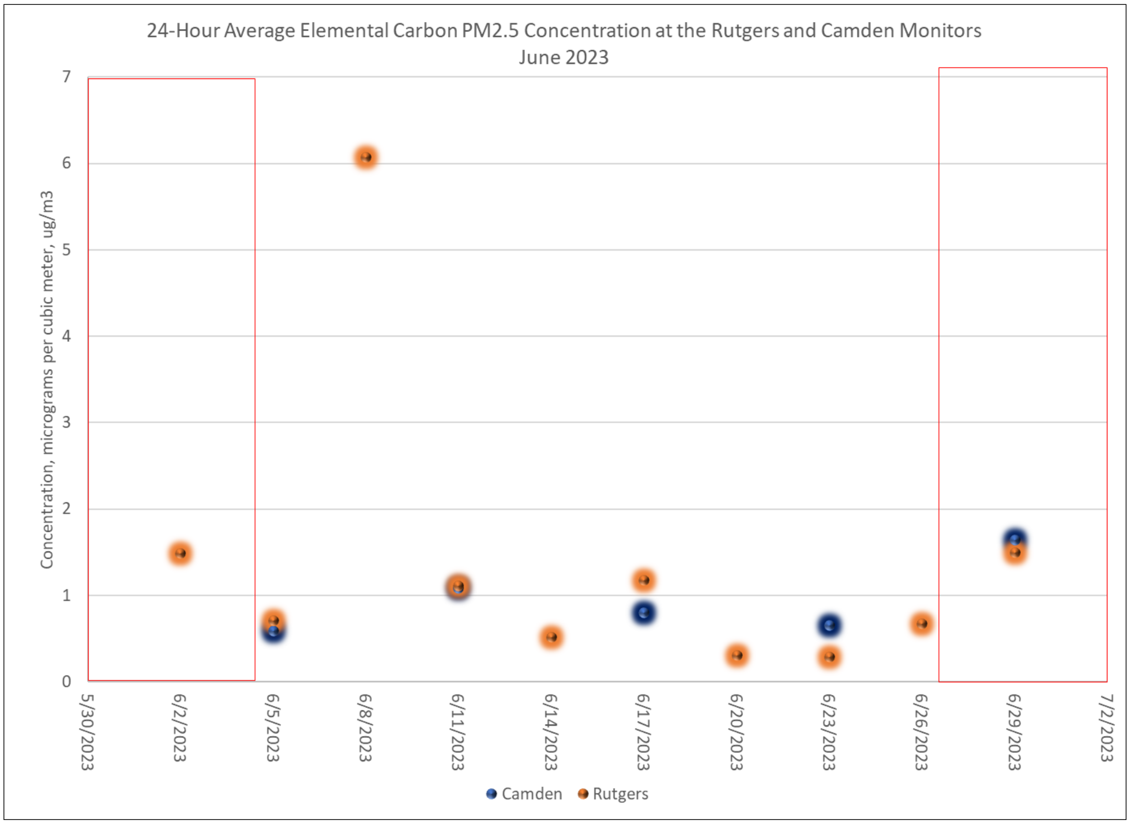


Figure 102: Preliminary Elemental Carbon (EC) Concentrations Measured from PM2.5 Speciation Sites at Rutgers and Camden, New Jersey Monitors in June 2023



4.1.2 Black Carbon

The presence of black carbon (BC) is an indicator of smoke originating from biomass burning during wildfires. As smoke from biomass burnings significantly contributes to ozone formation, detecting elevated levels of BC provides additional evidence of the impact of wildfire smoke on elevated ozone concentrations.[108] New Jersey measures near-real time black carbon in ambient air at five urban monitoring stations throughout the state.[109]

Figure 103 presents the hourly BC concentrations at three NJ monitors from May 30 to July 3 in 2023. On June 2, a noticeable spike in BC concentrations is evident, as highlighted within the red box on the figure. The BC concentrations recorded at the Bayonne and Elizabeth Trailer monitors were slightly higher than those at the Camden Spruce St monitor. Notably, both the Bayonne and Elizabeth monitors are upwind of Camden Spruce St based on the trajectories on this day and seen earlier in this document in Figure 98. The smoke plume originated in the north where these upwind areas experienced higher air pollutant concentrations along the smoke path before reaching the southern monitors. The average BC concentrations at Bayonne and Elizabeth Trailer consistently surpass those at Camden Spruce St. This

[108] NOAA. (2022, January 10). *Smoke from wildfires influences ozone pollution on a global scale.* https://research.Noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/
[109] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

trend is also reflected in Figure 104, which displays the daily BC concentrations from May 30 to July 3 in 2023. Specifically, June 2 displays a clear spike in BC concentration.

In June 2023, the average daily concentration of BC at the Camden Spruce St monitor was 0.556 ug/m³. However, on June 2, the average daily BC concentration spiked to 0.685 ug/m³, with the hourly concentrations reaching as high as 1.785 ug/m³. In addition, the average daily BC concentration on June 2, 2023, was over 50% larger than the average for June over the past five years (long-term average of 0.449 ug/m³ from 2019 to 2023).

Figure 103: Hourly Black Carbon Concentration at New Jersey Monitors from May 30 to July 3 in 2023

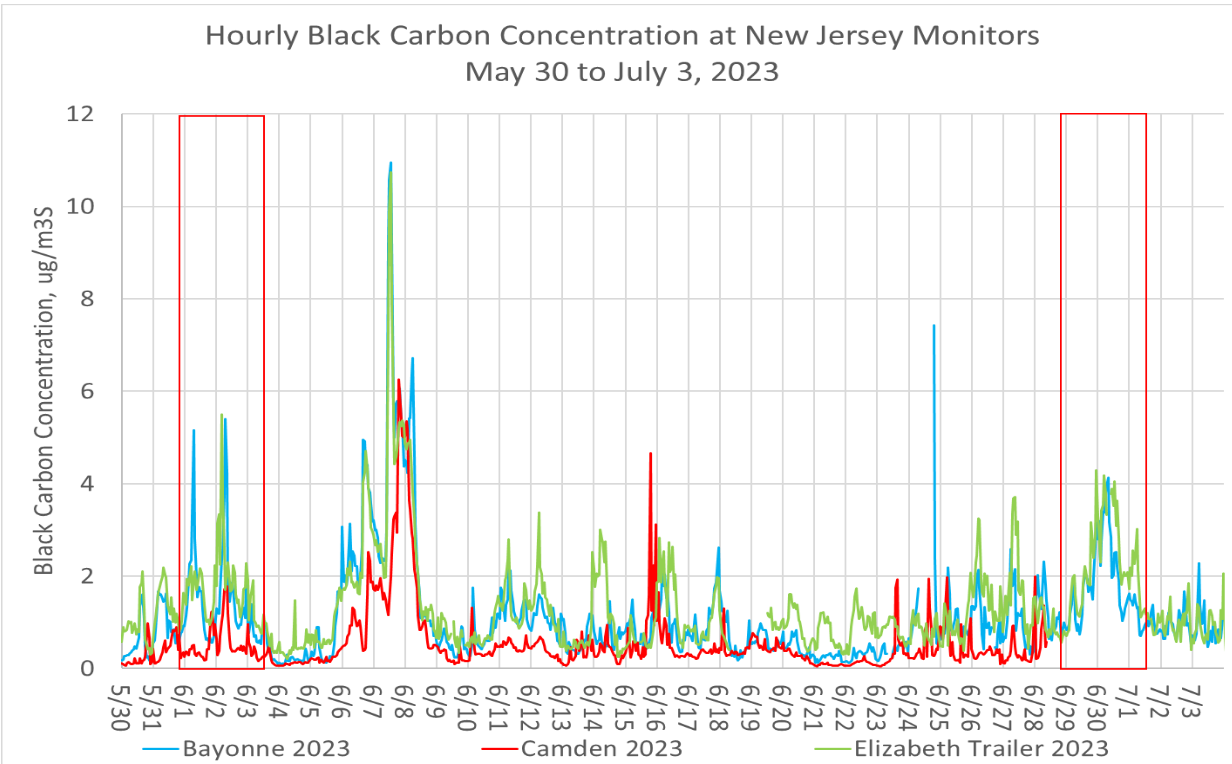
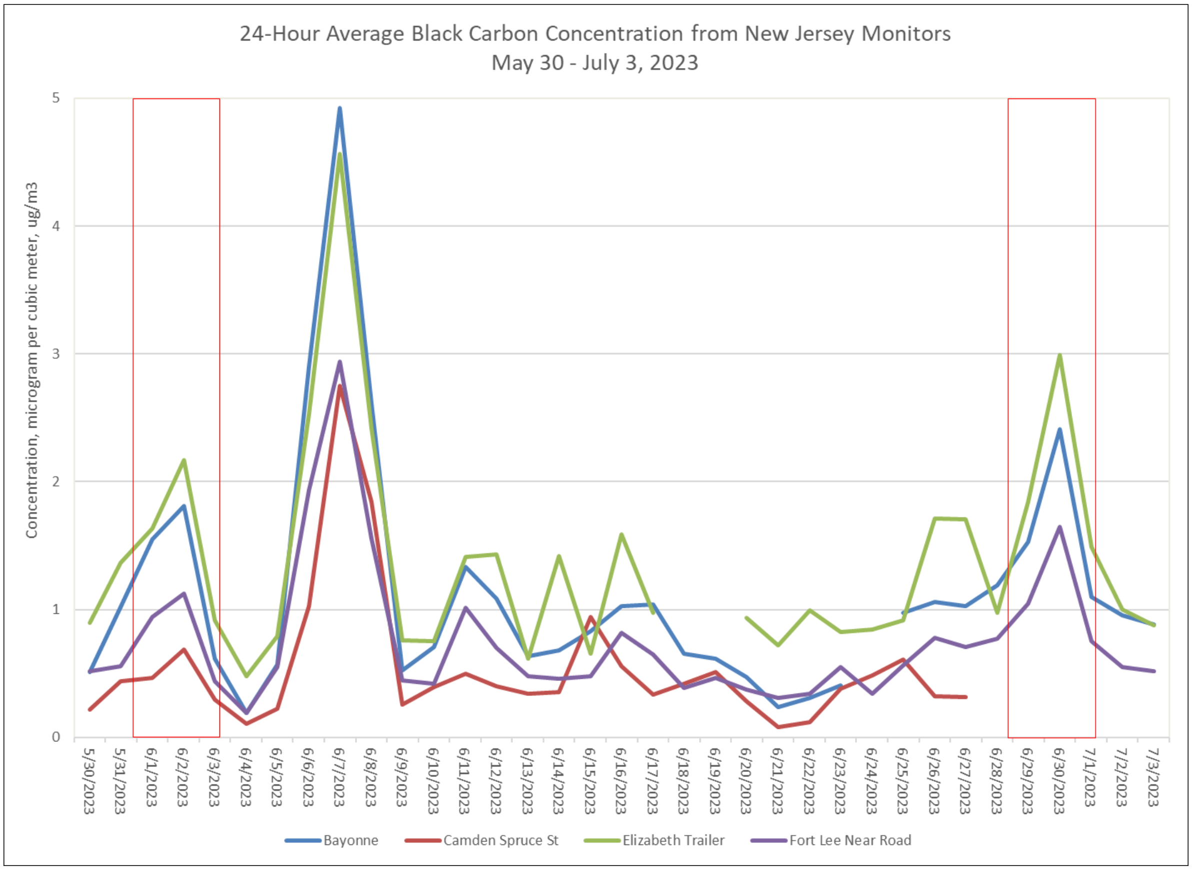


Figure 104: Daily Average Black Carbon Concentration at New Jersey Monitors, May 30 – July 3, 2023



4.2 Carbon Monoxide (CO)

Several research studies have investigated the impact of wildfires in Canada's boreal forests on trace gases and particles. One study determined that an intense wildfire event that occurred in northwestern Canada in June 1995 resulted in increased concentrations of carbon monoxide (CO) and ozone (O_3) concentrations in the midwestern and eastern United States. Therefore, a significant increase in carbon monoxide, in addition to other pollutants in the ambient air may signal a wildfire event.[110] New Jersey measures near-real time CO levels in the ambient air at five monitoring stations throughout the state.[111]

Figure 105 displays the hourly concentrations of CO between May 28 and July 2, 2023, while Figure 106 displays the daily average CO concentrations from May 31 to July 2, 2023. On June 2, elevated levels of CO are observed across all monitors, as highlighted within the red box.

In June 2023, the average hourly CO concentration at the Camden Spruce St monitor was 0.33 ppm, while the maximum hourly concentration on June 2 was 0.52 ppm. The average hourly concentration at Camden Spruce St for the period, April 1 to July 31, was 0.26 ppm. Comparing the maximum concentration on June 2 to the average June concentration and the seasonal average, it is evident that

[110] Yang, Z., Demoz, B., Delgado, R., Sullivan, J., Tangborn, A., & Lee P. (2022). Influence of the transported Canadian wildfire smoke on the ozone and particle pollution over the Mid-Atlantic United States. *Atmospheric Environment, 273*. Retrieved February 7, 2024, DOI: https://doi.org/10.1016/j.atmosenv.2022.118940
[111] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

the June 2 concentration significantly exceeds the norm, indicating elevated CO levels. This trend holds true for all monitors, with the June 2 maximum concentration consistently surpassing the average concentrations.

Figure 105: Hourly Carbon Monoxide Concentrations at New Jersey Monitors from May 28 to July 2, in 2023

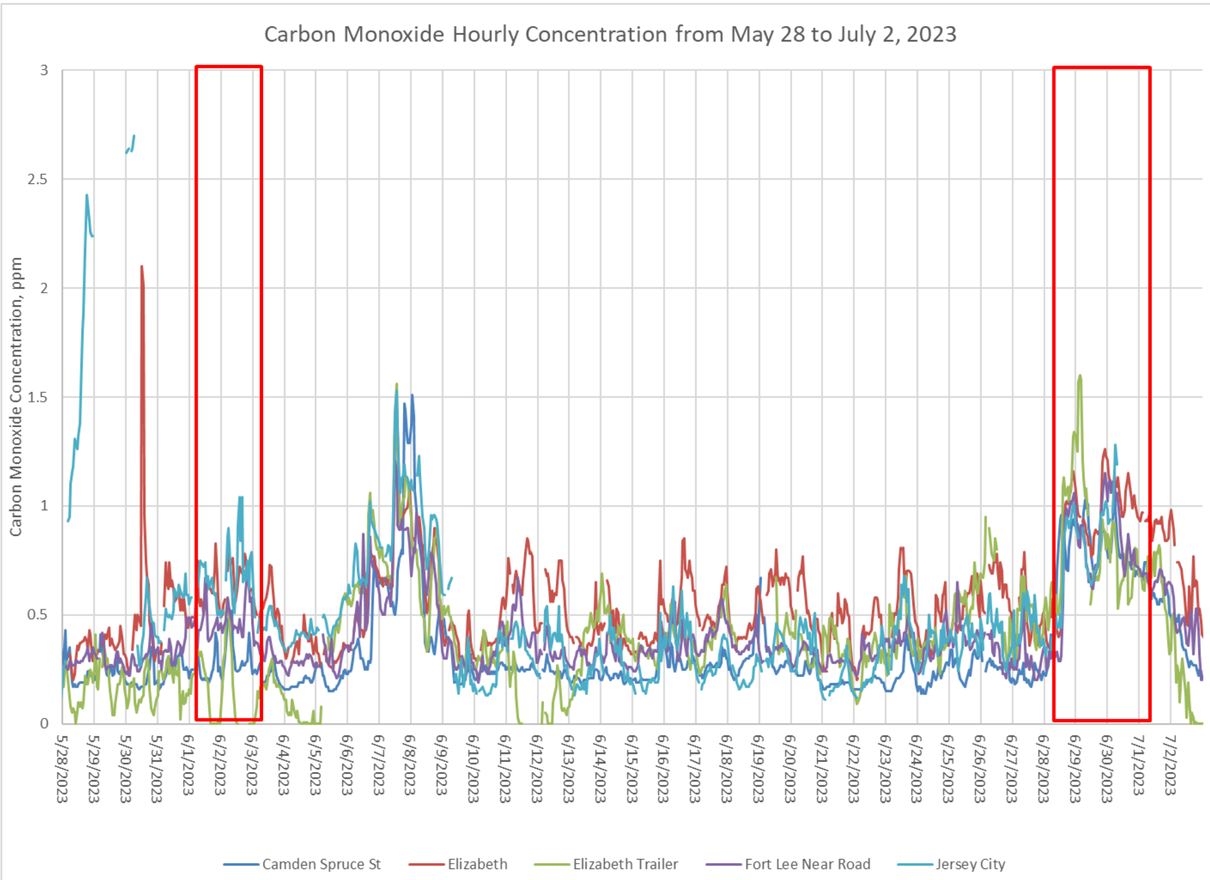
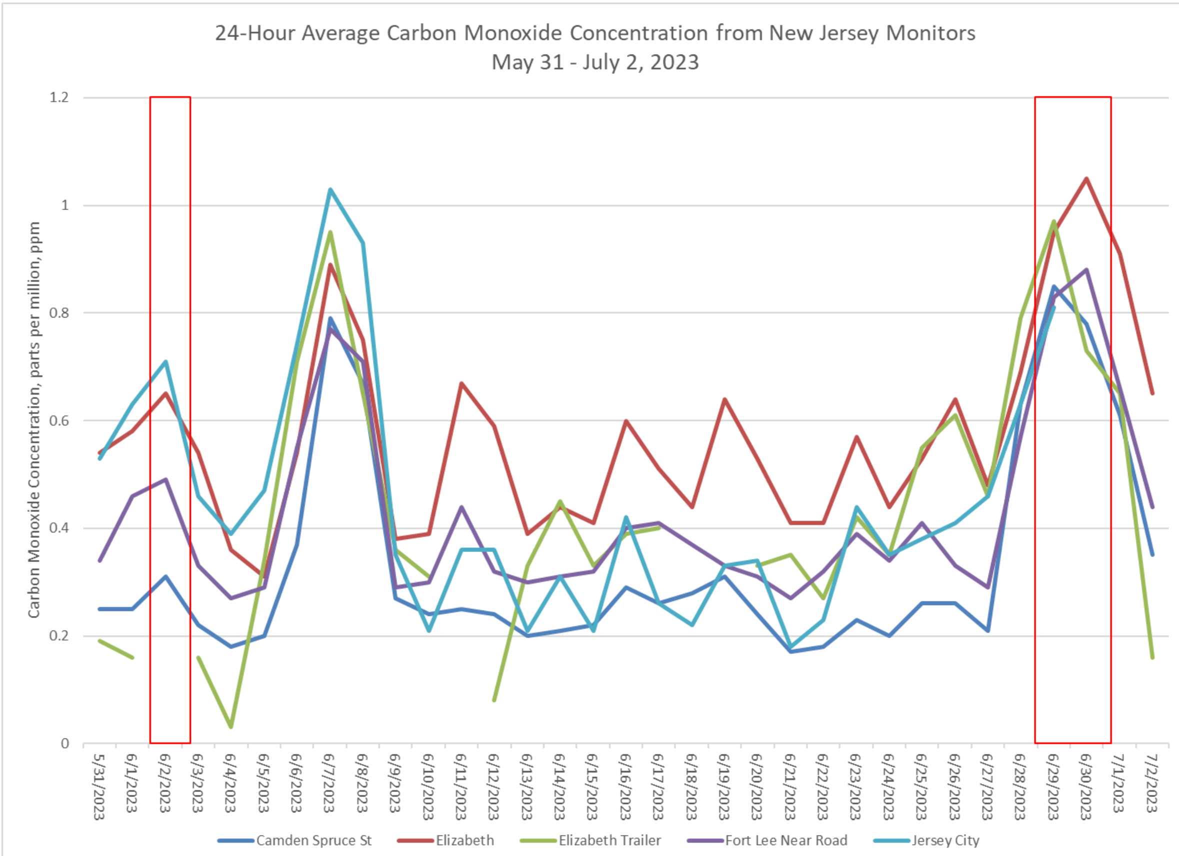


Figure 106: Daily Average Carbon Monoxide Concentrations at New Jersey Monitors from May 31 to July 2 in 2023



4.3 Nitrogen Dioxide (NO_2)

Nitrogen oxides (NOx) are emitted from wildfires and are precursors to ozone formation; therefore, analyzing NOx trends can provide additional evidence in demonstrating that the ozone exceedances on June 2 qualify as exceptional events. Two of the most common NOx compounds are nitrogen oxide (NO) and nitrogen dioxide (NO_2). NO oxidizes into NO_2 in the atmosphere. According to the USEPA, NO_2 often serves as an indicator for NOx levels.[112] New Jersey measures near-real time NO_2 levels in the ambient air at five monitoring stations throughout the state.[113]

Figure 107 displays the hourly NO_2 concentrations measured at the New Jersey Rutgers University monitor in June 2023. Figure 108 displays the corresponding daily average NO_2 concentrations in June 2023. On June 2, elevated levels of NO_2 values are observed, as highlighted within the red boxes. The maximum hourly NO_2 concentration on June 2 was 26 ppb, far exceeding the average hourly NO_2 concentration for June 2023, which was 5.37 ppb, and further surpasses the hourly average for June 2021-2023 of 4.65 ppb. The maximum daily average concentration in June 2023 also occurred on June 2. In summary, June 2, 2023, exhibited notable spikes in NO_2 levels, impacting both hourly and daily

[112] USEPA. (2023, July 25). *Basic Information about NO_2*. Retrieved February 7, 2024, from https://www.epa.gov/no2-pollution/basic-information-about-no2

[113] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

averages. These elevated levels surpassing historical norms are consistent with the conclusion that the ozone exceedance on June 2 was an exceptional event.

Figure 107: Hourly Concentration of NO_2 at the Rutgers Monitor in June 2023

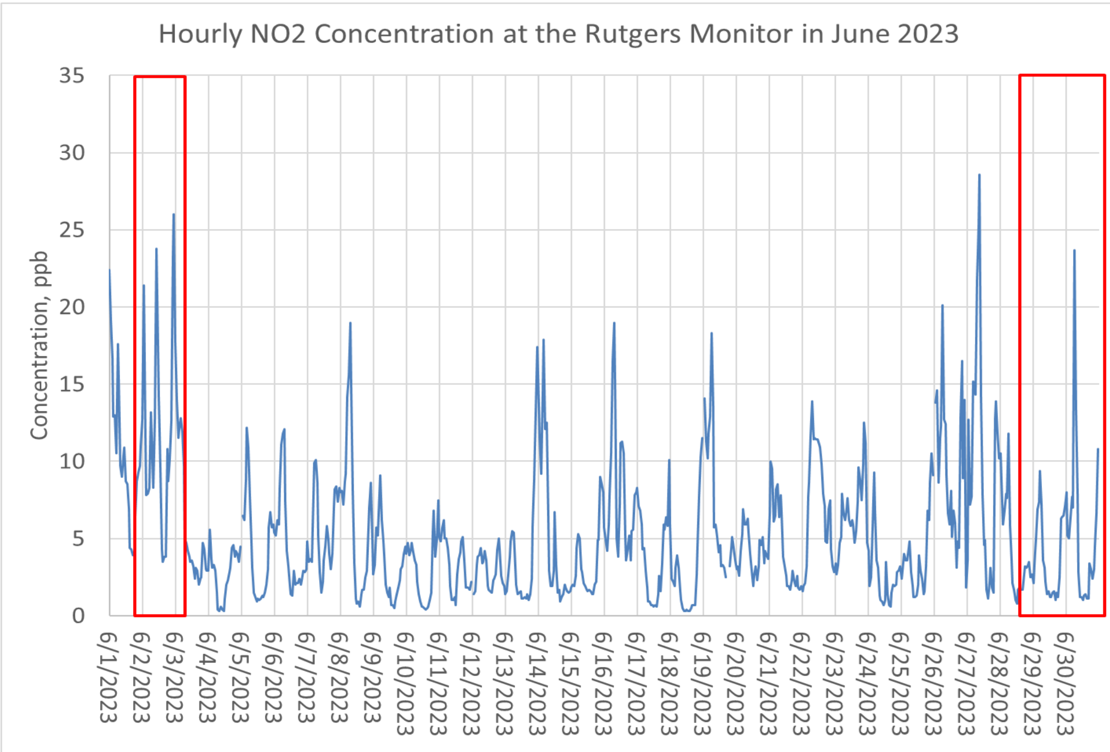
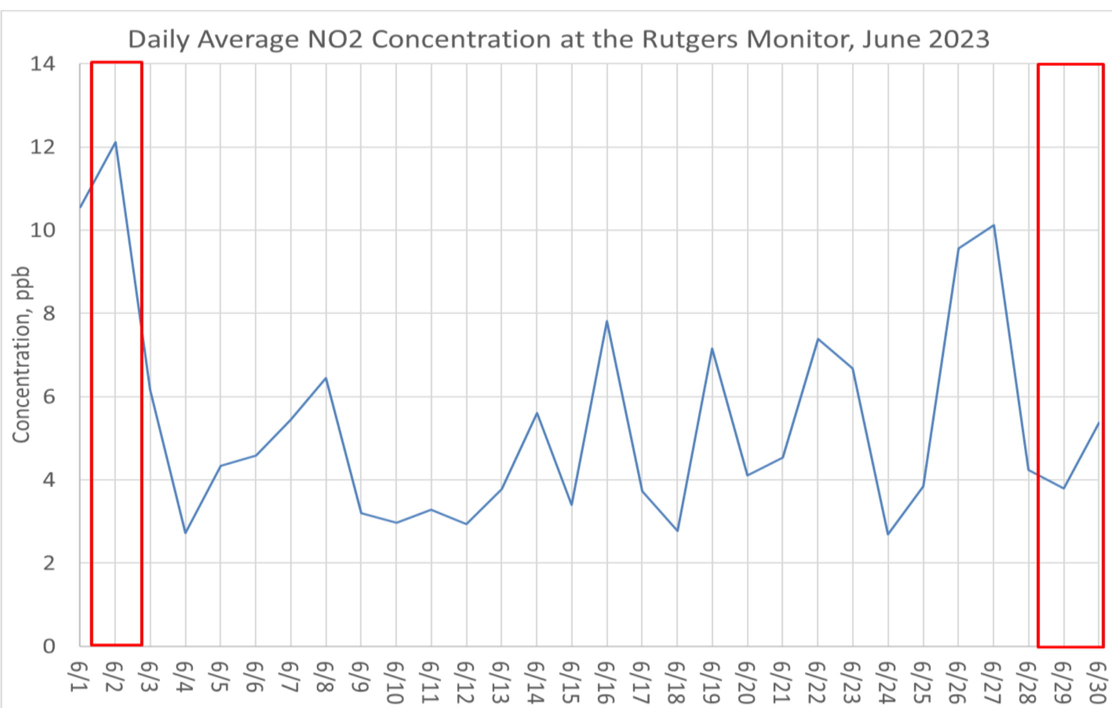


Figure 108: Daily Average Concentration of NO_2 at the Rutgers Monitor in June 2023



4.4 Non-Methane Volatile Organic Compounds (NMVOCs)

Non-methane volatile organic compounds (NMVOC) are considered one of the primary pollutants emitted from wildland fires, along with greenhouse gases, NOx, and aerosol.[114] In New Jersey, the Rutgers University monitor measures non-methane VOCs as part of the national Photochemical Assessment Monitoring Station (PAMS) program.

4.4.1 Formaldehyde (HCHO)

Formaldehyde (HCHO), one of the most abundant NMVOCs emitted by fires, is formed in fire plumes via VOC oxidation.[115] In this analysis, elevated formaldehyde levels are considered potential indicators of wildfire smoke presence.

Figure 109 and Figure 110 illustrate the hourly and daily average concentration of formaldehyde at the Rutgers monitor, with June 2 highlighted. Both graphs display elevated concentrations on June 2. Specifically, the hourly maximum concentration on June 2 was 8.29 parts per million by volume (ppbv), significantly surpassing the average hourly concentration of 2.11 ppbv. This maximum concentration was nearly four times larger than the typical hourly levels observed throughout the month. Similarly, the daily average concentration shows a similar peak in concentration on June 2, with levels consistently higher than those on the surrounding days. Overall, the formaldehyde concentration in June 2023 remained consistently low, except for the peaks around June 2 and June 7.

These elevated levels are consistent with the conclusion that the ozone exceedance on June 2 was an exceptional event.

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[114] Urbanski, S.P., Hao, W.M., & Baker, S. (2008). Chemical Composition of Wildland Fire Emissions. In Bytnerowicz, A, Arbaugh, M.J., Riebau, A.R., & Andersen, C. (Eds.), *Developments in Environmental Science* (Vol. 8, pp. 79-107). Elsevier. Retrieved January 24, 2024, DOI: 10.1016/S1474-8177(08)00004-1, https://www.fs.usda.gov/rm/pubs_other/rmrs_2009_urbanski_s001.pdf

[115] Liao, J., Wolfe, G.M., Hannun, R.A., St. Clair, J.M., Hanisco, T.F., Gilman, J.B., Lamplugh, A., Selimovic, V., Diskin, G.S., Nowak, J.B., Halliday, H.S., DiGangi, J.P., Hall, S.R., Ullmann, K., Holmes, C.D., Fite, C.H., Agastra, A., Ryerson, T.B., Peischl, J., … Neuman, J.A.. (2021). Formaldehyde evolution in US wildfire plumes during the Fire Influence on Regional to Global Environments and Air Quality experiment (FIREX-AQ). *Atmospheric Chemistry and Physics, 21*(24), 18319-18331. Retrieved December 3, 2023, DOI: 10.5194/acp-21-18319-2021, https://airbornescience.nasa.gov/content/Formaldehyde_evolution_in_US_wildfire_plumes_during_the_Fire_Influence_on_Regional_to_0 (Also see report in Non-methane VOC folder)

Figure 109: Hourly Concentration of Formaldehyde at the Rutgers University Monitor from May 22 to June 30, 2023

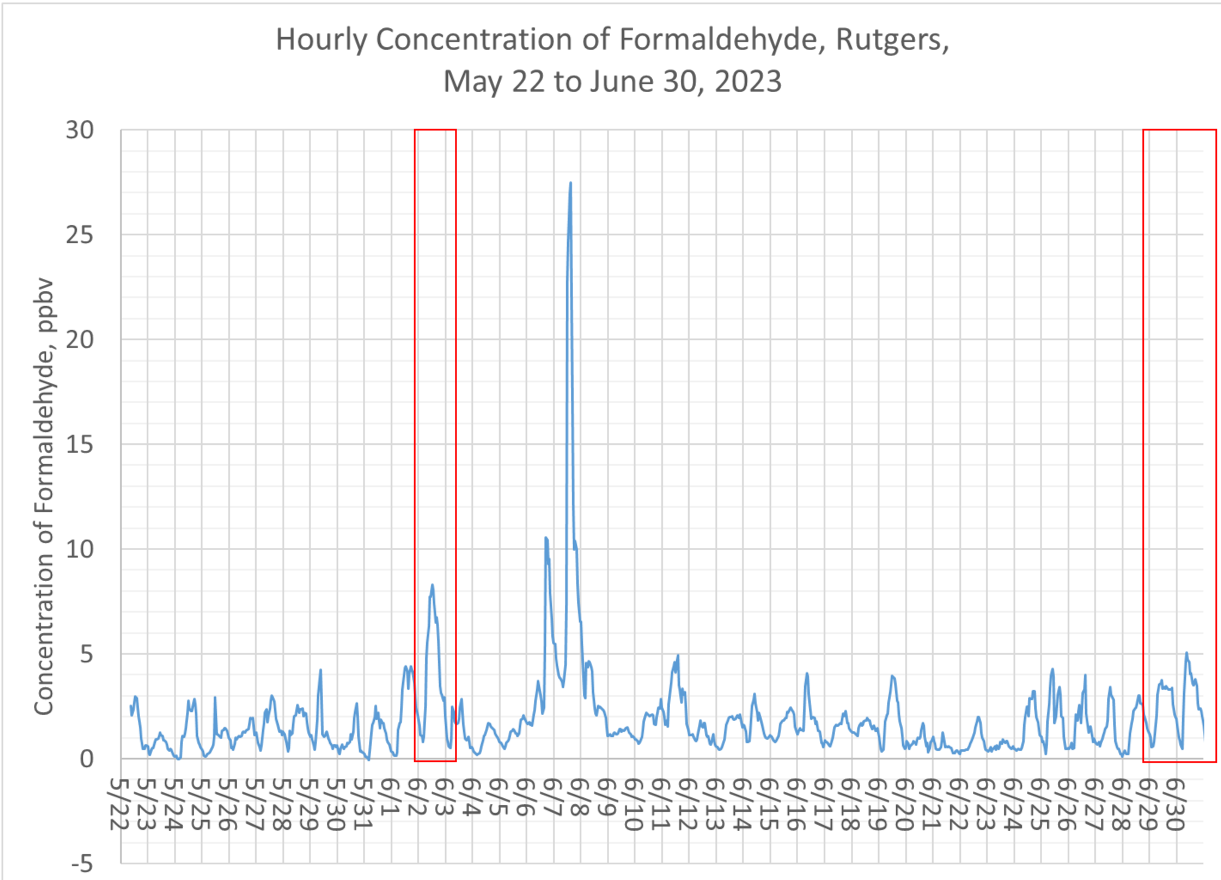
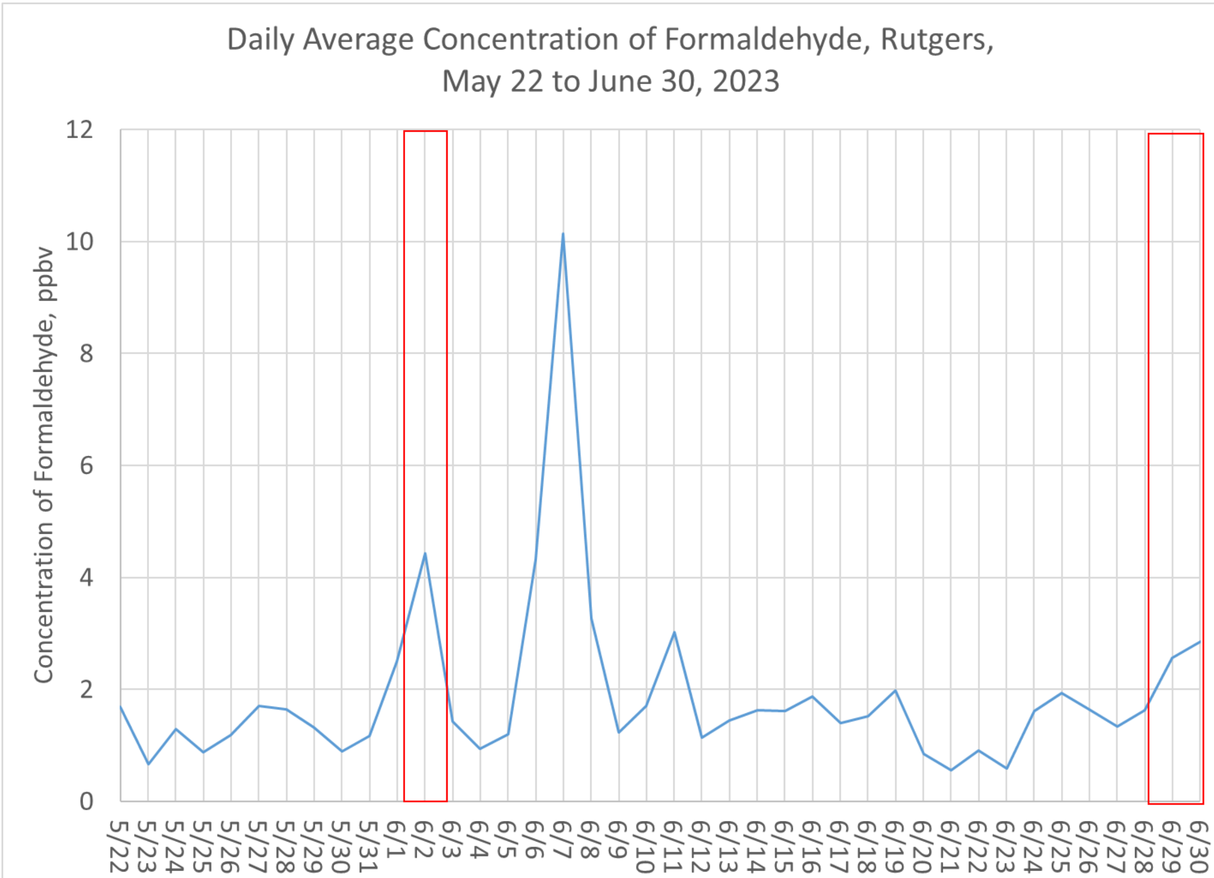


Figure 110: Daily Average Concentration of Formaldehyde at the Rutgers University Monitor from May 22 to June 30, 2023



4.4.2 Benzene (C_6H_6)

Wildfire smoke has also been documented to contain toxic carcinogens such as benzene.[116,117] Benzene is classified as an aromatic hydrocarbon, and research indicates that aromatic hydrocarbons constitute approximately 8 percent of emissions from wildfire.[118] In this analysis, we will interpret elevated

[116] Gould, C.F., Heft-Neal, S., Prunicki, M., Aguilera, J., Burke, M., & Nadeau, K. (2024). Health Effects of Wildfire Smoke Exposure. *Annual Review of Medicine, 75*(1), 227-292. Retrieved February 8, 2024, DOI: 10.1146/annurev-med-052422-020909, https://web.stanford.edu/~samhn/papers/Gould%20et%20al%202023%20-%20ARM.pdf (pdf in NMVOC folder)

[117] Kormacher, M. & Moore, A. (2023, July). *The Health Effects of Wildfire Smoke.* University of Washington Interdisciplinary Center for Exposures, Diseases, Genomics and Environment. Retrieved February 8, 2024, from https://deohs.washington.edu/edge/sites/deohs.washington.edu.edge/files/2023-09/Wildfire%20Smoke%20Fact%20Sheet%20JH%20VB%20EDITS.pdf (pdf saved in NMVOC folder)

[118] Urbanski, S.P., Hao, W.M., & Baker, S. (2008). Chemical Composition of Wildland Fire Emissions. In Bytnerowicz, A, Arbaugh, M.J., Riebau, A.R., & Andersen, C. (Eds.), Developments in Environmental Science (Vol. 8, pp. 79-107). Elsevier. Retrieved February 8, 2024, DOI: 10.1016/S1474-8177(08)00004-1, https://www.fs.usda.gov/rm/pubs_other/rmrs_2009_urbanski_s001.pdf

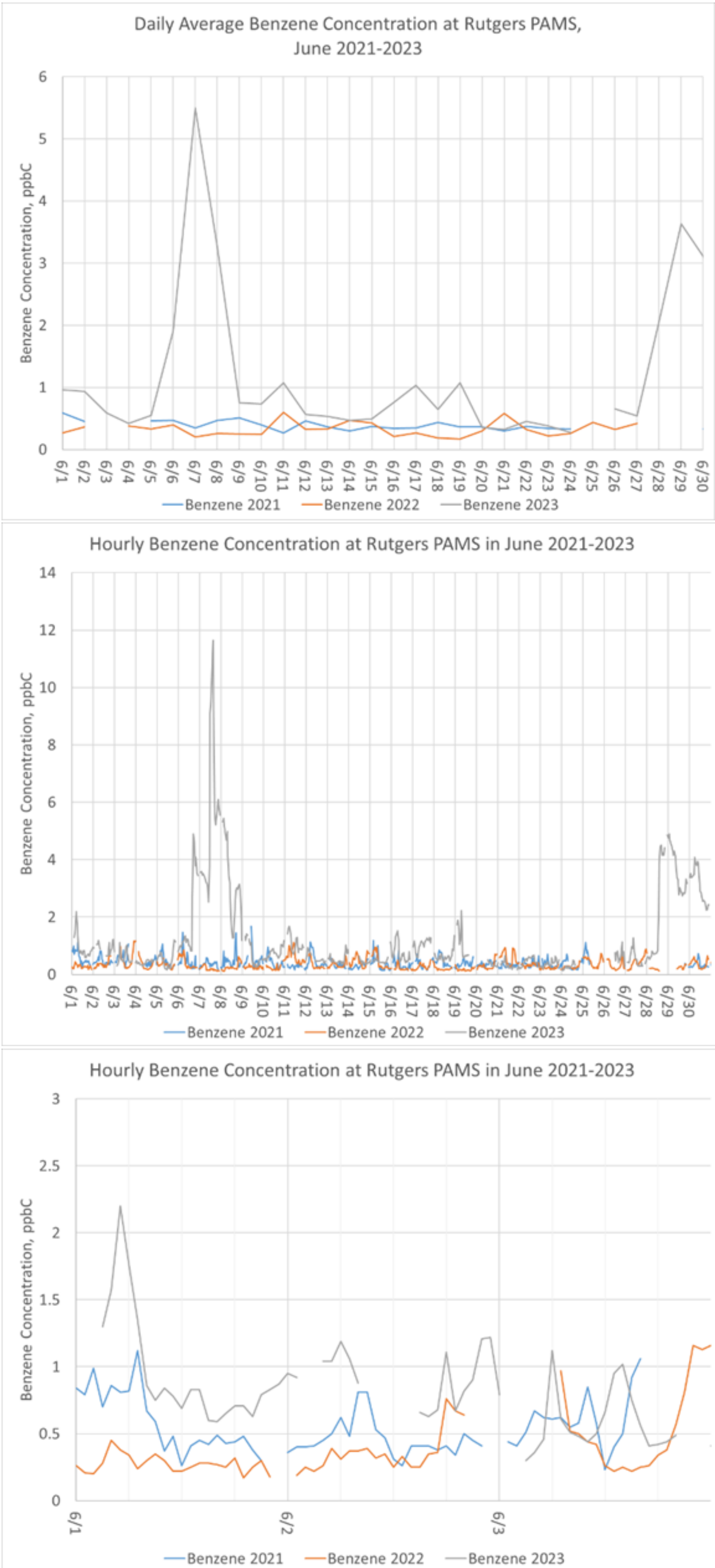
benzene levels as potential indicators of wildfire smoke presence, while acknowledging that benzene is a trace component and other factors may also contribute to its presence.

Figure 111 presents three figures that compare the benzene concentrations at the Rutgers PAMS monitor for the following: daily average concentrations in June from 2021 to 2023, hourly concentrations in June from 2021-2023 and hourly concentrations for June 1-2, 2023. The benzene values were consistently higher in 2023 compared to the preceding years. This trend is particularly evident in the daily average concentration graph. The June 1-3, 2023, graph highlights the hourly concentration on June 2, which was notably higher in 2023, than in 2022 and 2021. In summary, benzene concentrations exhibited elevated levels in June 2023.

On June 2, 2023, the average daily concentration was 0.94 parts per billion as carbon (ppbC), notably larger than the average concentration in June from 2021 to 2023, which was 0.66 ppbC. The maximum hourly concentration on June 2 was significantly higher, at 1.22 ppbC. The summer average concentration, including June through August, was 0.60 ppbC from 2021 to 2023, significantly less than the concentration on June 2, 2023.

These elevated levels surpassing historical norms are consistent with the conclusion that the ozone exceedance on June 2 was an exceptional event.

Figure 111: Benzene Concentrations (ppbC) at the Rutgers PAMS Monitor: Daily Average (top) and Hourly (middle) in June 2021-2023 and Hourly Graph from June 1-3, 2023 (bottom)



4.5 Non-Methane Hydrocarbons (NMHC)

Non-methane hydrocarbons are produced from wildfires and contribute to the enhancement of ozone formation to the ambient air.[119] In this analysis, we will interpret elevated levels as potential indicators of wildfire smoke presence, while acknowledging that these pollutants are trace components and other factors may also contribute to their presence.

The hydrocarbons examined include ethylene, propylene, ethane, propane, and n-butane.

[119] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

Figure 112 presents hourly concentrations of these hydrocarbons between June 1 and June 3 in 2021, 2022, and 2023. All five of the graphs of these hydrocarbons show a peak in concentration around 6:00 AM on June 2, 2023, and another increase from 6:00 PM through the end of the day on June 2, 2023. Additionally, the graphs reveal that non-methane hydrocarbon concentrations were consistently higher on June 2, 2023, compared to the preceding years. This trend is particularly evident in the daily average concentration graphs of these hydrocarbons during June in 2021, 2022, and 2023, as shown in Figure 113. Elevated levels within the red boxes in the graphs indicate the exceptional event on June 2.

Figure 112: Hourly concentration of non-methane hydrocarbons from June 1 to June 3 in 2021, 2022, and 2023 – a) Ethylene, b) Propylene, c) Ethane, d) Propane, and e) n-Butane

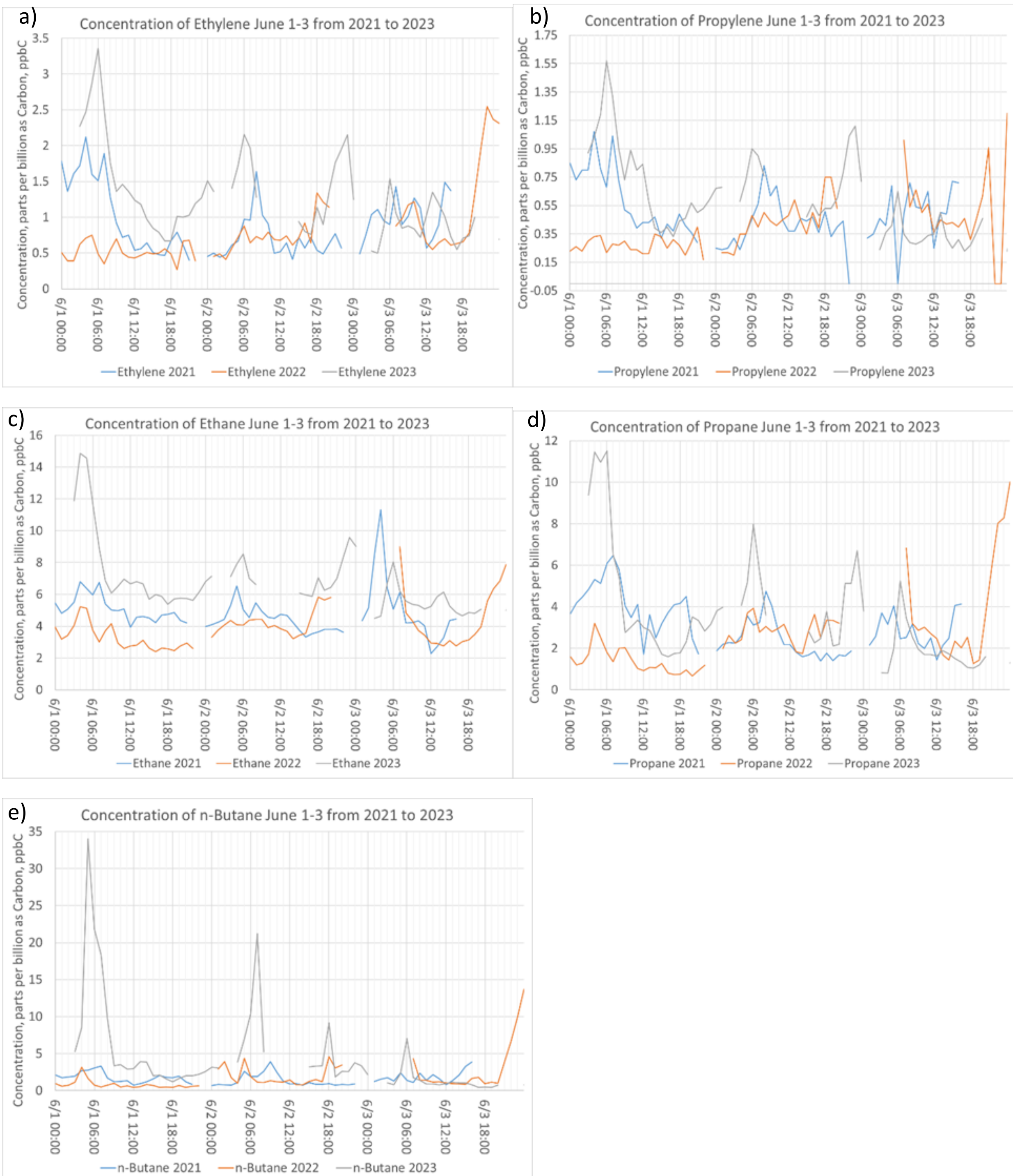
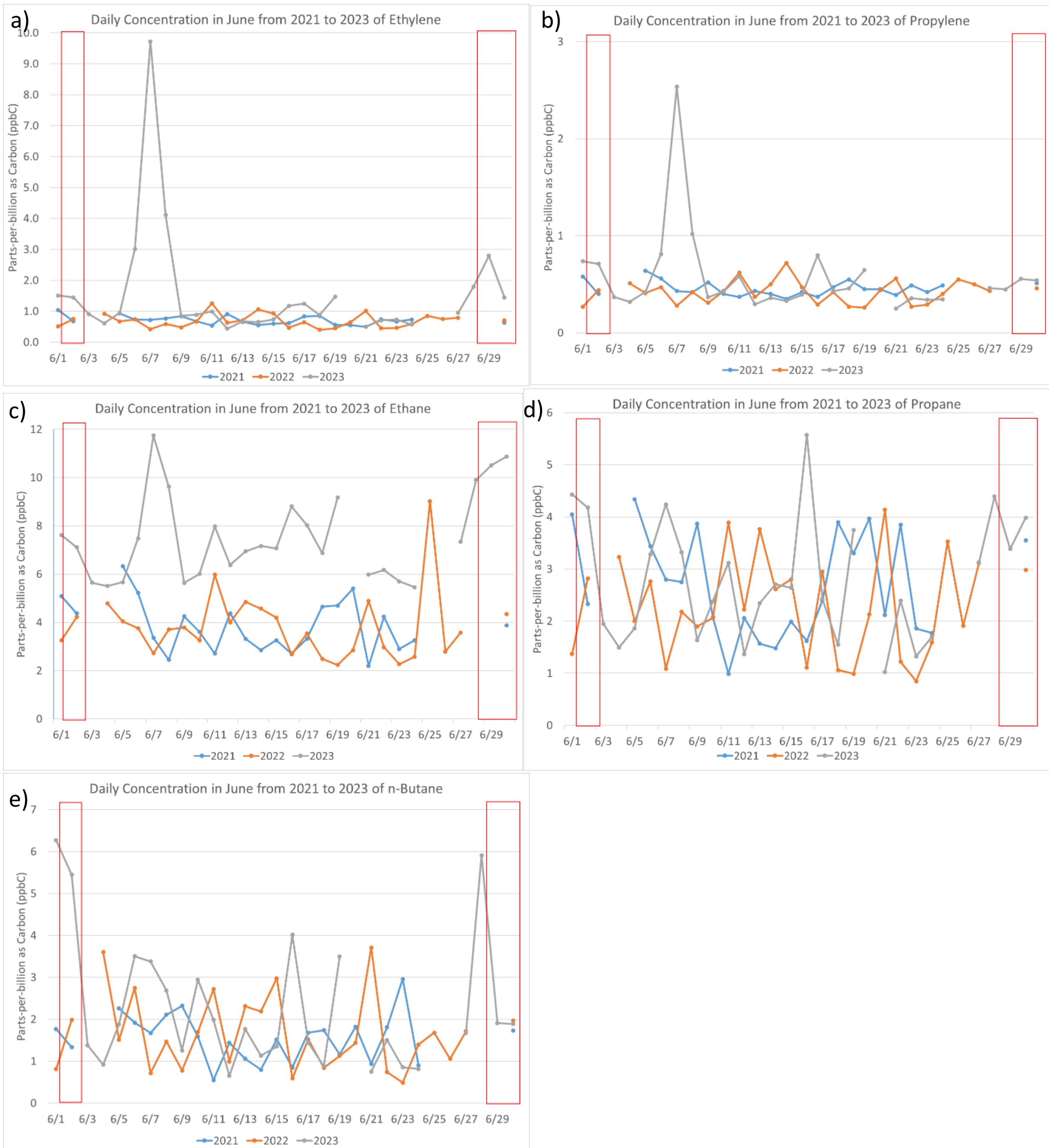


Figure 113: Daily concentration of non-methane hydrocarbons in June 2021, 2022, and 2023 – a) Ethylene, b) Propylene, c) Ethane, d) Propane, and e) n-Butane



4.6 Light Extinction

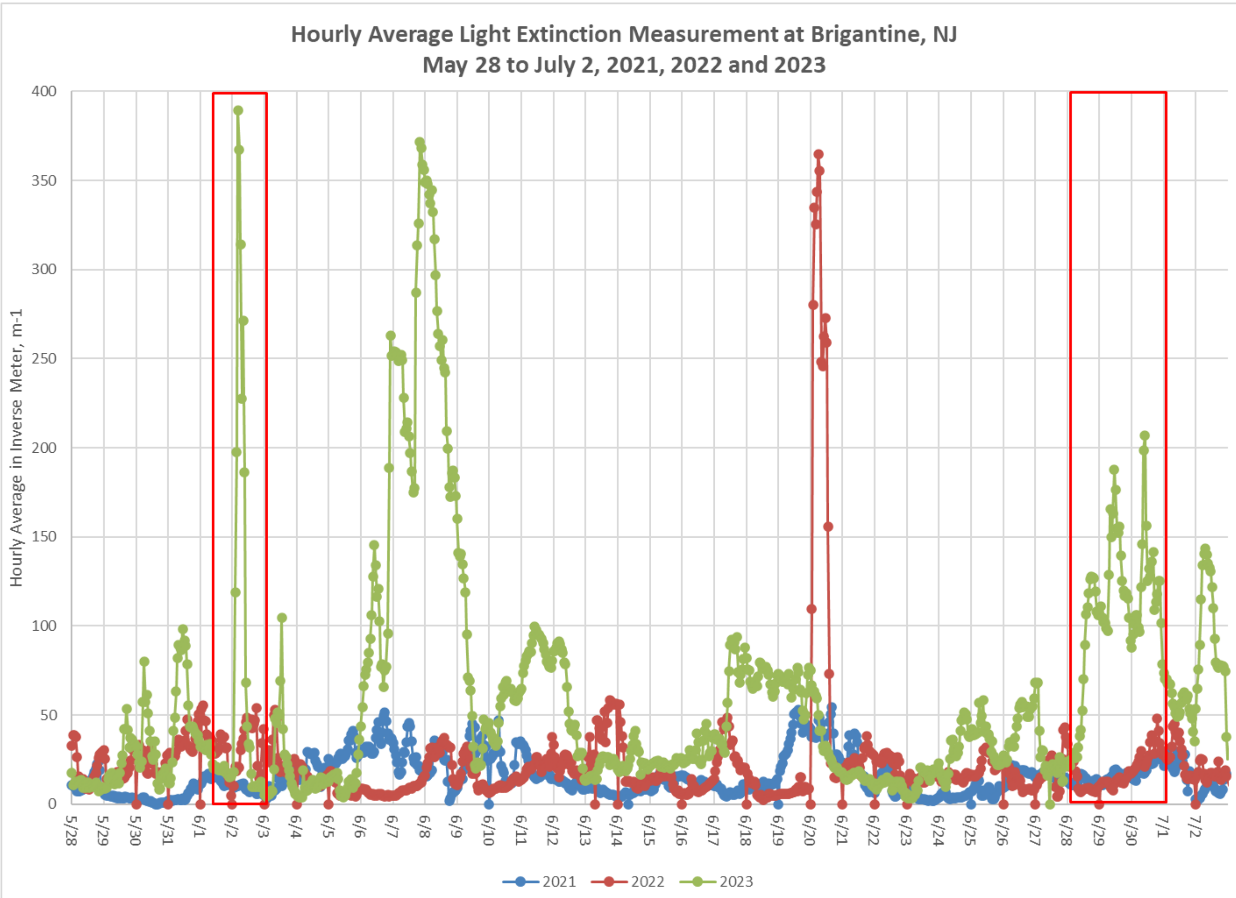
According to the USEPA Guidance, elevated light extinction measurements at or near the ozone monitoring site that cannot be explained by emissions from other sources and are consistent with wildfire impact can be used as evidence to support the impact of fire emissions on affected monitors.[120]

New Jersey measures visibility using a nephelometer at the Brigantine monitor. Light extinction data from April 1 to July 31, in 2021, 2022, and 2023 was obtained and analyzed. The highest light extinction concentration during this period, 389m-1, occurred on June 2, 2023. Figure 114 presents light extinction data from May 28 to July 2, in 2021, 2022, and 2023. A visible peak can be seen on June 2, 2023. As shown on the chart, the light extinction levels at Brigantine were generally low in 2021 and 2022, while 2023 had higher levels during this period. This peak can be attributed to the local fires that occurred in New Jersey on June 1; the Allen Road, Flat Iron and Fort Dix fires, and some smoke transport from the west-central Canadian wildfires.

Brigantine is located in a rural area and usually does not experience elevated light extinction levels; however, on June 2, 2023, the light extinction levels at Brigantine were higher-than-normal. Light extinction levels were also generally higher throughout June 2023 than at the same period in previous years. Therefore, considering the wildfire and smoke events of 2023, it is evident that the peak and elevated levels were caused by smoke from the fires.

[120] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

Figure 114: Average Hourly Visibility Light Extinction Measurement at the Brigantine, NJ Monitor from May 28 to July 2, in 2021, 2022, and 2023



4.7 Evidence of Changes in Spatial/Temporal Patterns of Ozone and NOx

This section presents satellite evidence of smoke and ozone precursors to demonstrate changes in the spatial and temporal patterns of ozone and NOx and the impacts on New Jersey monitors.

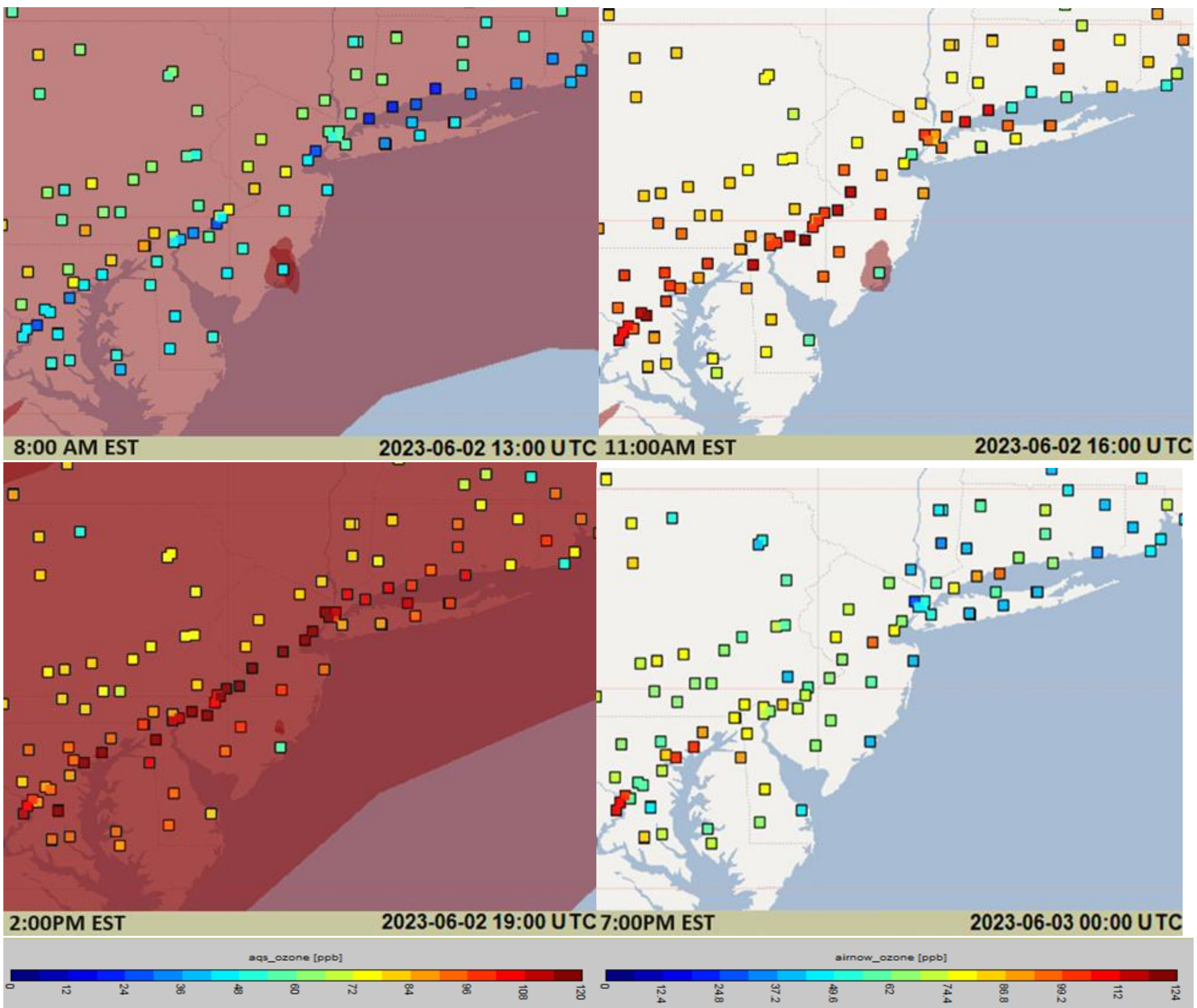
Videos of ozone and smoke patterns were generated using the Remote Sensing Information Gateway (RSIG) application, RSIG3D, and screenshots from the videos are presented below.[121] The videos present hourly monitoring data for nitrogen dioxide and ozone from USEPA AirNow and Air Quality System (AQS) data inventories. Smoke information was obtained from the National Aeronautics and Space Administration (NASA) Hazard Mapping System (HMS) Fire and Smoke Product data inventory. In Figure 115, the location of the smoke plume is indicated by dark red contours. The hourly data is reported in Coordinated Universal Time (UTC), which is five hours ahead of the local Eastern Standard Time (EST), therefore the data continues until 05:00 UTC the next day. EST will be used for this analysis. As indicated by the scale in Figure 115 and Figure 116, red represents higher ozone values and blue represents lower ozone values at the monitors.

[121] USEPA. (2024). *Remote Sensing Information Gateway (RSIG)* (Version 20231206). Retrieved January 25, 2024, from https://www.epa.gov/hesc/remote-sensing-information-gateway

4.7.1 Analysis of Changes in Spatial/Temporal Patterns of Ozone Using RSIG3D.

Figure 115 presents screenshots from a video (see Attachment 1) generated using RSIG3D. The video presents the ozone monitoring data with a smoke overlay for June 2, 2023. Unusually elevated ozone levels are observed throughout New Jersey on this day. At the beginning of June 2, the ozone levels were low. However, after 6:00AM EST (11:00 USC), ozone levels at the monitors began to rise. As seen in Figure 115, the smoke overlay at 8:00AM EST shows that the smoke levels began to increase. Several monitors began to violate the 70 ppb 2015 8-Hour ozone NAAQS at 9:00AM EST. Ozone concentration levels continued to rise in the hours that followed, and a denser smoke cloud can be seen in the HMS data during the subsequent timestamps. Around 2:00 PM, a line of monitors with extremely elevated ozone levels can be seen across surrounding states; NY, NJ, PA, DE, and MD. Ozone levels only began to decrease at 5:00PM, with some monitors still showing elevated levels, as observed at 7:00 PM in Figure 48. By 9:00PM - 10:00PM EST, the ozone concentration at the monitors returned to lower levels.

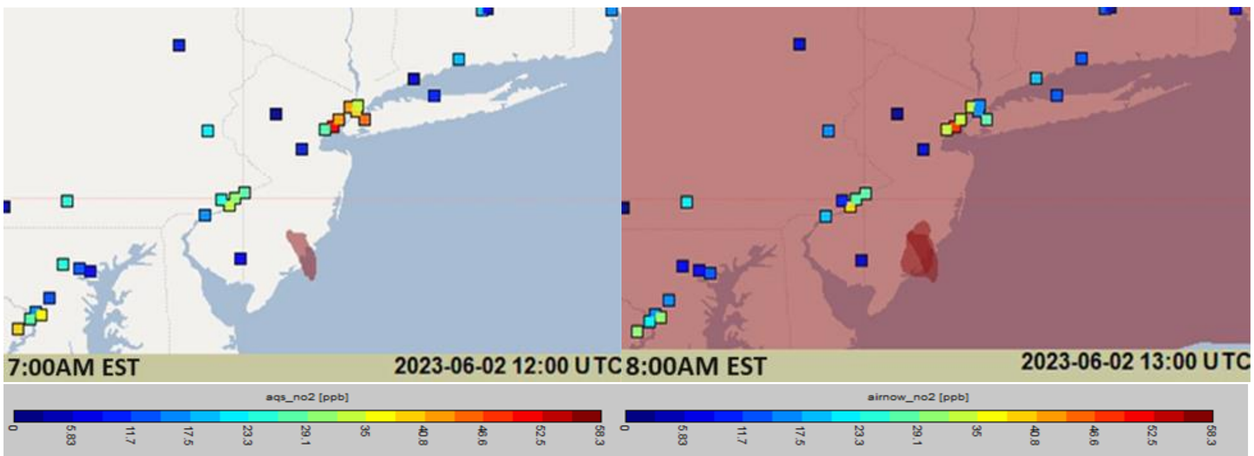
Figure 115: Ozone Monitoring and HMS Smoke Patterns on June 2, 2023



4.7.2 Analysis of Changes in Spatial/Temporal Patterns of Nitrogen Dioxide (NO_2) Using RSIG3D

Figure 116 presents screenshots from a video generated using RSIG3D. The video presents the nitrogen dioxide monitoring data with a smoke overlay for June 2, 2023. For most of the day, ozone concentrations at the northern NJ monitors were elevated, while the levels at the southern NJ monitors began increasing around 2:00AM EST and reached a peak around 7:00AM and 8:00AM EST. See Figure 116. The areas upwind of the monitors under consideration had a higher concentration and followed the pathway of the smoke plume before reaching the monitors in the Southern NJ-PA-MD-DE-nonattainment area. Nitrogen oxides are precursors to ozone, and when analyzing this alongside the ozone video from the same day, the peak time for nitrogen dioxide occurred at the same time that the ozone levels began increasing.

Figure 116: Nitrogen Dioxide Monitoring and HMS Smoke Patterns on June 2, 2023



4.8 Visual Photographic Evidence of Ground-level Smoke at the Monitor (Hazecam Pictures from Brigantine)

New Jersey uses remote cameras at Brigantine, NJ, to evaluate visibility conditions throughout the year.[122] Figure 117 and Figure 118 show pictures taken during and after the exceptional event that occurred in New Jersey on June 2, 2023. On June 2, the skylines of Atlantic City were obscured, discolored, and hazy in appearance. However, on June 5, days after the exceptional event, when the smoke plume moved out of the southern parts of the state, a noticeable improvement in visibility and haze conditions occurred.

[122] Camnet (n.d.). Visibility Hazecam. https://hazecam.net/

Figure 117: Hazecam Picture from Brigantine, NJ on June 2, 2023, 8:00 AM EST

Figure 118: Hazecam Picture from Brigantine, NJ on June 5, 2023, 11:15 AM EST

III. Analyses Comparing the Claimed Event-Influenced Concentrations to Concentrations at the Same Monitoring Site at Other Times

A similar day analysis identifies specific meteorological conditions observed on the exceptional event day (in this case June 2, 2023) and compares those conditions to other days with the same conditions in past history but did not yield unusually elevated ozone concentrations. Therefore, days with similar meteorology when no smoke is present should not produce ozone exceedances of the same magnitude. No data from the year 2020 was used in the similar day analysis due to the unusual anthropogenic emissions conditions caused by the pandemic.

The parameters/criteria that were used for the reference day meteorology include the following:

- Surface analysis showing high pressure over Great Lakes/northeast;
- High temperature at KPHL and/or KPNE 90° F or higher;[123]
- 0.00" precipitation;
- General surface wind direction out of the northeast;
- No ozone exceedances (or 1 questionable, isolated exceedance);
- Solar radiation data from Bristol, PA monitor favoring mostly sunny skies;[124,125]
- Length of day/Peak sun angle;

Figure 119 presents surface analysis for the reference day, June 2, 2023.

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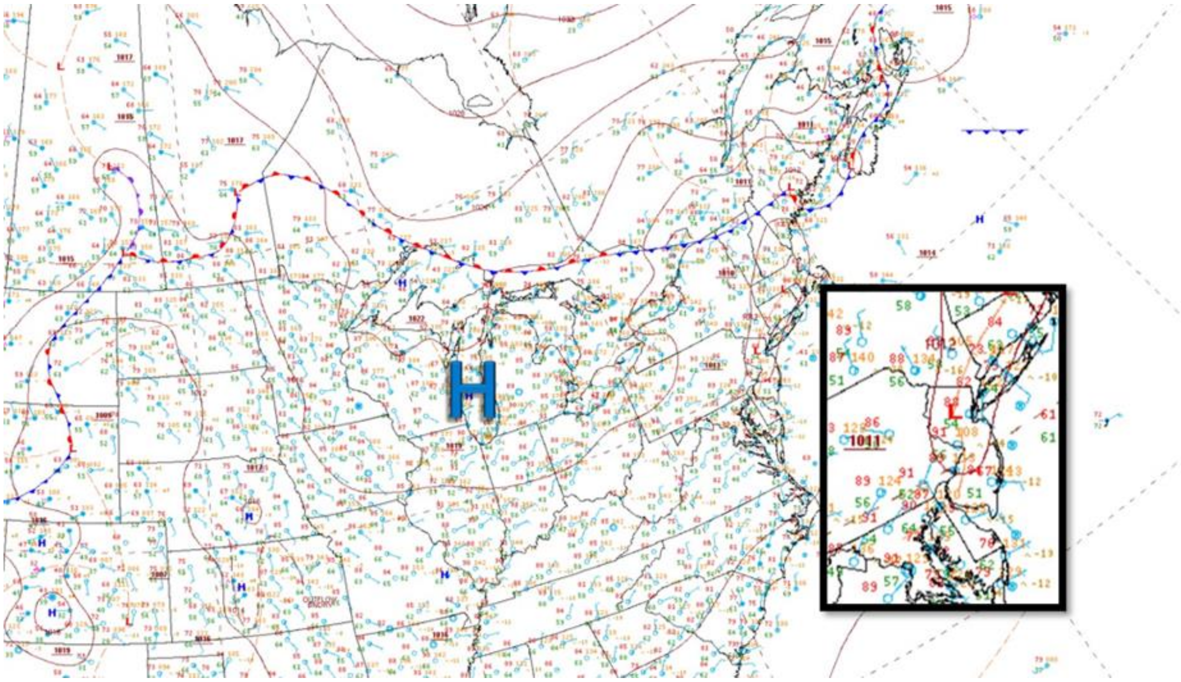
[123] KPHL is the International Civil Aviation Organization (ICAO) code for Philadelphia International Airport. KPNE is the ICAO code for Northeast Philadelphia Airport.

[124] Office of Energy Efficiency & Renewable Energy, Department of Energy. (n.d.) *Solar Radiation Basics*. https://www.energy.gov/eere/solar/solar-radiation-basics#:~:text=Solar%20radiation%2C%20often%20called%20the,using%20a%20variety%20of%20technologies
Solar radiation data the amount of energy that the sun emits and reaches the Earth's surface.

[125] National Solar Radiation Database. (n.d.) https://nsrdb.nrel.gov/
Solar radiation data is used to calculate the amount of solar energy that can be captured for various applications.

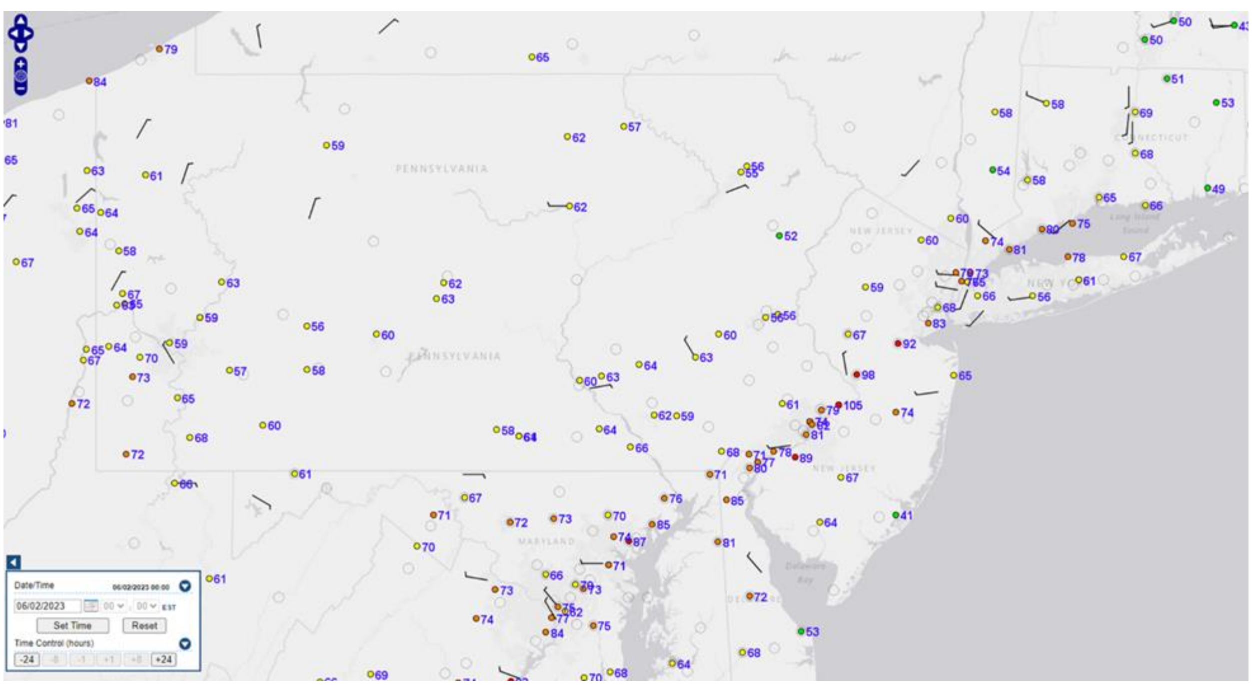
Figure 119: Reference Day Surface Analysis– June 2, 2023, 12UTC



Note: Surface high pressure marked with blue "H". Surface temperatures indicated by red numbers showing nearby range from 87-91 degrees F. Mostly sunny skies indicated by blue wind barbs with hollow circles.

Figure 120 presents the maximum 8-hour ozone concentration on the reference day, June 2, 2023.

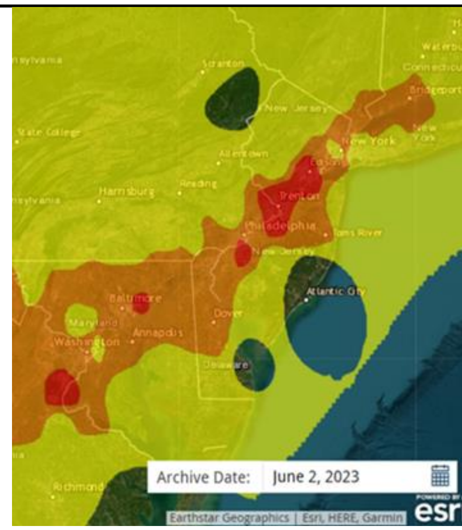
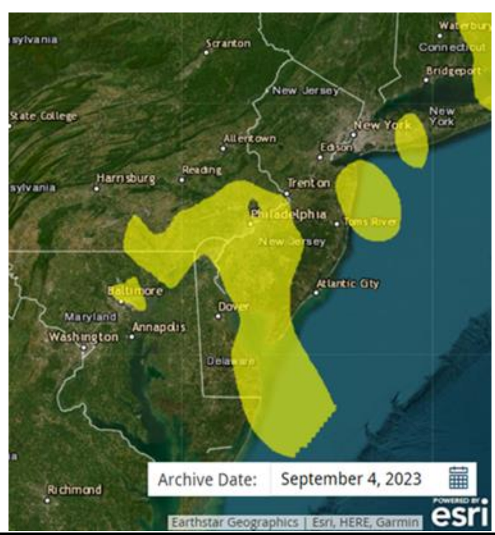
Figure 120: Reference Day 8hr Max Ozone Concentrations on June 2, 2023

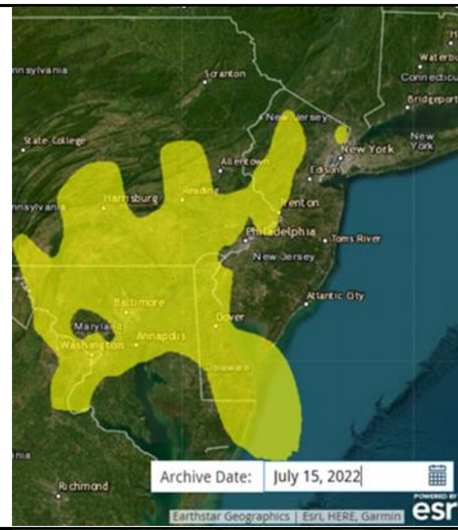
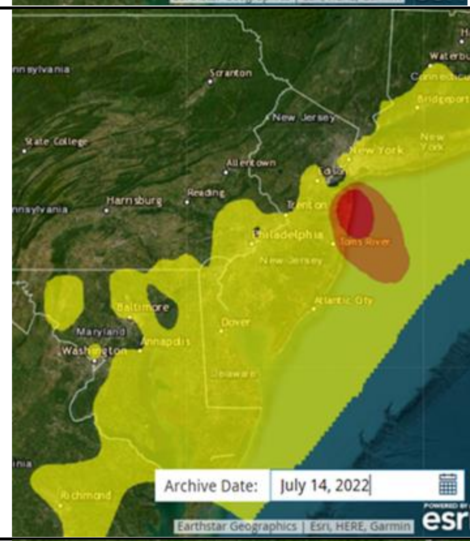
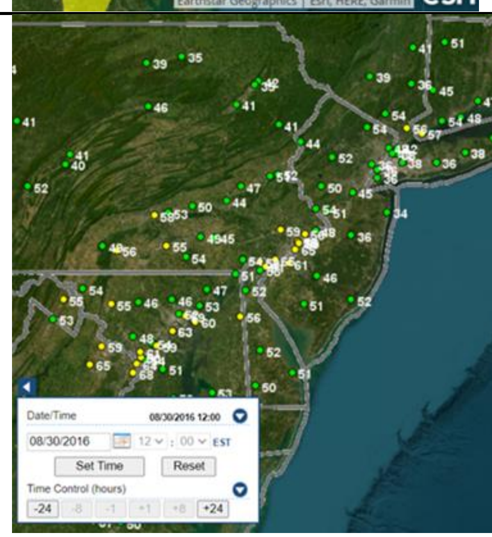


Based on the surface analysis and ozone concentrations represented in Figure 119 and Figure 120, Table 18 presents dates that were chosen as similar days for June 2, 2023 because they were characterized by similar meteorological conditions. As noted in Table 18, while the meteorological conditions were similar, the ozone levels on these days were not elevated listed as seen on June 2, 2023. Therefore, the widespread ozone exceedance concentrations on June 2, 2023 can be attributed to an exceptional event due to wildfire smoke.

Table 18: Similar Day Comparison of Max Ozone Concentration, Max Temperature, and AQI Map for June 2, 2023

Note: Ozone (ppb) represents the monitor that recorded the highest observed ozone concentration on the specified day in the New Jersey portion of the Southern NJ-PA-DE-MD nonattainment area. Temperature represents the highest recorded temperature on specified date at KPHL.

Date	Ozone (ppb)	Temp (F)	AQI Map
Reference Day June 2, 2023	98	95	
September 4, 2023	60 - Camden	96	

July 15, 2022	54 - Clarksboro	90	
July 14, 2022	67 – Colliers Mills	92	
August 30, 2016	65 - Camden	90	

IV. A Demonstration that the Exceptional Event was Both Not Reasonably Controllable and Not Reasonably Preventable

According to the Clean Air Act and the Exceptional Events Rule, an exceptional event must be "not reasonably controllable or preventable."[126,127] The USEPA states in its July 2018 "Update to Frequently Asked Questions" for the 2016 Revisions to the Exceptional Events Rule "it is presumptively assumed that if evidence supports that a wildfire occurred on wildland, such a wildfire event will satisfy both factors of the "not reasonably controllable or preventable" criterion, provided the Administrator determines that there is no compelling evidence to the contrary in the record."[128] The USEPA Exceptional Event Guidance also states that wildfire events on wildland are not generally reasonable to control or prevent.[129]

As previously stated in this document and reported in news articles, the Canadian and New Jersey fires pertinent to this demonstration, were ignited by lightning, accidental human activities, or unknown sources, and occurred in wildland areas.[130,131,132,133] The Canadian wildfires, which occurred outside of the United States can be considered not reasonably controllable or preventable by New Jersey. The New Jersey fires were wildfires on wildland, and NJDEP is not aware of any evidence clearly demonstrating that prevention or control efforts beyond those that were made would be reasonable. Therefore, emissions from these wildfires were not reasonably controllable or preventable and meet the criterion for an exceptional event.

V. Caused by Human Activity that is Unlikely to Recur at a Particular Location or a Natural Event

According to the CAA and the Exceptional Events Rule, an exceptional event must be "an event caused by human activity that is unlikely to recur at a particular location or a natural event"[134,135] The Exceptional Events Rule's definition of wildfire is "… any fire started by an unplanned ignition caused by lightning;

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[126] 42 U.S.C. 7401 et seq.
[127] 40 CFR 50.14
[128] USEPA. (2018, July). *2016 Revisions to the Exceptional Events Rule: Update to Frequently Asked* Questions.
[129] 42 U.S.C. 7619(b)(1)(iii), *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentration*s. EPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. Page 30: https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf
[130] Korte, C. (2023, June 27). How did the Canadian wildfires start? A look at what caused the fires that are sending smoke across the U.S. *CBS News*. https://www.cbsnews.com/news/how-did-wildfires-in-canada-start-spread-to-europe-midwest/
[131] Reuters. (2023, August 19). Canada wildfires: what are the causes and when will it end. https://www.reuters.com/world/americas/canadas-record-wildfire-season-whats-behind-it-when-will-it-end-2023-08-17/
[132] Yousif, N. (2023, June 1). Nova Scotia battles its largest wildfire on record. *BBC*. https://www.bbc.com/news/world-us-canada-65755795
[133] Ignudo, T. (2023, June 20). Lightning strikes caused 2 different New Jersey wildfires, officials say. *CBS News*. https://www.cbsnews.com/philadelphia/news/new-jersey-wildfires-acron-hill-flatiron-burlington-county/
[134] 42 U.S.C. 7401 et seq.
[135] 40 CFR 50.14

volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event." [136,137]

The fires examined in this analysis, encompassing both west central Canada and New Jersey fires, are categorized as wildfires. Sections I and II of this demonstration provide detailed descriptions and visual representations, demonstrating that these fires meet the criteria for being considered a "natural event". The unplanned fires were ignited by lightning in wildland areas or due to unknown causes. The USEPA generally considers the emissions of ozone precursors from wildfires on wildland to meet the regulatory definition of a natural event at 40 CFR 50.1(k), defined as one 'in which human activity plays little or no direct causal role.' As such, NJDEP has demonstrated that these events qualify as natural occurrences and may be considered for treatment as exceptional events.

[136] 42 U.S.C. 7619(b)(1)(iii), *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentration*s. EPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. Page 30: https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[137] 40 CFR 50.1(n)

Exceptional Event Demonstration Analysis for Ozone During June 29 and 30, 2023

I. A Narrative Conceptual Model and a Discussion of the Event that Led to Exceedances at New Jersey Monitors

1. A Description of New Jersey's Ozone Nonattainment Areas

New Jersey is associated with two multi-state nonattainment areas: the New York-Northern New Jersey-Long Island Nonattainment area (hereafter referred to as the Northern New Jersey-New York-Connecticut or Northern NJ-NY-CT Nonattainment area) and the Philadelphia-Wilmington-Atlantic City Nonattainment area (hereafter referred to as the Southern New Jersey-Pennsylvania-Delaware-Maryland or Southern NJ-PA-DE-MD Nonattainment Area). The Northern NJ-NY-CT Nonattainment area includes counties in the states of New York and Connecticut and the New Jersey counties of: Bergen, Essex, Hudson, Hunterdon, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union, and Warren. The Southern NJ-PA-DE-MD Nonattainment area includes counties in the states of Pennsylvania, Delaware, and Maryland and the New Jersey counties of: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Ocean, and Salem. The entire State of New Jersey is classified as Moderate nonattainment for the ozone health standard of 70 parts per billion (ppb) with an attainment deadline of August 2024.

2. Non-Event Ozone Formation in the New Jersey Nonattainment Areas

New Jersey typically experiences high ambient air ozone levels in the summer months. This section of the document discusses the normal patterns of ozone formation in New Jersey's air to characterize how the April 13, 2023, June 2, 2023, June 29 and 30, 2023 exceptional events caused by various wildfires differs from the usual weather patterns and locations of emissions that cause New Jersey to exceed the National Ambient Air Quality Standard (NAAQS) for ozone.

The evolution of elevated ozone episodes in the eastern U.S. often begins with the movement of a large air mass from the Midwest to the middle or southern Atlantic states, where it assimilates into and becomes an extension of the Atlantic (Bermuda) high pressure system.[138] During its movement east, the air mass accumulates air pollutants emitted by large coal-fired power plants and other sources located outside the Ozone Transport Region (OTR). As the air mass passes over the eastern U.S., sources within the OTR contribute to the air pollution. These expansive weather systems are conducive to the formation of ozone by creating a vast area of clear skies and high temperatures. These two prerequisites for elevated ozone formation are further compounded by a circulation pattern favorable for pollution transport over large distances. In the worst cases, the high-pressure systems stall over the eastern U.S. for days, creating ozone episodes of strong intensity and long duration.

The transport patterns (high pressure) that are conducive to ozone formation often carry ozone/pollutants within them, which can come from locations of farther distance. High pressure systems have a gentle sinking motion (subsidence) that causes air to sink and enhances stagnation of pollutants at the surface. As a result, air traveling more slowly and being trapped at the surface allows the pollutants to accumulate. Under a strong area of high pressure, the mechanisms that usually disperse

[138] NJDEP. (2007). *State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standard 8-Hour Ozone Attainment Demonstration Final, Chapter 2: Nature of the ozone air quality problem in the northeast – the conceptual model*. https://dep.nj.gov/wp-content/uploads/airplanning/1997-8-hour-ozone-2007/final_completesip.pdf

pollutants are not present, which leads to a shorter boundary layer giving the pollutants less "volume" to disperse among compared to if the boundary layer was higher/taller. Also, winds that typically disperse pollutants over large areas are not present, so all the pollution generated/transported becomes trapped in very low levels.

One transport mechanism that can play a key role in moving pollution long distances is the nocturnal, low-level jet stream. The jet is a regional scale phenomenon of higher wind speeds that often forms during ozone events a few hundred meters above the ground. It can convey air pollution several hundreds of miles overnight from the southwest to the northeast, directly in line with the major population centers of the Northeast Corridor stretching from Washington, D.C. to Boston, Massachusetts. The nocturnal, low-level jet extends the entire length of the corridor from Virginia to Maine and has been observed as far south as Georgia. It can thus be a transport mechanism for bringing ozone and other air pollutants into the OTR from outside the region, as well as to move locally formed air pollution from one part of the OTR to another. Other transport mechanisms occur over smaller scales, including land, sea, mountain, and valley breezes that can selectively affect relatively local areas.[139]

The different transport regimes into and within the OTR provide a conceptual picture of unhealthy ozone air quality days. Normally air cools as elevation increases above ground level. However, a nocturnal temperature inversion can occur after sunset if the ground cools faster than the air above it. In this instance, air temperature increases with elevation, which creates a stable boundary layer that prevents the vertical movement of air and thus traps pollutants near the ground. The stable boundary layer extends from the ground to only a few hundred meters in altitude. The air movement within the stable boundary layer is also minimal due to friction from the ground, and ground-level structures. Above this stable boundary layer, a nocturnal low-level jet can form with higher velocity winds due to the absence of frictional forces. Ozone contained in the low-level jet is unable to mix down to the ground because of the presence of a temperature inversion and is thus not subject to removal on surfaces or chemical destruction. Ozone in high concentrations can be entrained in the nocturnal low-level jet and transported several hundred kilometers downwind overnight. The next morning, as the sun heats the Earth's surface, the nocturnal boundary layer begins to break up, and the ozone transported overnight mixes down to the surface where concentrations rise rapidly, partly from mixing and partly from ozone generated locally. By the afternoon, abundant sunshine combined with warm temperatures promotes additional photochemical production of ozone from local emissions. As a result, ozone concentrations reach their maximum levels through the combined effects of local and transported pollution.

During unhealthy ozone exceedance episodes associated with high pressure systems, these multiple transport features are embedded within a large ozone reservoir arriving from source regions to the south and west of the OTR. Thus, ozone exceedance episodes can contain elements of long-range air pollution transport from outside the OTR, regional scale transport within the OTR from channeled flows in nocturnal low-level jets, and local transport along coastal shores due to bay, lake, and sea breezes. These typical patterns that usually result in unhealthful ozone levels were not present in New Jersey on

[139] Downs, T., Fields, R., Hudson, R., Kheirbek, I., Kleiman, G., Miller, P., & Weiss, L. (2006). *The Nature of the Ozone Air Quality Problem in the Ozone Transport Region: A Conceptual Description*. NESCAUM. Retrieved January 22, 2024, fromhttps://www.nescaum.org/documents/2010_o3_conceptual_model_final_revised_20100810.pdf

June 29 and 30, 2023, when air flowed from a direction not normally associated with high ozone levels in New Jersey as explained later in this document.

Ozone formation within the OTR is primarily due to nitrogen oxides (NOx), but volatile organic compounds (VOCs) are also important because they influence how efficiently ozone is produced by NOx, particularly within urban centers. Recent studies suggest that aged wildfire smoke, containing VOCs, transported into urban areas like New Jersey where an abundant supply of NOx exists, will lead to the creation of higher ozone levels because of the extra VOC from the wood smoke.[140] This is discussed in more detail in the Conceptual Model of Ozone Formation from Wildfires section of this document.

3. Wildfire Description

The wildfires across Canada in 2023 broke records, burning significantly more than the seasonal averages, as shown in Figure 121a, and affected large areas across Canada. Additionally, the duration of the fires exceeded the norm.[141] The abnormally dry conditions contributed to this especially severe fire season, along with drought, high temperatures, and low snowfall in the preceding winter.[142] By June 28, 2023, Canadian Wildland Fire Information System (CWFIS) reported a total-to-date burned area of 7,974,865 hectares (ha)with 363 active fires, which was 2,016,839 ha more burned compared to the total-to-date for the previous week.[143] Figure 121b shows the weekly area burned during the 2023 fire season, with June 28 being shown as week 10.

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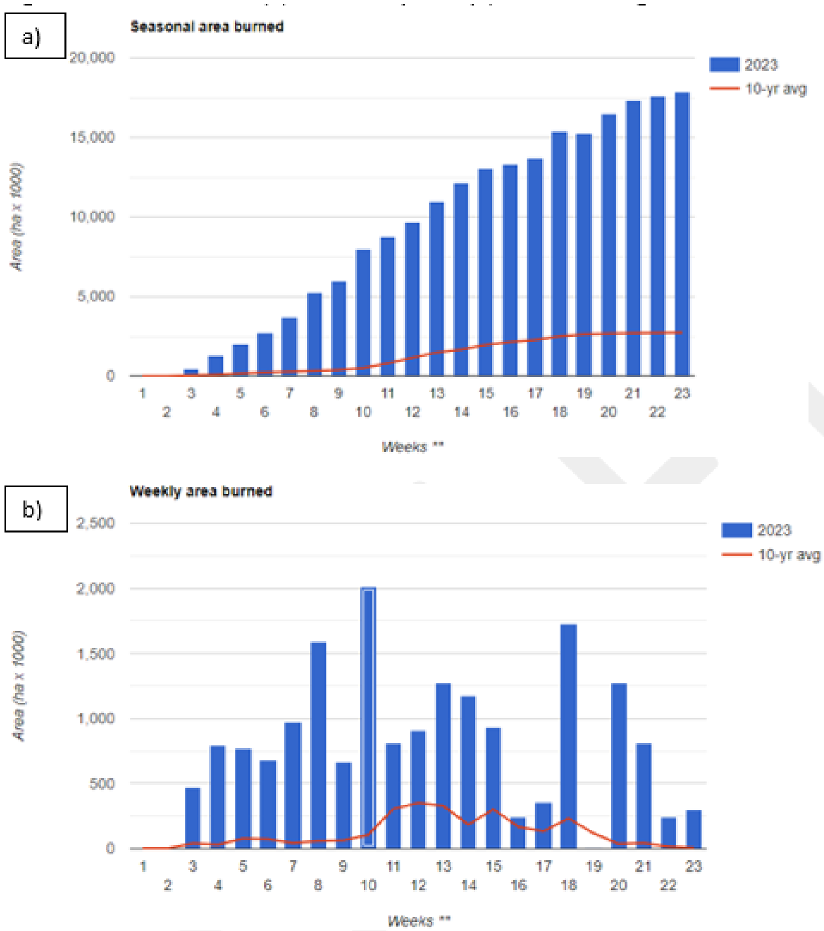
[140] Val Martin, M., Honrath, R.E., Owen, R.C., Pfister, G., Fialho, P., & Barata, F. (2006). Significant enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires. *Journal of Geophysical Research: Atmospheres, 111*(D23). DOI: 10.1029/2006JD007530

[141] NASA Earth Observatory. (2023, October 24). *Tracking Canada's Extreme 2023 Fire Season*. Retrieved February 22, 2024, from https://earthobservatory.nasa.gov/images/151985/tracking-canadas-extreme-2023-fire-season

[142] Reuters. (2023, August 19). Canada wildfires: what are the causes and when will it end. Retrieved February 22, 2024 from https://www.reuters.com/world/americas/canadas-record-wildfire-season-whats-behind-it-when-will-it-end-2023-08-17/

[143] Canadian Wildland Fire Information System. (n.d.). Archived Reports. Retrieved February 22, 2024, from https://cwfis.cfs.nrcan.gc.ca/report/archives?year=2023&month=06&day=28&process=Submit

Figure 121: Seasonal area (a) and weekly area (b) burned during the 2023 Canadian wildfire season[144]



Note: Weeks since the fire season began on April 26, 2023

In early June, lightning ignited numerous wildfires in Quebec, which spread and experienced a huge surge in late June and early July. The surge was likely due to the abnormally high temperatures and drought conditions in this area.[145] During the week preceding June 29 and 30, 2023 (specifically, June 19 to 25, 2023), Quebec saw 989,249 ha burned.[146] Smoke from these fires spread throughout Canada and the Northeastern US, with some plumes reaching as far as Europe (See Figure 122 and Figure 123).[147] Figure 124 and Figure 125 illustrate the large area of land impacted by the largely uncontrolled wildfires leading up the exceptional events.

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[144] Canadian Wildland Fire Information System. (n.d.). Weekly Graphs. Retrieved February 22, 2024, from https://cwfis.cfs.nrcan.gc.ca/report/graphs#gr6

[145] NASA Earth Observatory. (2023, October 24). *Tracking Canada's Extreme 2023 Fire Season*. Retrieved February 22, 2024, from https://earthobservatory.nasa.gov/images/151985/tracking-canadas-extreme-2023-fire-season

[146] Livingston, I. (2023, June 26). It's Canada's worst fire season in modern history, as smoke fills skies. *The Washington Post*. Retrieved February 22, 2024, from https://www.washingtonpost.com/weather/2023/06/26/canada-wildfire-worst-season-quebec-ontario-smoke/

[147] Ibid.

Figure 122: Fires, Air Quality Index, and Smoke Plume Showing Massive Scope of Wildfires[148]

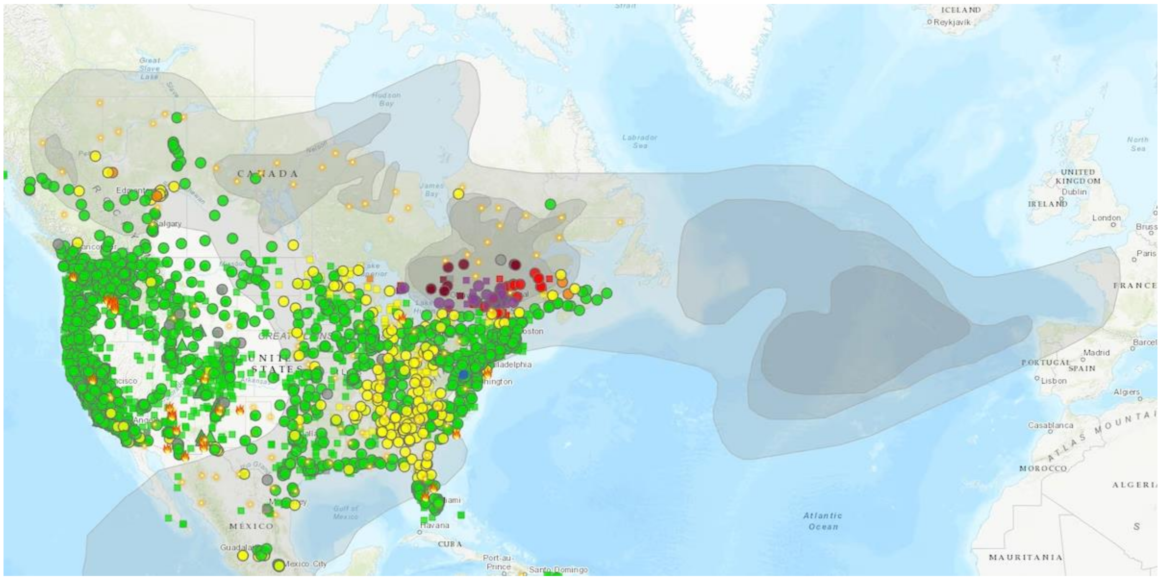


Figure 123: Image of Wildfire Smoke from Quebec Reaching Europe on June 26, 2023[149]

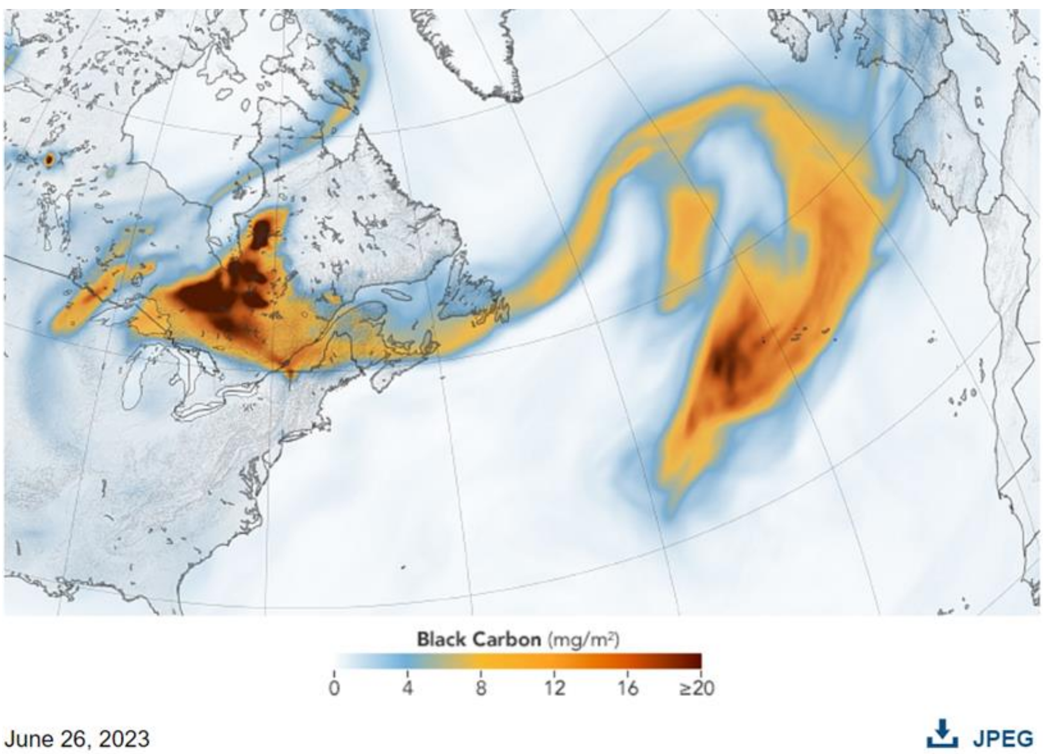


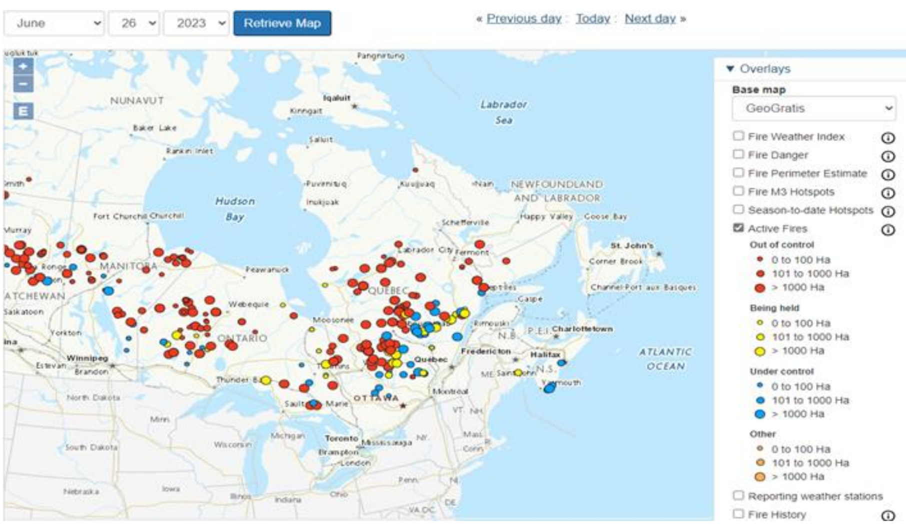
Image from: [Moderate Resolution Imaging Spectroradiometer] (MODIS) on NASA's [Terra] satellite.

[148] AirNow. (n.d.). *Interactive Map of Air Quality*. Retrieved February 22,2024, from https://gispub.epa.gov/airnow/index.html?tab=3

[149] NASA Earth Observatory. (2023, June 26). *Canadian Wildfire Smoke Reaches Europe*. Retrieved March 15, 2024, from https://earthobservatory.nasa.gov/images/151507/canadian-smoke-reaches-europe.

Figure 124: Satellite Image of Quebec on June 25, 2023[150]

Figure 125: Active Fires in Quebec on June 26, 2023



Note: Active fires are color coded depending on control status[151]

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[150] NASA. (n.d.). *Worldview Snapshots*. Retrieved February 22, 2024, from https://wvs.earthdata.nasa.gov/?LAYERS=MODIS_Terra_CorrectedReflectance_TrueColor,MODIS_Terra_Thermal_Anomalies_Day&CRS=EPSG:4326&TIME=2023-06-25&COORDINATES=44.1105,-80.8925,63.4595,-55.9775&FORMAT=image/jpeg&AUTOSCALE=TRUE&RESOLUTION=10km&COUNTRY=CAN&SUB_COUNTRY=QC&PADDING=5

[151] Canadian Wildland Fire Information System. (n.d.). *Interactive Map*. Retrieved February 22, 2024, from https://cwfis.cfs.nrcan.gc.ca/interactive-map?zoom=0&center=-50805.10211146048%2C1168759.4948053593&month=6&day=26&year=2023 - iMap

4. Conceptual Model of Ozone Formation from Wildfires (Interaction of Emissions and Chemistry of event) and Ozone Chemistry that Characterized the Episode Including the Meteorological Conditions and Transport Patterns

Smoke from wildfires has been known to cause elevated ozone levels downwind and expanding observational evidence has demonstrated a clear connection between vegetation fires and photochemical ozone formation within their plumes.[152] Long-range transport of boreal wildfire emissions can result in greater levels of carbon monoxide (CO), organic and black carbon (BC) aerosol, NOx, PM2.5, and aerosol mass downwind of the fire location. Also, greater amounts of CO in the plume can also enhance ozone formation.[153]

A study of the impacts from a 2002 Quebec, Canada wildfire event on the northeastern U.S. reported that ozone levels within the plume are also much greater, reaching 75 parts-per-billion by volume (ppbv) in one instance. [154]

Smoke from wildfires also appears to have a greater effect on enhancing ozone formation in urban areas compared to rural areas. One previous study of Canadian wildfires (not related to this exceptional event) found that in urban areas, or any region modified by nearby NOx sources, ozone levels were more sensitive to long-range fires compared to less populated or polluted regions."[155]

In this study, researchers proved that:

> "Both observations and model results show enhanced O_3 from air transported from the Northwest Territory. The model results imply that, during the period of strongest fire influence, a 10 to 30 ppbv enhancement of O_3 throughout a large region of the central and eastern United States was due to these fires."

4.1 Conceptual Model Overview

During the first week of June 2023 in North America, a strong omega pattern (a *weather pattern characterized by a prominent, stationary high-pressure system in the* shape of the Greek letter omega, Ω) set up allowing a strong ridge over central Canada to suppress precipitation over most of eastern North America. In the weeks following, this pattern remained the dominant weather set up but the persistent blocking pattern slowly weakened during the week of June 21-26.[156] Meanwhile, an intense burn period

[152] Andreae, M.O. (1983). Soot carbon and excess fine potassium: Long range transport of combustion-derived products. *Science, 220*(4602), 1148-1151. DOI: 10.1126/science.220.4602.1148

[153] Val Martin, M., Honrath, R.E., Owen, R.C., Pfister, G., Fialho, P., & Barata, F.. (2006). Significant enhancements of nitrogen oxides, black carbon, and ozone in North Atlantic lower free troposphere resulting from North American boreal wildfires. *Journal of Geophysical Research: Atmospheres, 111*(D23). DOI: 10.1029/2006JD007530

[154] DeBell, L.J., Talbot, R.W., Dibb, J.E., Munger, J.W., Fischer, E.V., & Frolking, S.E.. (2004). A major regional air pollution event in northeastern United States caused by extensive forest fires in Quebec, Canada. *Journal of Geophysical Research: Atmospheres, 109*(D19). DOI: 10.1029/2004JD004840

[155] McKeen, S.A., Wotawa, G., Parrish, D.D., Holloway, J.S., Buhr, M.P., Hübler, G., Fehsenfeld, F.C., & Meagher, J.F. (2002). Ozone production from Canadian Wildfires during June and July of 1995. *Journal of Geophysical Research: Atmospheres, 107*(D14). DOI: 10.1029/2001JD000697

[156] NOAA National Centers for Environmental Information, Monthly Synoptic Discussion for June 2023, published online July 2023, retrieved on March 11, 2024, from https://www.ncei.noaa.gov/access/monitoring/monthly-report/synoptic/202306.

was initiated in Quebec (See gray cloud in Figure 126) due to the extreme drought conditions experienced over northwestern Canada. During this burning, stagnation existed over Quebec, allowing smoke to accumulate to concentrations over parts of southern Quebec that exceeded the EPA Air Quality Index (AQI) scale with a maximum PM2.5 24-hour average concentration of 593 $\mu g/m^3$, achieved on June 25.[157] This value is a good indicator for smoke in the atmosphere when compared to the PM2.5 24-hour average National Ambient Air Quality Standard of 35 $\mu g/m^3$.

This burn period was exacerbated by the recirculation of high pressure passing by during this week (noted with blue "H" in Figure 126). By June 26th, an intensifying area of low pressure (noted with red "L" in Figure 126) migrated eastward allowing the omega pattern to break. As this low tracked northeastward through June 29, counterclockwise winds provided a direct pathway for wildfire smoke from Quebec into the Mid-Atlantic albeit slowly Meanwhile, high pressure filled in behind as the next weather maker through June 30, allowing subsidence to transport smoke at higher levels of the atmosphere to ground level. A simplified illustration of the weather pattern is shown in Figure 126.

[157] Maryland Department of the Environment, 2023, "Exceptional Event Demonstration and Analysis of the June 2023 Quebec Wildfires and their Impact on Maryland Air Quality" https://mde.maryland.gov/programs/air/AirQualityMonitoring/Documents/ExceptionalEvents/MDE_Ozone_EE_Demo_2023_June_29-30.pdf

Figure 126: Simplified, Illustrated Conceptual Model Diagram of June 29-30, 2023 Wildfire Event

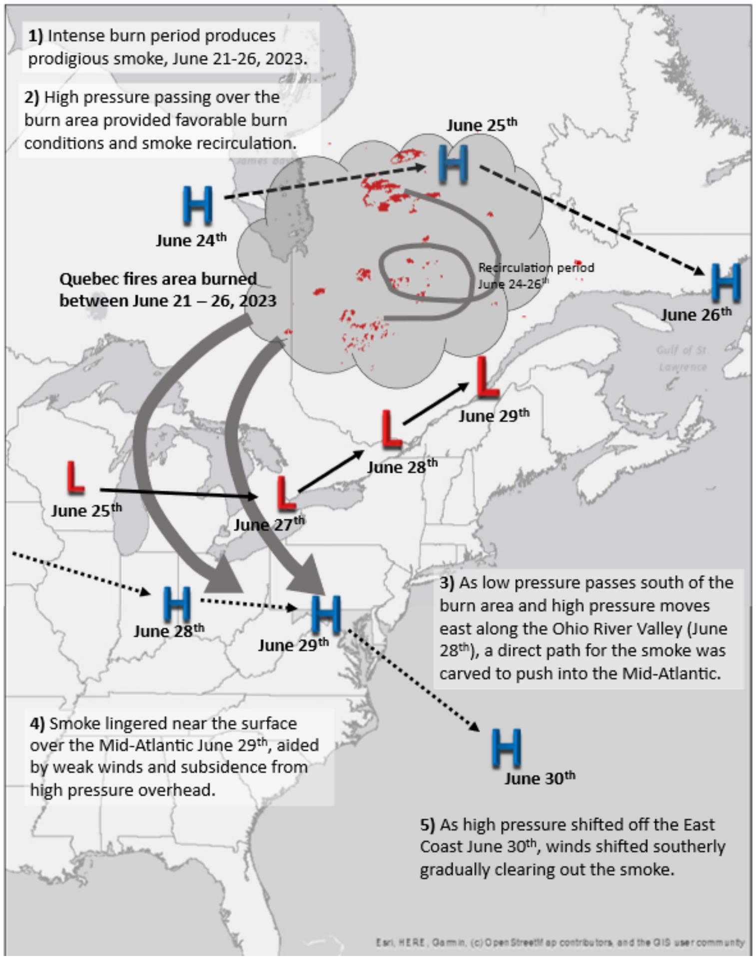


Image courtesy of Maryland Department of the Environment

4.2 Surface Analysis – Transport & Wind Pattern

A broad area of high pressure across Quebec provided light winds with little atmospheric ventilation at the burn location on June 25 (Figure 127 Meanwhile, high pressure located over the Mid-Atlantic was slowly being pushed eastward as a strong area of low pressure across the western Great Lakes, followed closely behind (Figure 128). On June 26, (Figure 129) widespread unsettled weather across the northern Great Lakes and Ontario/Quebec was observed as the intensifying area of low pressure began to pull smoke southwestward as its progression eastward slowed. This allowed winds on the western side of the low to begin to pull smoke southward on June 26 and 27 (Figure 130) over the Great Lakes, as high pressure developed across the Midwest and Ohio River Valley resulting in a broad area of divergent winds from Wisconsin through Ohio and Pennsylvania. Due to the abundant cloud cover and unsettled weather, much of the smoke progression was not visible on satellite imagery (Figure 131). As high pressure strengthened over the Ohio Valley on June 28 (Figure 132), the smoke progressed eastward within the area of high pressure. Winds in this area remained light, and as a result, smoke transport was slow, and lingered over portions of Ohio (Figure 133). On June 29, high pressure strengthened and migrated overhead of the Mid-Atlantic (Figure 134). Here, air experienced subsidence (gentle sinking motion within high pressure systems), which allowed wildfire smoke and ozone precursors aloft to reach the surface beginning on this day. Figure 135 shows the extent of the dense wildfire smoke plume impacting portions of the northeast and southern New Jersey on June 29. Under the influence of high pressure (Figure 136), smoke lingered for a second day into June 30, leading to the increased build-up of smoke and ozone precursors at the surface due to light winds, limited atmospheric ventilation, and subsidence. As a result, wildfire smoke at the surface continued to accumulate through June 30, while becoming more widespread and diffuse (Figure 137). In the following days, smoke continued to dissipate as unsettled weather helped to provide cleaner air to the region.

Figure 127: Aerosol Watch Satellite Imagery –June 25, 2023, 18UTC

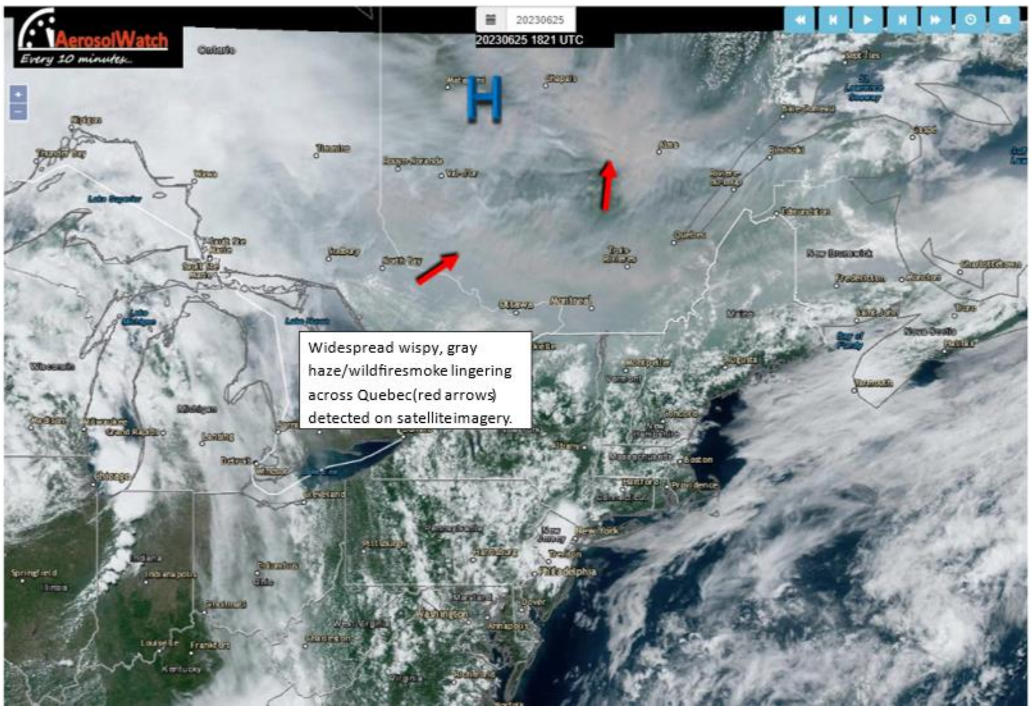


Figure 128: Surface Analysis for June 25, 2023 18UTC

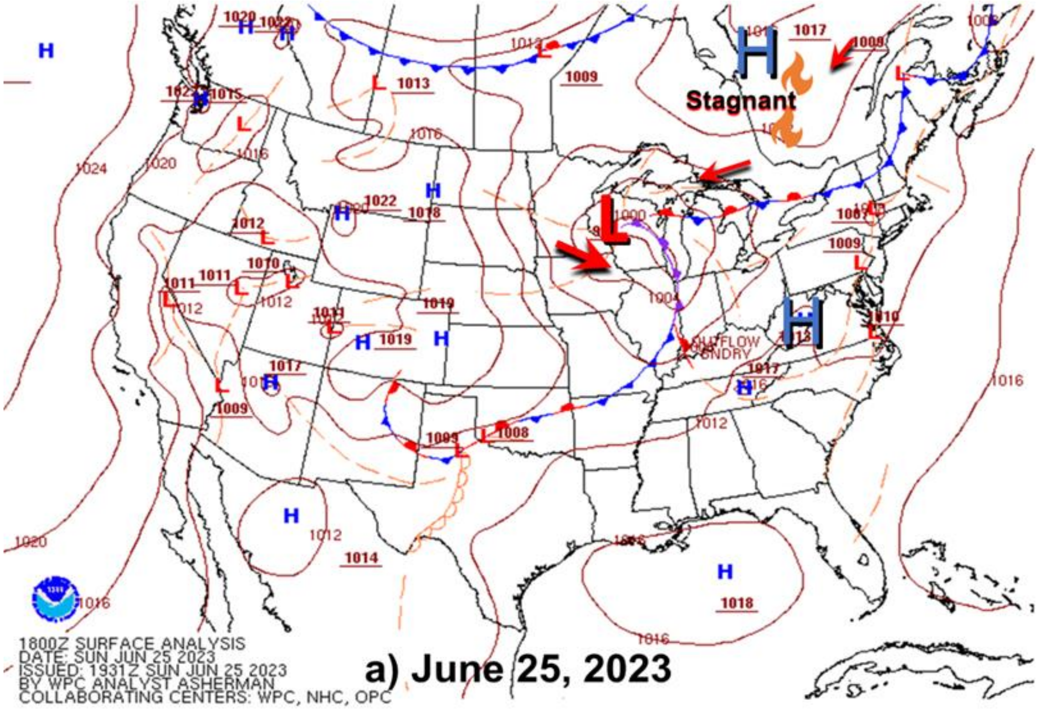


Figure 129: Surface Analysis for June 26, 2023, 18UTC

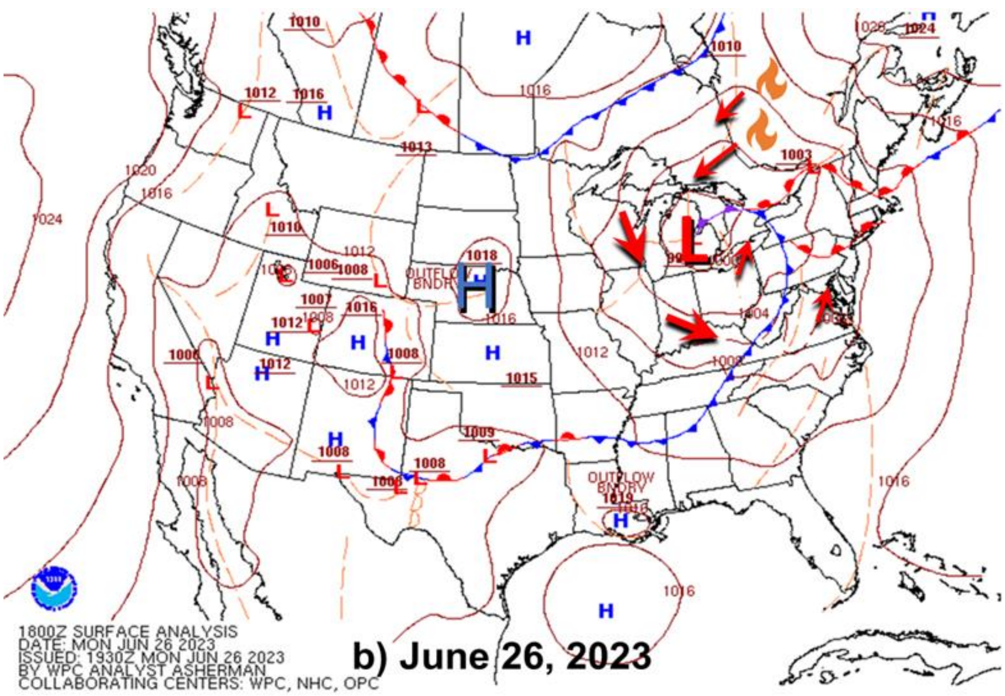


Figure 130: Surface Analysis for June 27, 2023, 18UTC

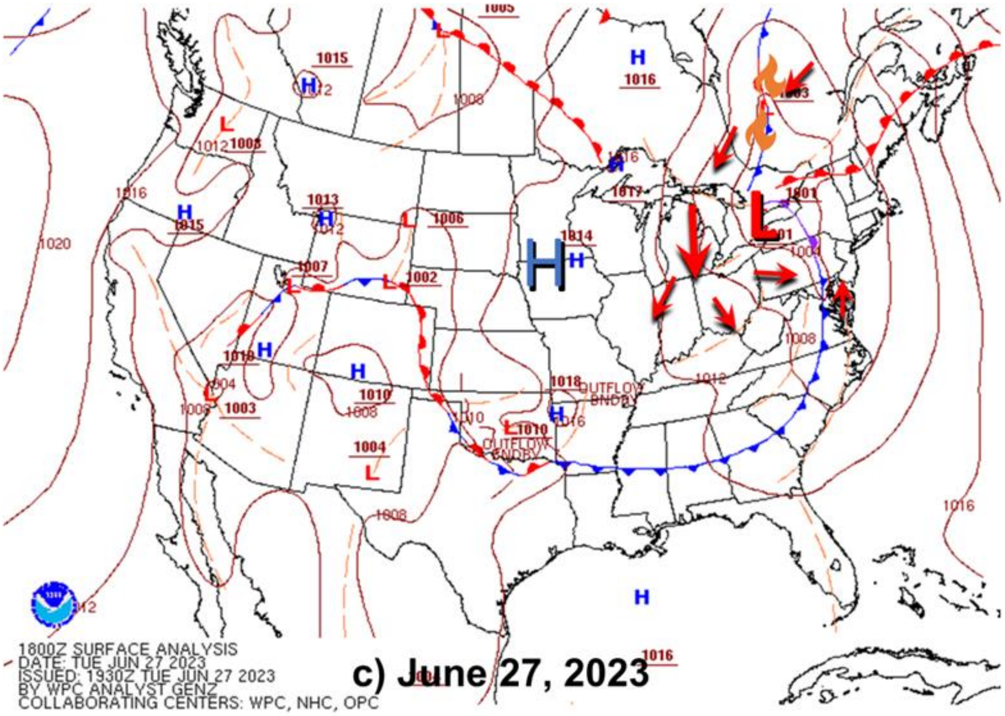


Figure 131: Aerosol Watch Satellite Imagery – June 27, 2023, 15UTC

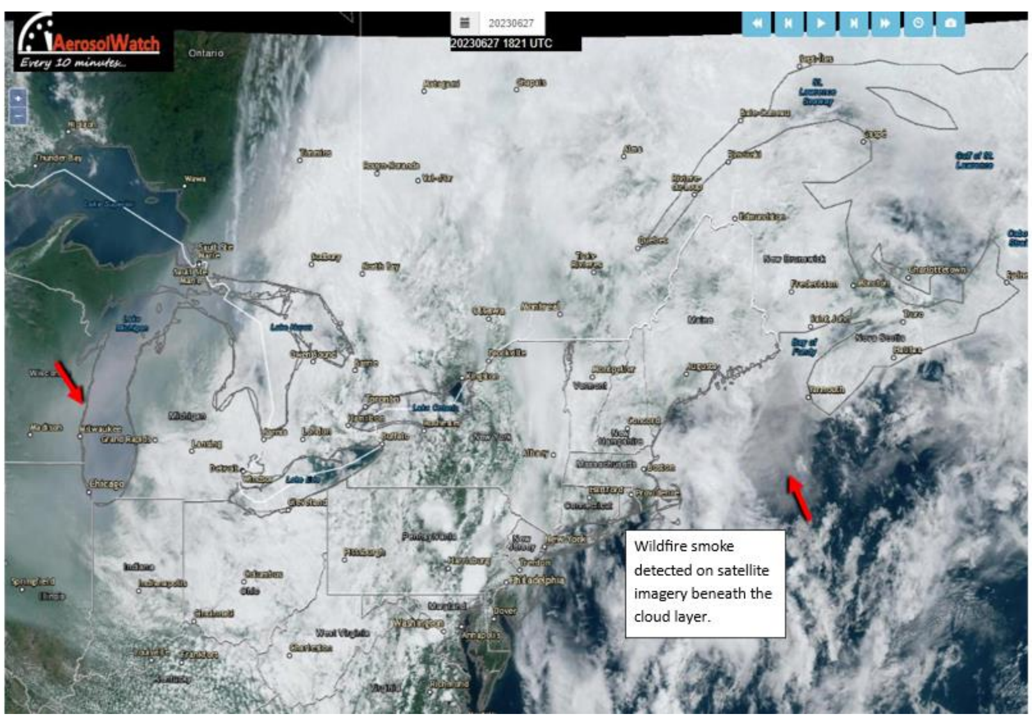


Figure 132: Surface Analysis for June 28, 2023, 18UTC

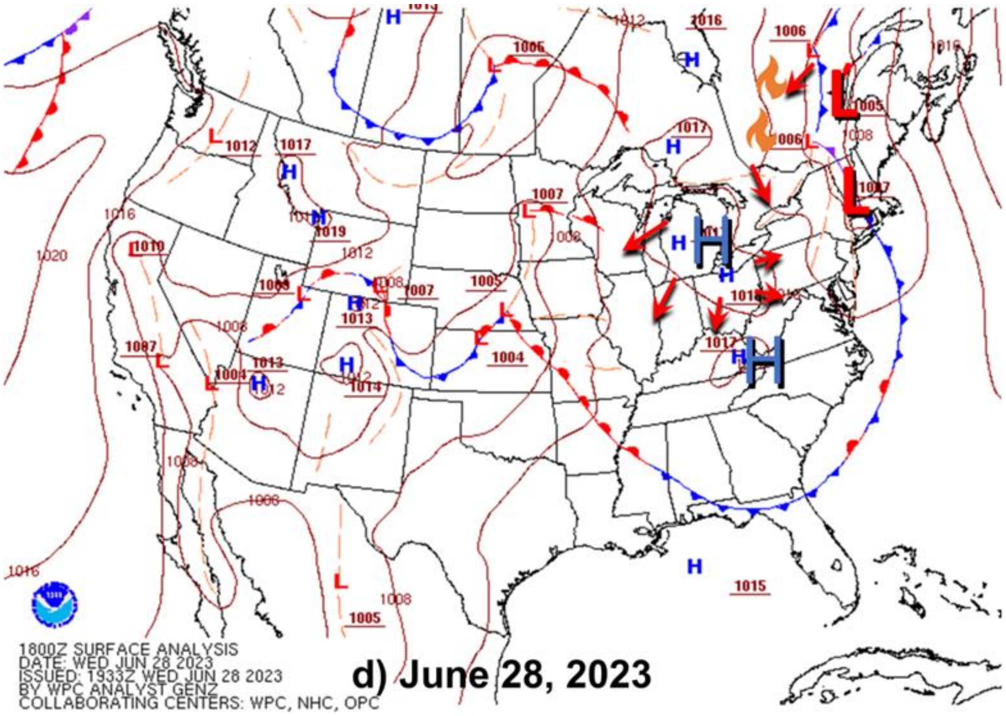


Figure 133: Aerosol Watch Satellite Imagery – Early Morning East Coast – June 28, 2023, 11UTC

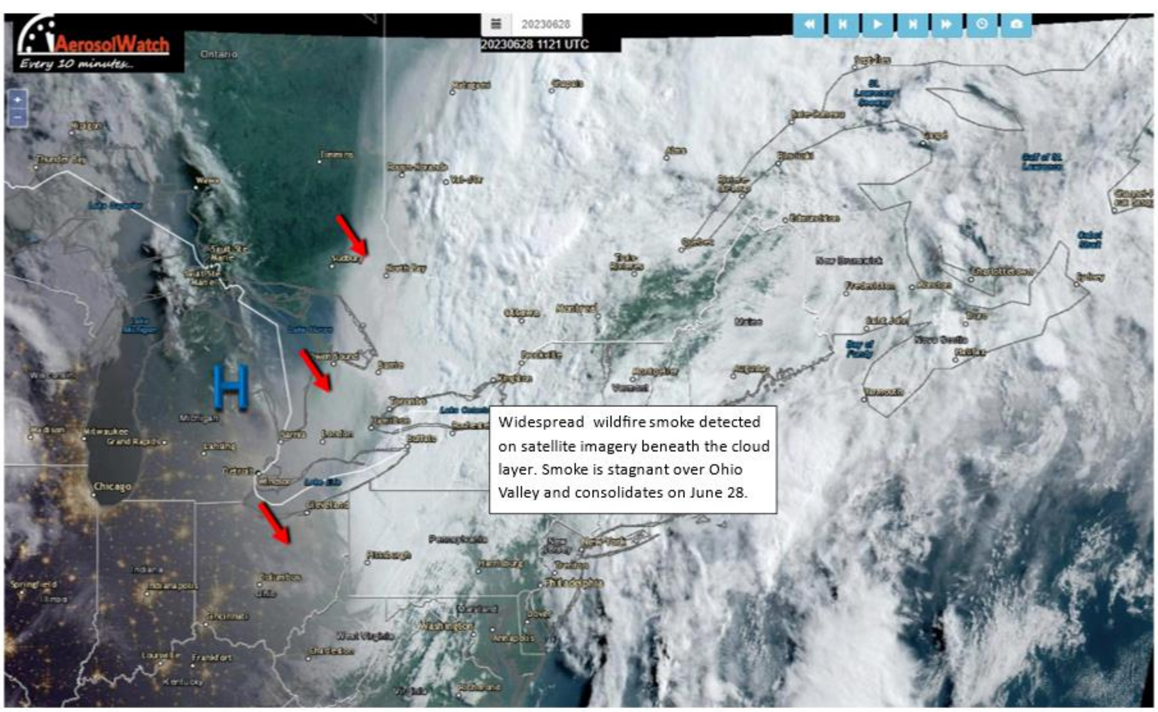


Figure 134: Surface Analysis for June 29, 2023, 18UTC

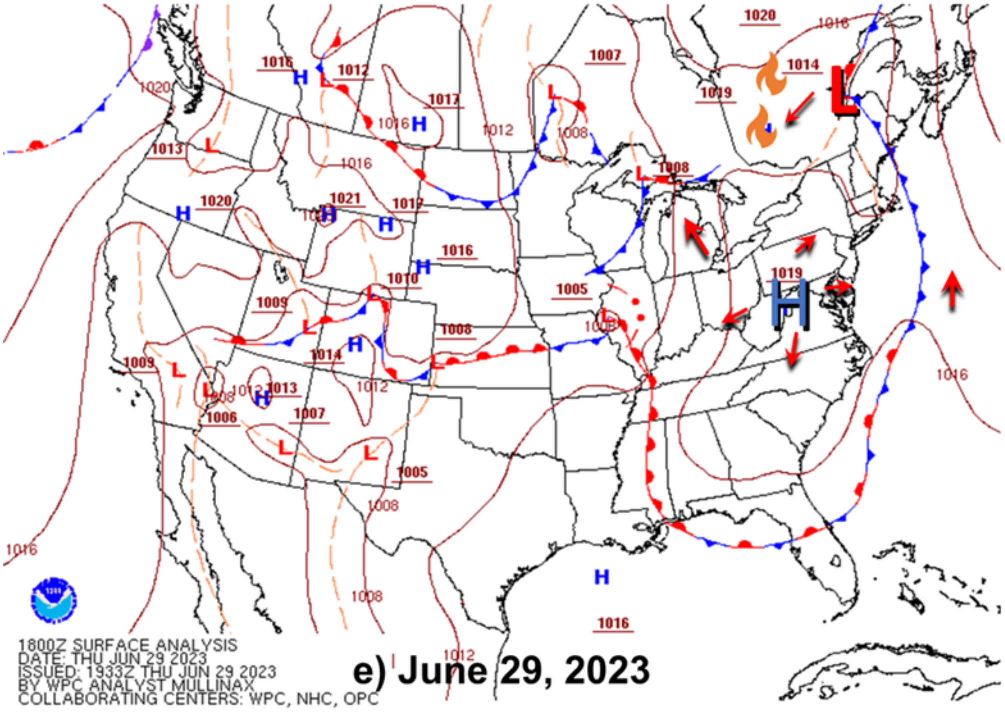


Figure 135: Aerosol Watch Satellite Imagery – Early Morning East Coast June 29, 2023, 11UTC

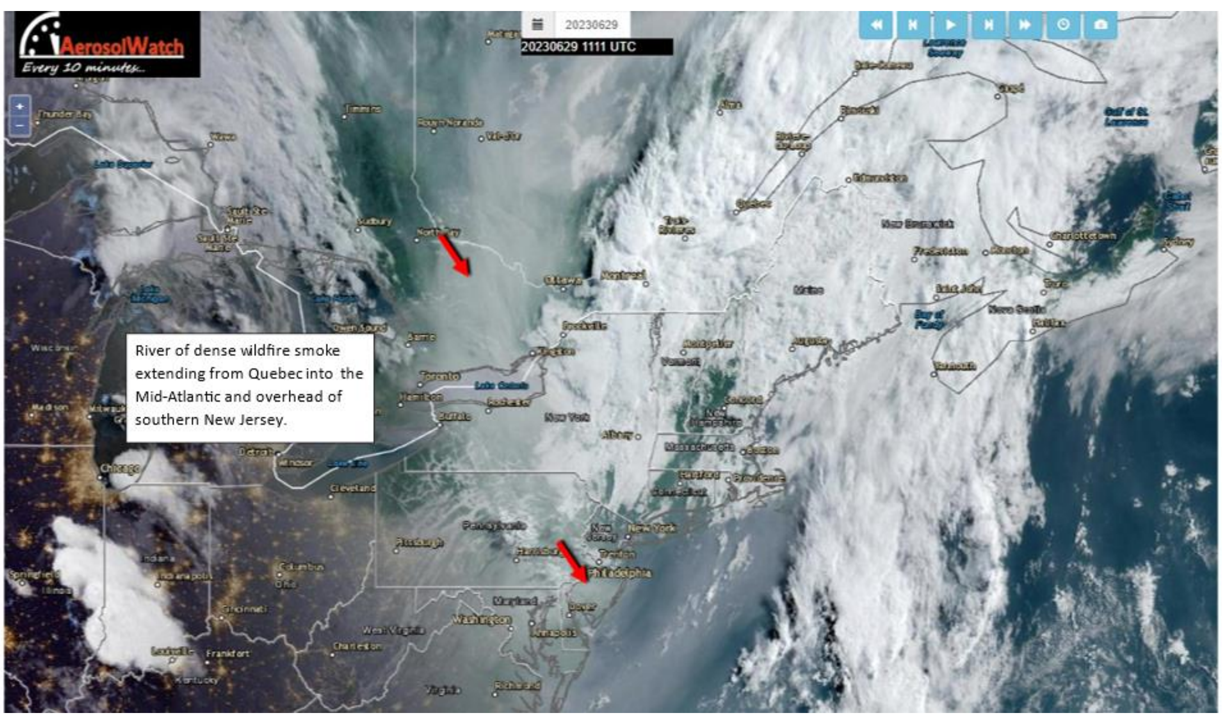


Figure 136: Surface Analysis for June 30, 2023, 18UTC

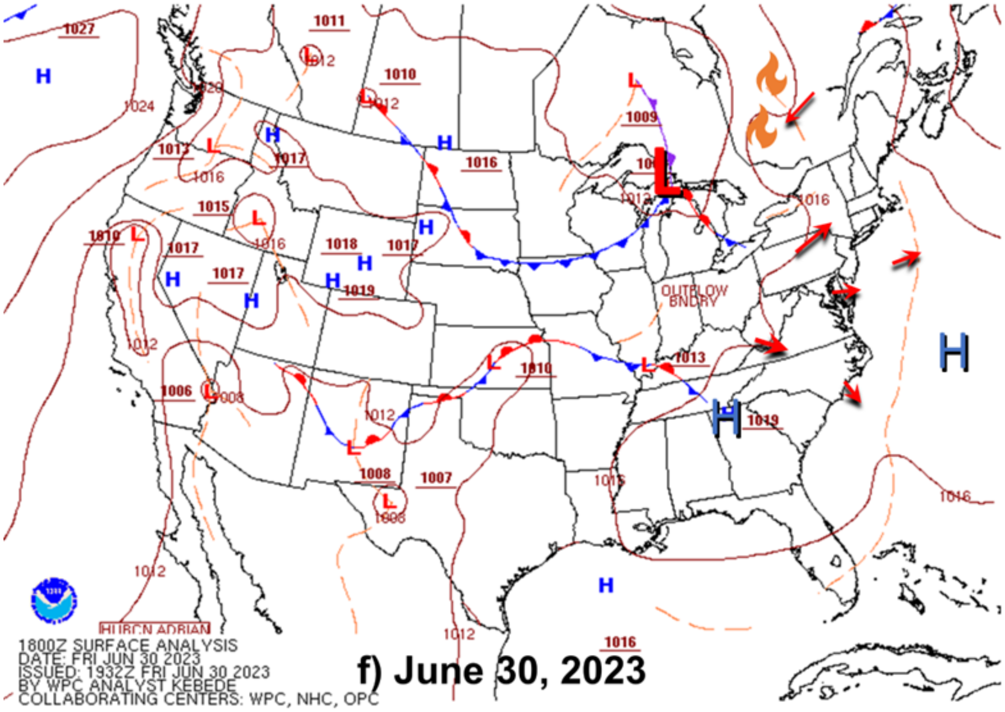


Figure 137: Aerosol Watch Satellite Imagery – Early Morning East Coast – June 30, 2023, 11UTC

4.3 Upper Air Analysis

This section will provide an upper air analysis occurring at the 850 millibar (mb) level (approximately 1500 m above sea level). This upper air level sits near the top of the planetary boundary layer (PBL), the atmospheric layer in which ozone pertinent to surface observations and human health develops, and so can serve as a guide for the transport of pollutants. The analysis of this atmospheric level is given for June 25 – 30, 2023, in Figure 138-Figure 143 below.

Beginning on June 25, the area of low pressure, "L", over the northern plains continued to strengthen through the 26 and migrate eastward into the Great Lakes. Meanwhile, a weak area of high pressure aloft, "H", over Quebec provided recirculation to the burn area and subsidence, allowing wildfire smoke to accumulate in this area (Figure 138 and Figure 139). This pattern is consistent with observations in the surface analysis. By June 27 at 850mb, the area of low pressure begins to weaken as a ridge of high pressure, "H", fills in behind it from the west. Here, smoke finds a direct pathway between these two air masses where air converges aloft (red arrows, Figure 140) allowing smoke to penetrate the Mid-West region. On June 28 (Figure 141), the ridge of high pressure sinks south/east while the area of low pressure continues to weaken and drift farther eastward creating a pathway for the wildfire smoke to push into the Ohio Valley (red arrows, Figure 141). Here, south/southeasterly winds on the backside of the low in combination with subsidence around the perimeter of high pressure helped to keep wildfire smoke near the surface as it approached the Mid-Atlantic region. At the start of the event on June 29, few changes in the upper-level pattern were observed from the previous day which allowed the smoke to continue flowing into the Mid-Atlantic from the northwest (Figure 142). The final day of the event, June 30, was largely a transition day where the departing airmass, laden with wildfire smoke, gradually departed and a new air mass arrived. At this time, much of the stable weather pattern had weakened and high pressure migrated south/eastward and was pumping a new airmass into the region from the southwest (red arrows, Figure 143).

Figure 138: 850mb Upper Air Analysis, June 25, 2023

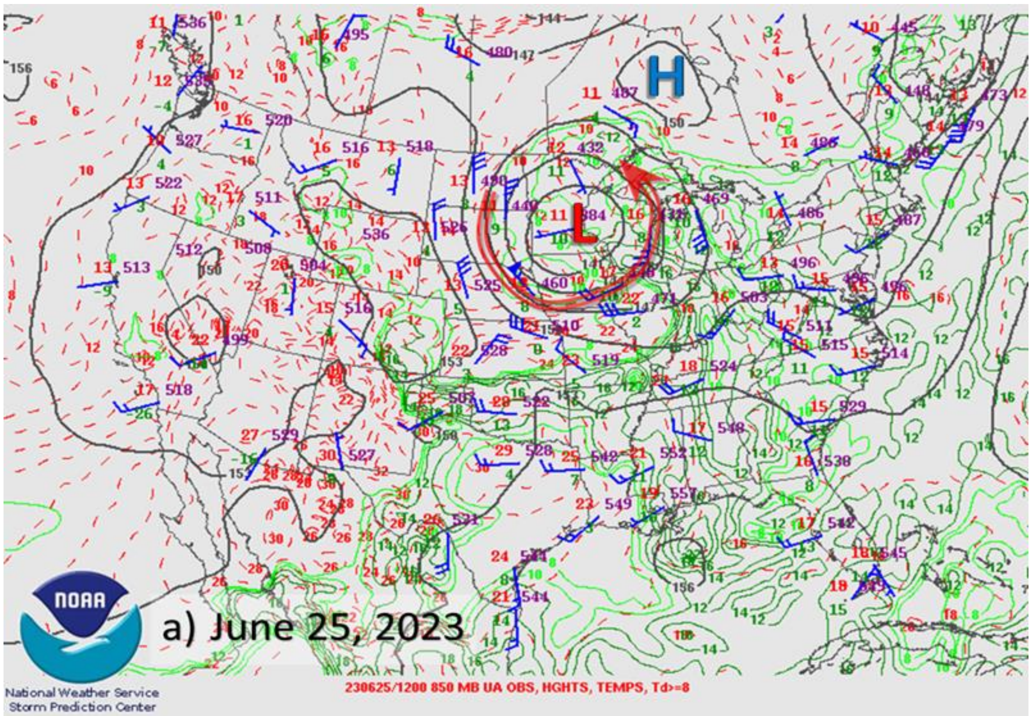


Image courtesy of Maryland Department of the Environment

Figure 139: 850mb Upper Air Analysis, June 26, 2023

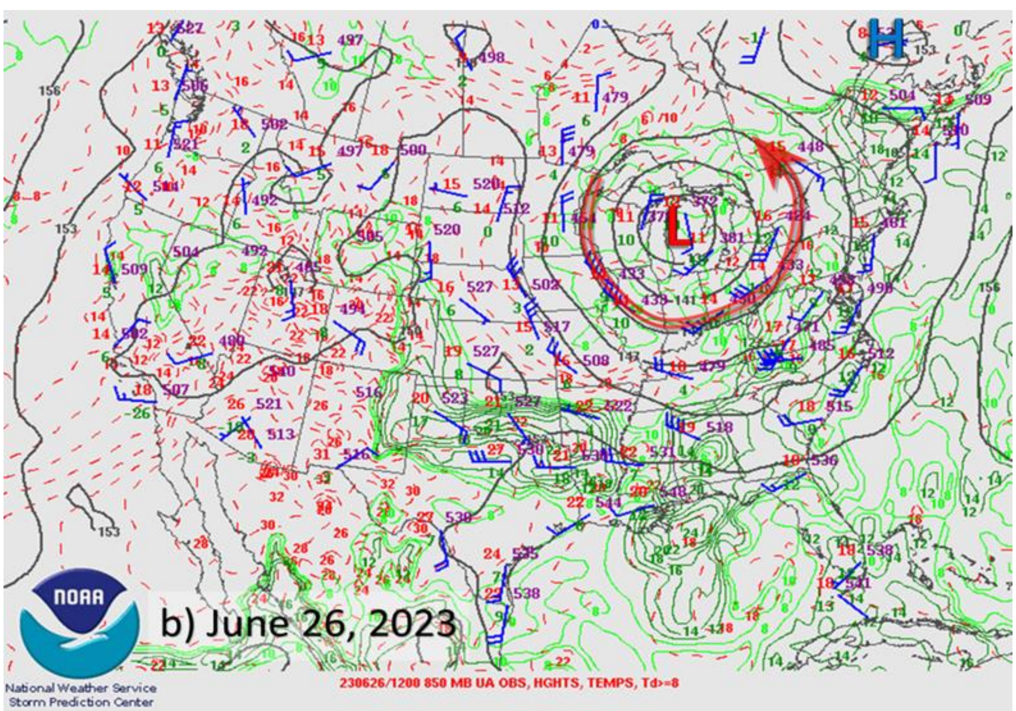


Image courtesy of Maryland Department of the Environment

Figure 140: 850mb Upper Air Analysis, June 27, 2023

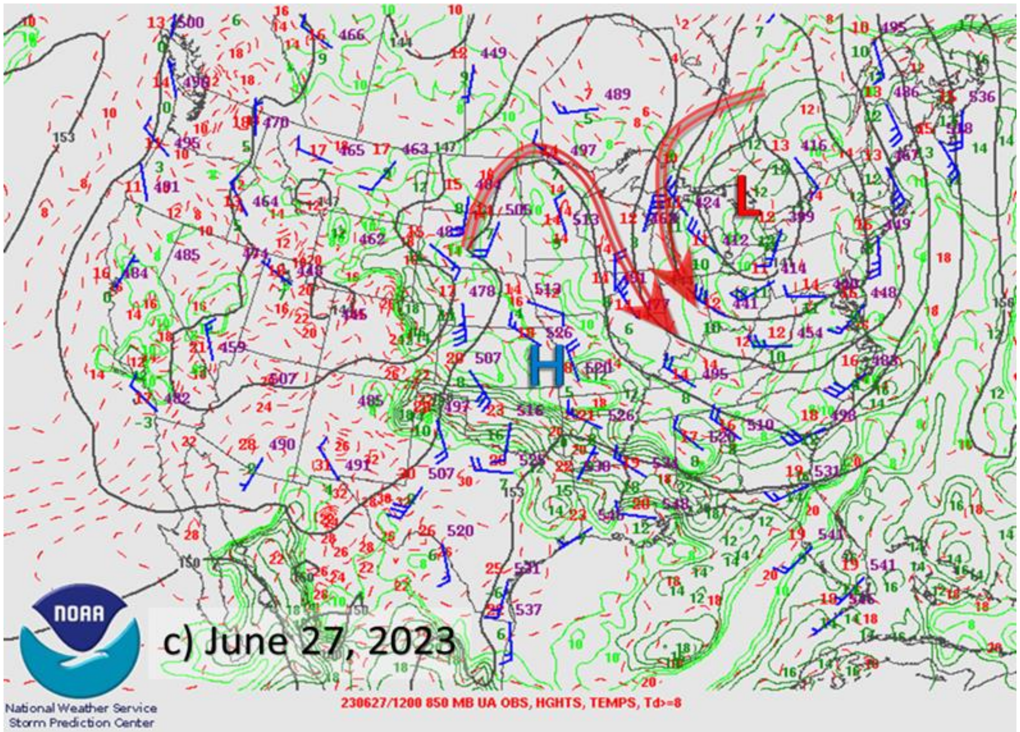


Image courtesy of Maryland Department of the Environment

Figure 141: 850mb Upper Air Analysis, June 28, 2023

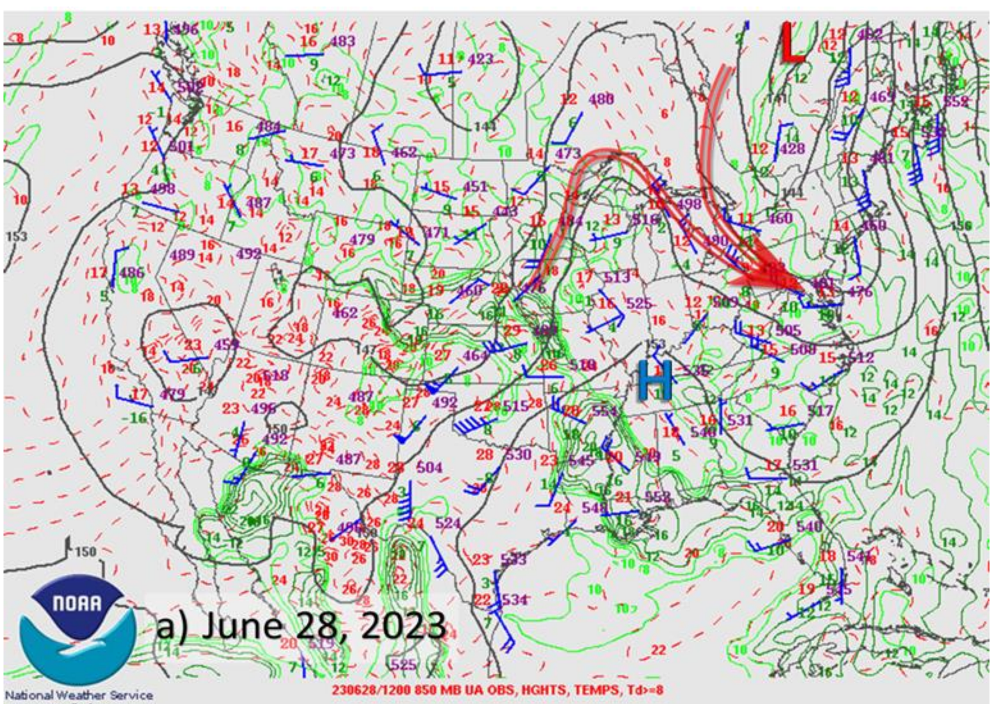


Image courtesy of Maryland Department of the Environment

Figure 142: 850mb Upper Air Analysis, June 29, 2023

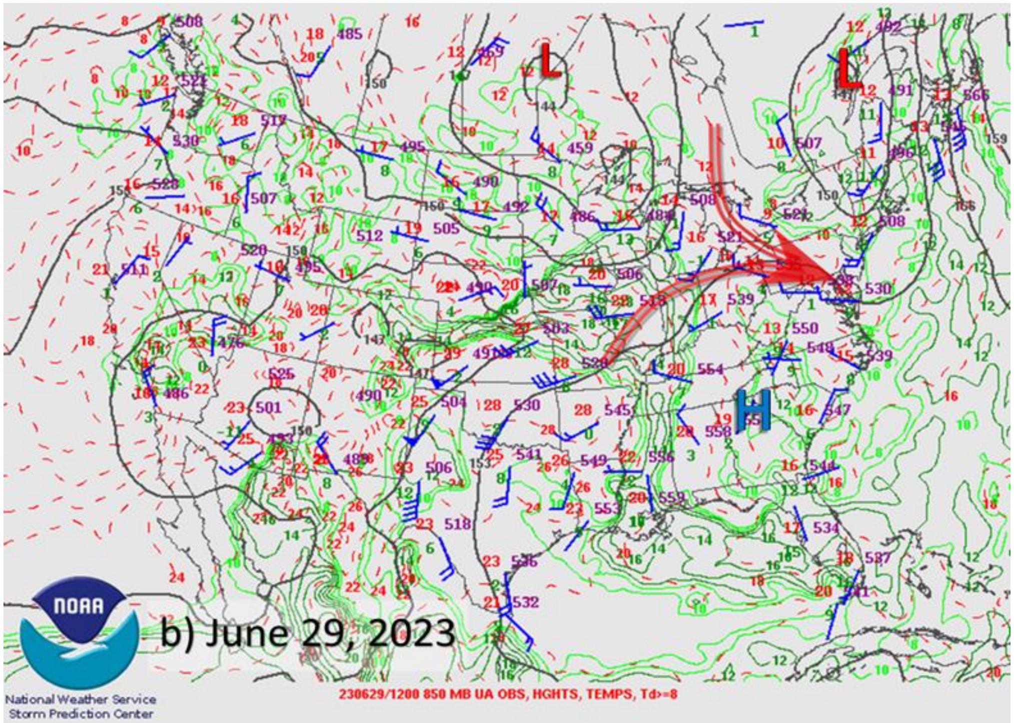


Image courtesy of Maryland Department of the Environment

Figure 143: 850mb Upper Air Analysis, June 30, 2023

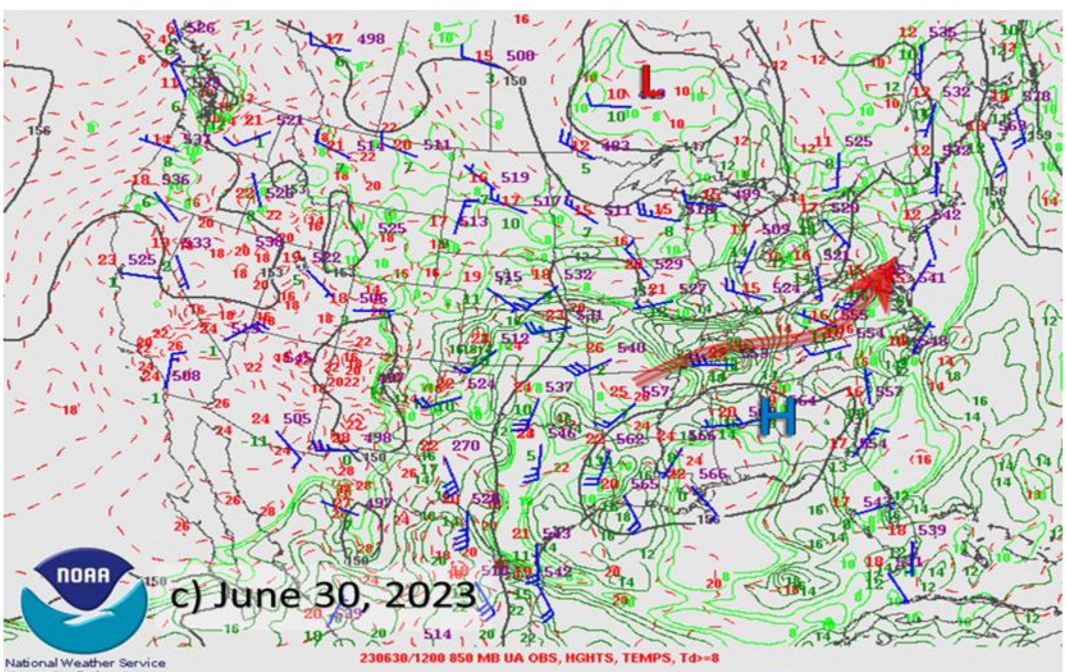
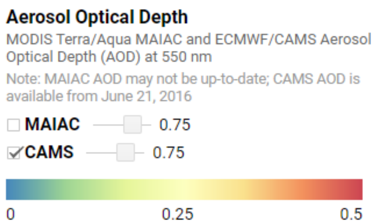


Image courtesy of Maryland Department of the Environment

4.4 Aerosol Optical Depth

Figure 144 – Figure 149 show aerosol optical depth (AOD) in the days leading up to the high ozone exceedance event on June 29–30, 2023. AOD is a measure of smoke in the atmosphere that is blocking sunlight. Therefore, it is a helpful indicator of wildfire smoke and how much direct sunlight is prevented from reaching the ground by aerosol particles. An extremely clean atmosphere corresponds to a value of 0.01 (dark blue) and a very hazy condition would correspond to a value of 0.4 (orange-red).[158] In the following images, AOD is indicated by the color scale from cool tones (blue) to warm tones (red), which represents a scale from 0.0 to 0.5.



Beginning on June 25 and 26, the plume of heavy, dense smoke (circled, Figure 144) is concentrated in the Quebec/Ontario region as the influence of high pressure on this area allowed the wildfire smoke to recirculate and linger while the fires continued to burn. Figure 144 and Figure 145, show the widespread, dense nature of the plume, and the spatial extent it encompasses. An optically dense smoke plume of this magnitude can block enough sunlight to limit ozone formation at the surface.

On June 27 and 28 (Figure 146 and Figure 147) dense smoke was pulled southeastward into the Ohio Valley and Great Lakes as smoke swirled counterclockwise around low pressure. This is shown as the circled area in Figure 146. The heaviest concentrations of smoke arrived over New Jersey and the Mid-Atlantic region on June 29 and 30 (Figure 148 and Figure 149), encompassing much of the region. The aerosol optical depth maps shown below provide additional support for the magnitude and size of the wildfire smoke plume impacting New Jersey on the exceedance days.

[158] NOAA Earth System Research Laboratories. (n.d.). *SURFRAD Aerosol Optical Depth*. Retrieved December 13, 2023, from https://gml.noaa.gov/grad/surfrad/aod/ - :~:text=Aerosol%20optical%20depth%20is%20a,ground%20by%20these%20aerosol%20particles.

Figure 144: Aerosol Optical Depth June 25, 2023

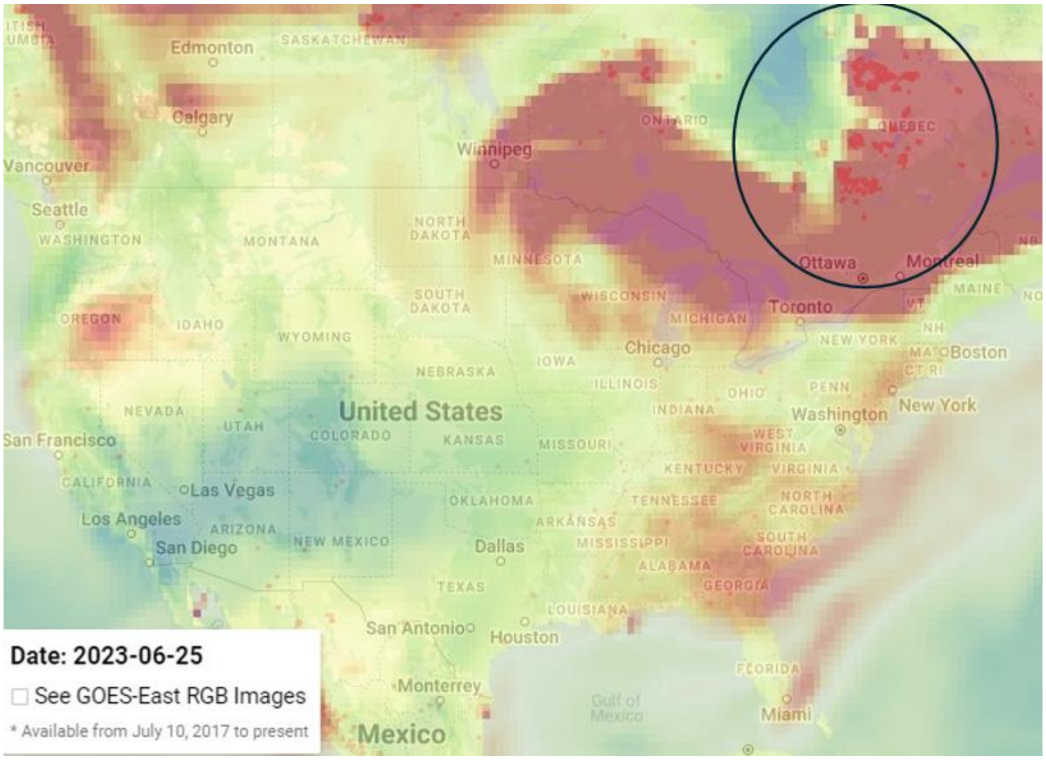


Figure 145: Aerosol Optical Depth June 26, 2023

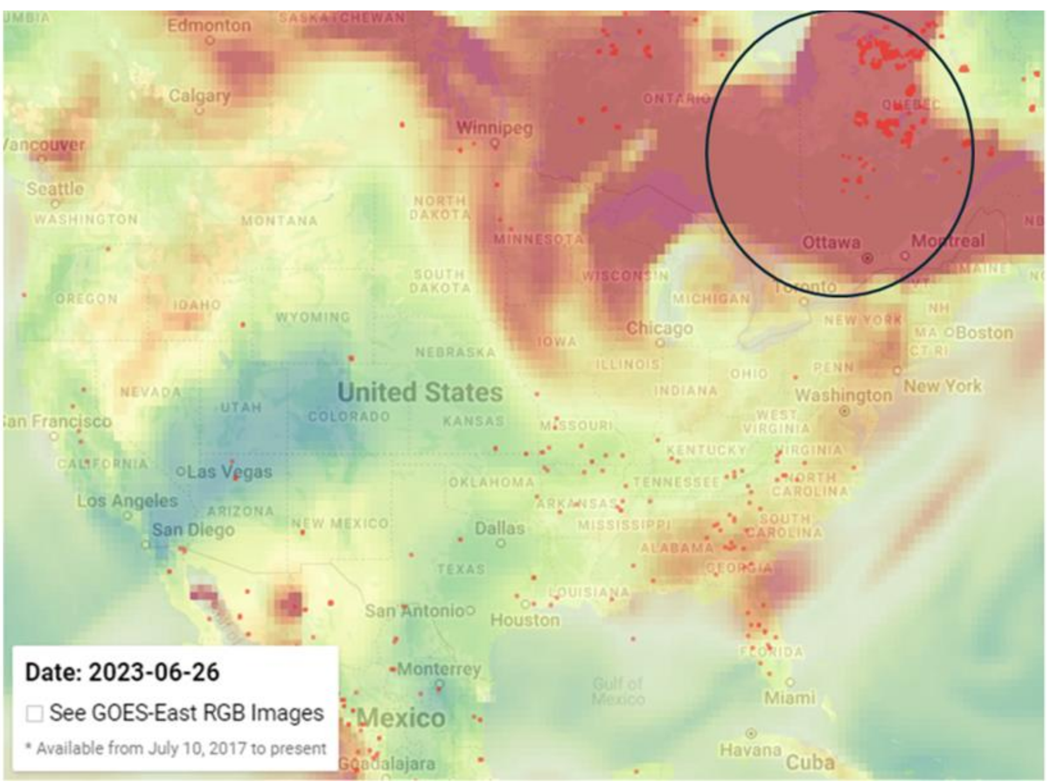


Figure 146: Aerosol Optical Depth June 27, 2023

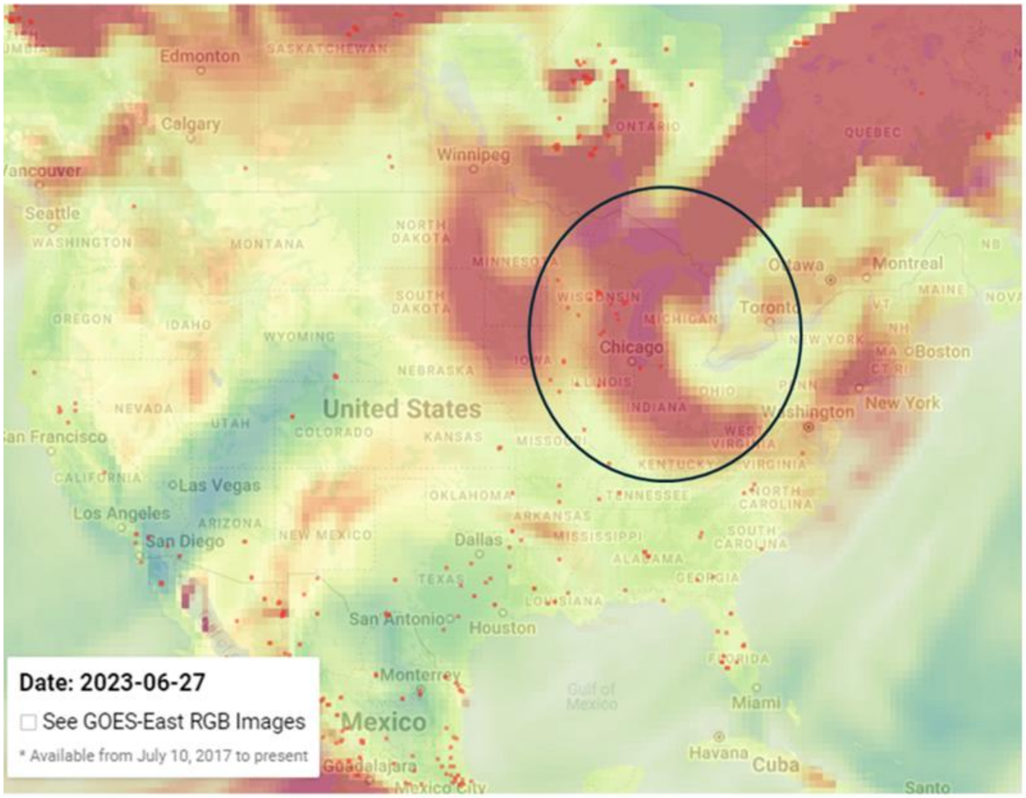


Figure 147: Aerosol Optical Depth June 28, 2023

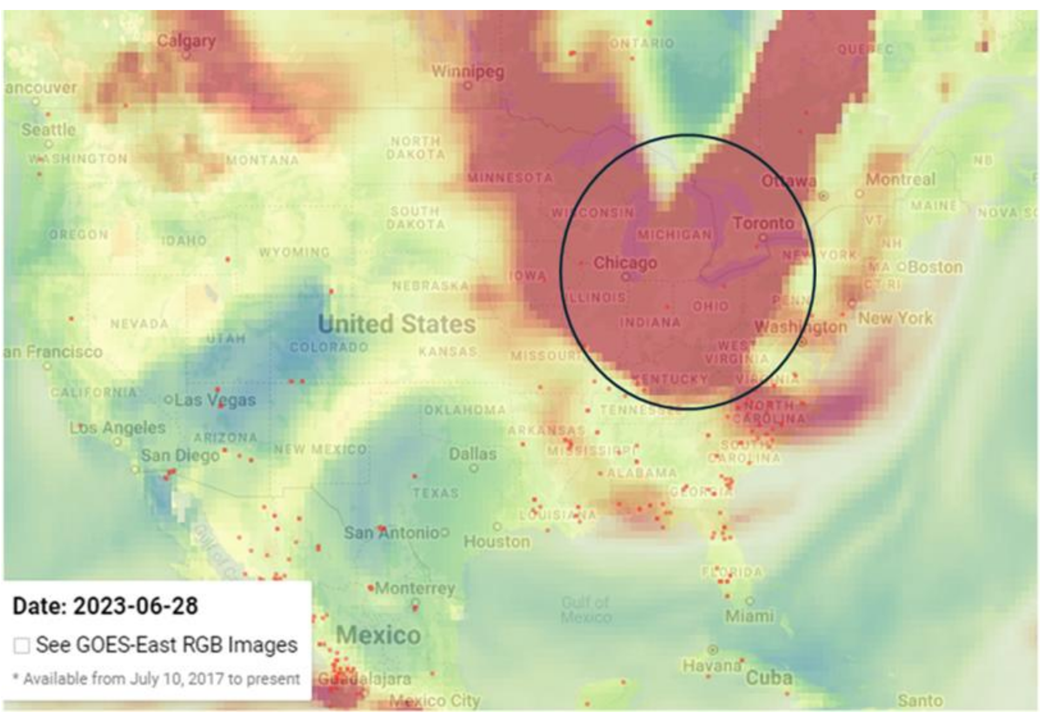


Figure 148: Aerosol Optical Depth June 29, 2023

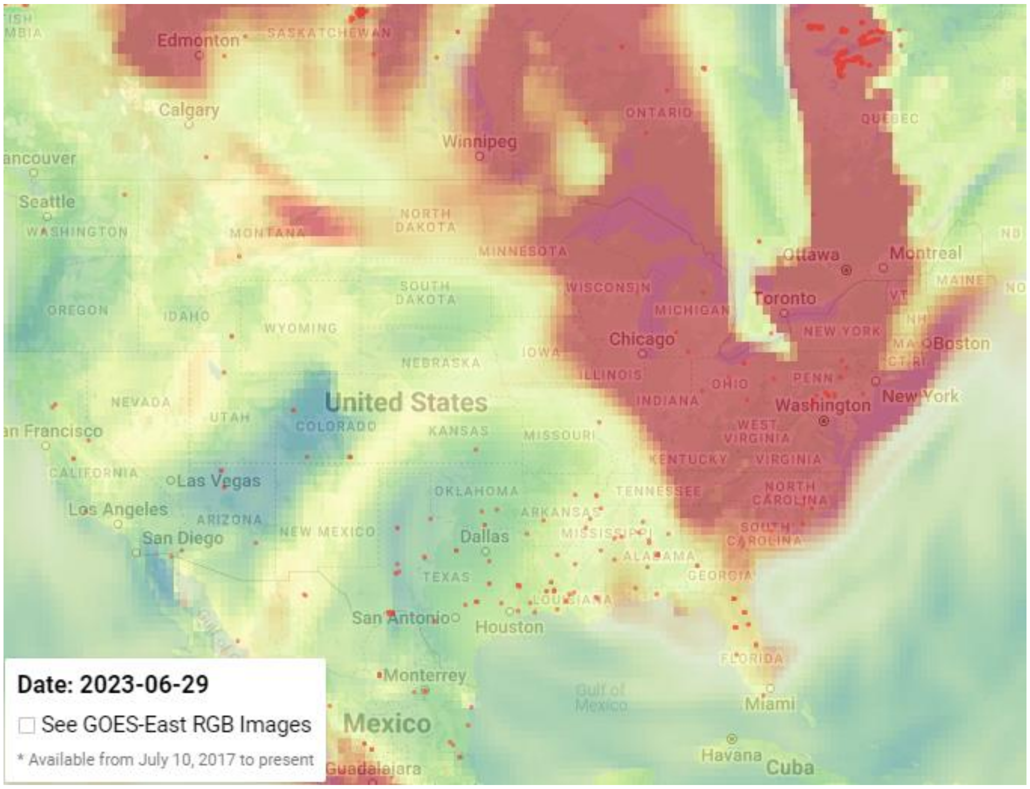
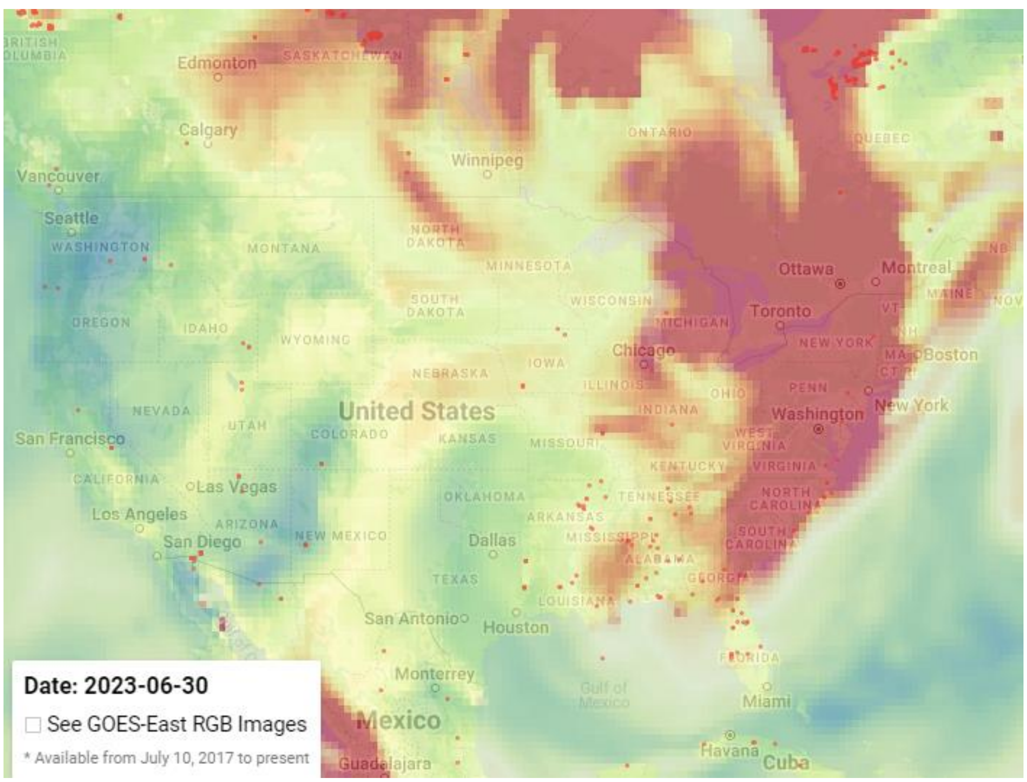


Figure 149: Aerosol Optical Depth June 30, 2023



4.5 Daily Ozone AQI Maps

The following images (Figure 150-Figure 155) show Daily Air Quality Index (AQI) levels observed across the continental United States during the days leading up to and including the exceptional event occurring on June 29 - 30, 2023. The changing level of the AQI in these images correspond to the progression of ozone and PM2.5 levels in ambient air leading up to the high ozone exceptional event. The PM2.5 AQI levels are provided as an indicator of the presence of the smoke plume. An exceedance of the ozone standard (>70ppb) is represented by the colors red and orange. Red signifies Unhealthy ozone levels where the concentrations of ozone (86 – 105ppb) can begin to have adverse health effects on the general population. Orange shows where ozone concentrations (71 – 85ppb) reached levels that are Unhealthy for Sensitive Groups (USG), such as asthmatics and the elderly. Yellow represents Moderate ozone (55 – 70ppb) and air quality is acceptable at this level except for those that are unusually sensitive. Green represents Good ozone levels (0 – 55ppb) and pose little risk.

Beginning on June 25 and 26, as wildfire smoke recirculated under the influence of high pressure in Quebec, surface level ozone concentrations remained in an acceptable range for human health and did not reach exceedance levels where the plume was located (Figure 150 and Figure 151). As noted in the previous section, a plume of this density has the ability to block sunlight, therefore limiting ozone concentrations at the surface. This explains the lack of ozone formation in the days immediately following the intense burn. However, PM2.5 concentrations at the surface reflect the smoke plume location indicating that the plume was so dense that it greatly impacted PM2.5 and limited ozone.

By June 27, as low pressure pulled smoke southward into the Great Lakes and upper Mid-West, PM2.5 concentrations rose dramatically. Here, ozone concentrations began to climb (Figure 152) into the moderate and USG category as smoke had been in the atmosphere for many days, increasing in concentration as the plume aged. This pattern repeats again the following day on June 28, with unhealthy and very unhealthy PM2.5 concentrations becoming widespread while ozone concentrations simultaneously expand and rise into the unhealthy category (Figure 153).

The heaviest smoke arrived in New Jersey on June 29 and 30 and ozone concentrations increased into the unhealthy for sensitive groups and unhealthy categories upon arrival (Figure 154 and Figure 155). Ozone exceedances were observed across the Mid-Atlantic and Mid-West regions indicating that smoke from the same airmass influenced elevated ozone concentrations across this large area.

Figure 150: Daily AQI June 25, 2023

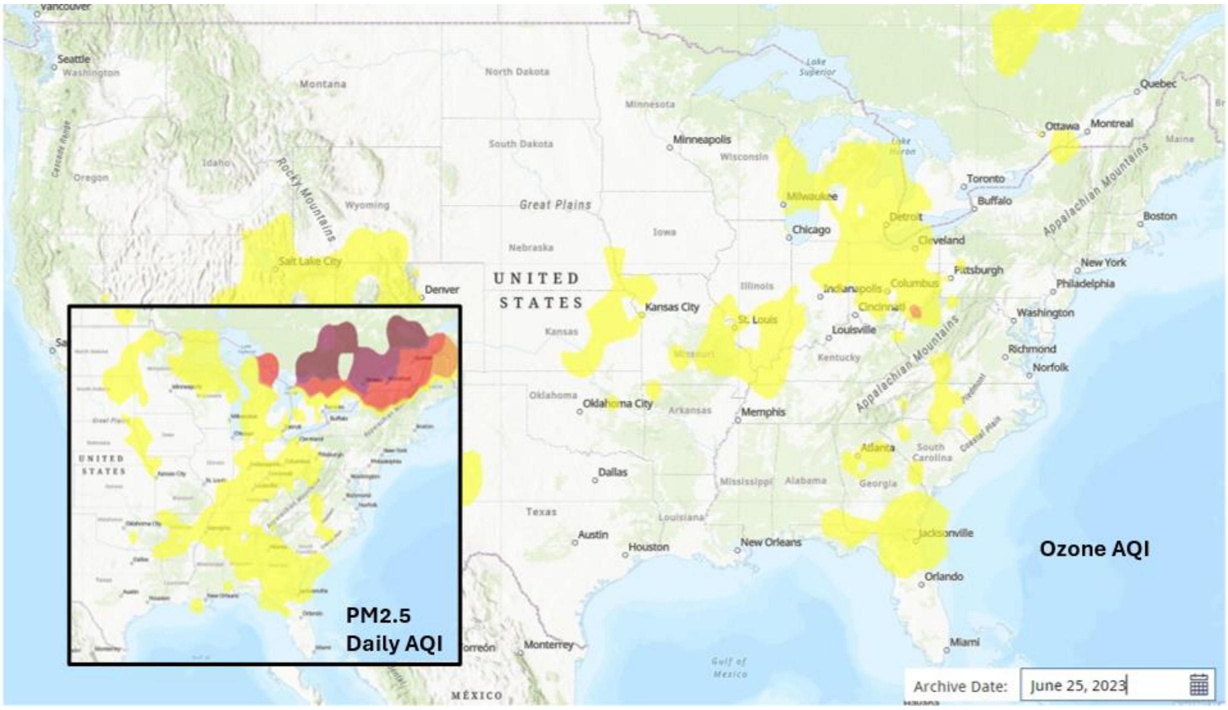


Figure 151: Daily AQI June 26, 2023

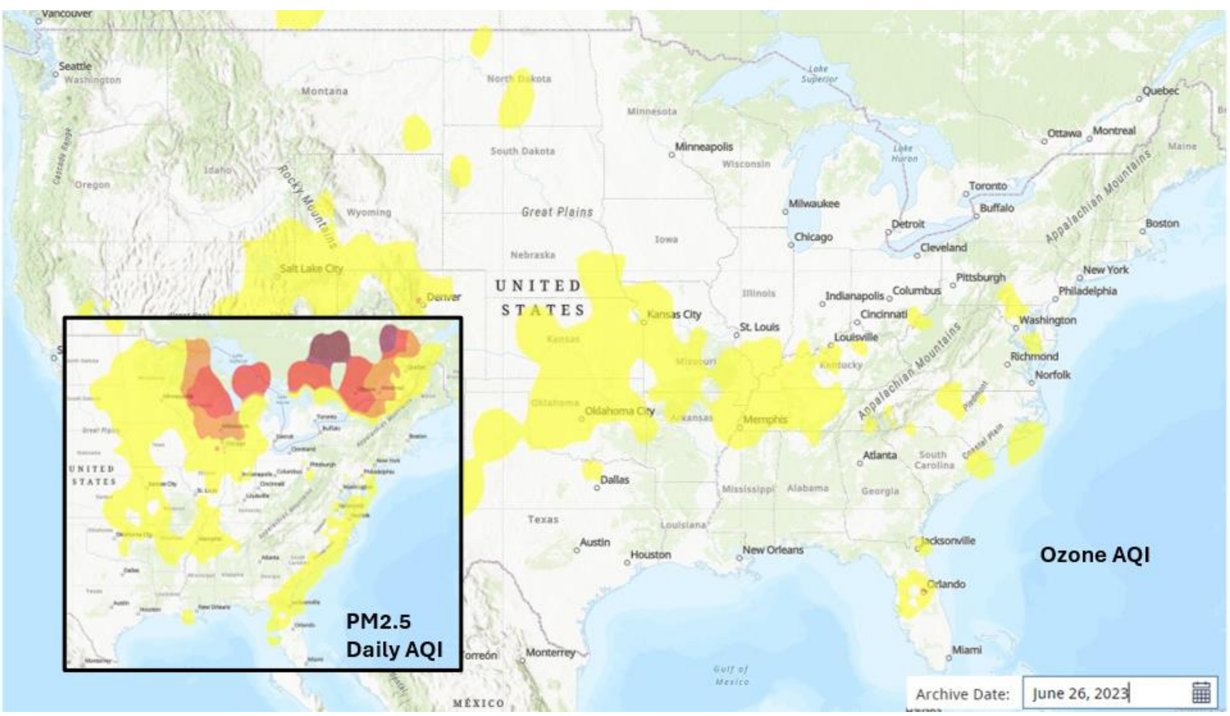


Figure 152: Daily AQI June 27, 2023

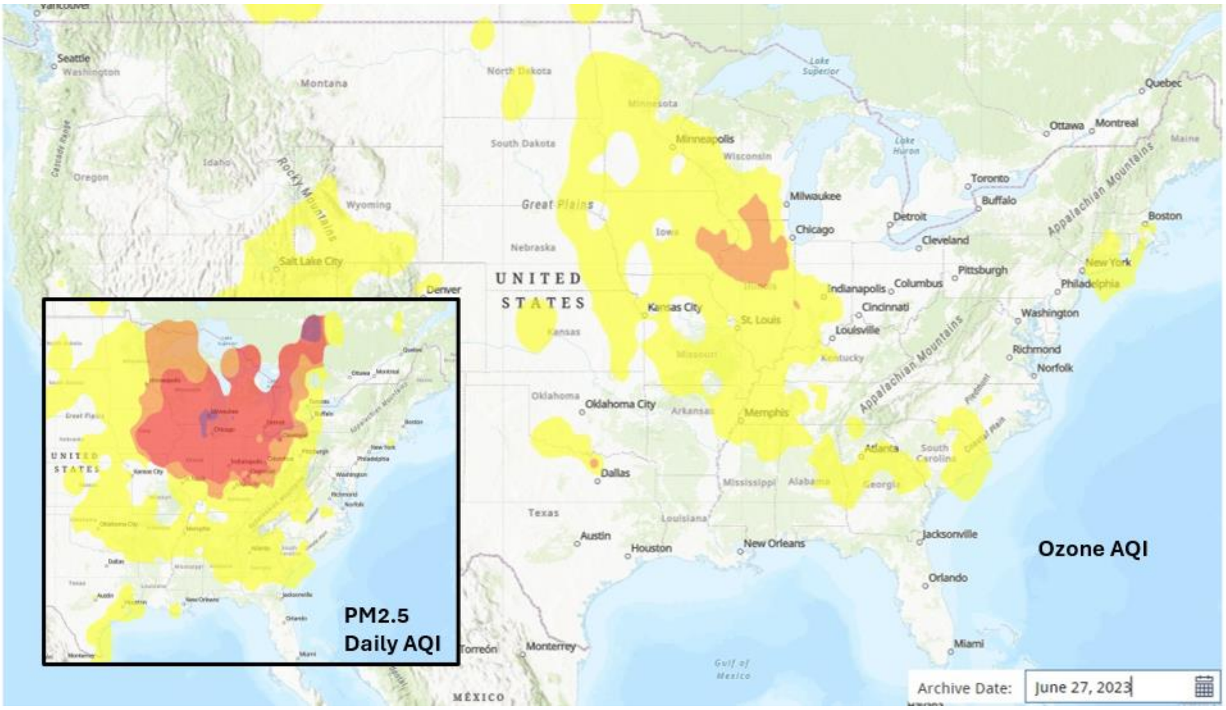


Figure 153: Daily AQI June 28, 2023

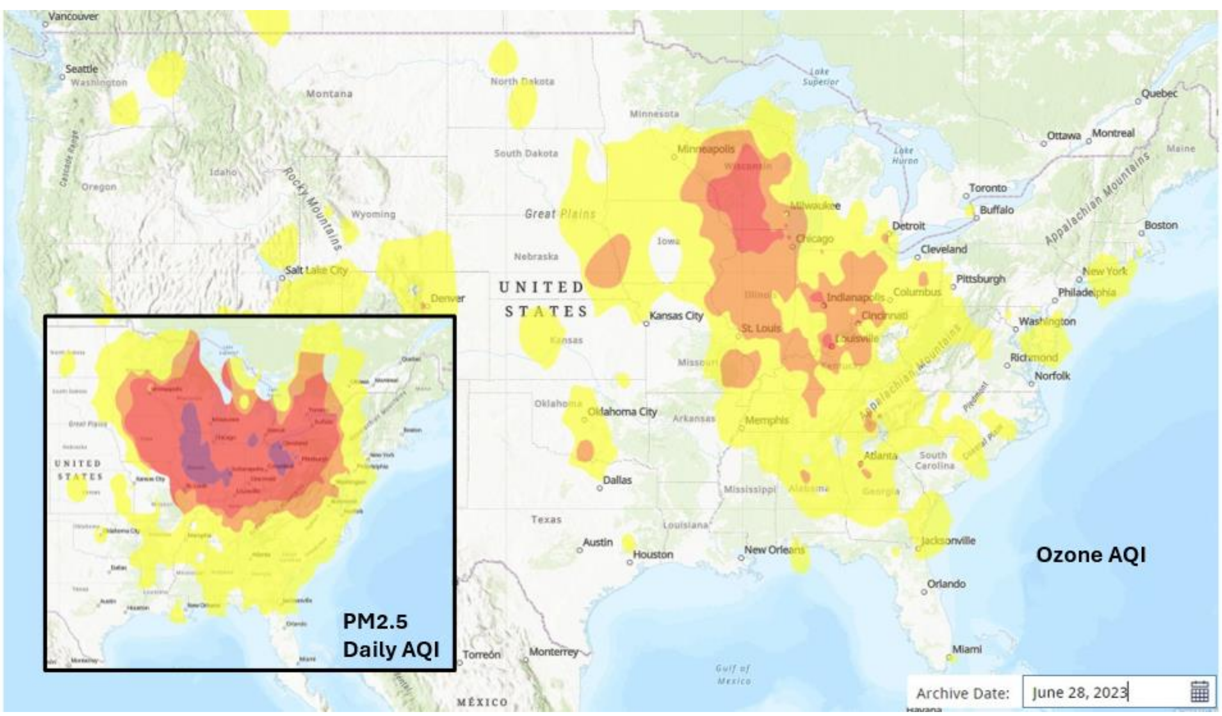


Figure 154: Daily AQI June 29, 2023

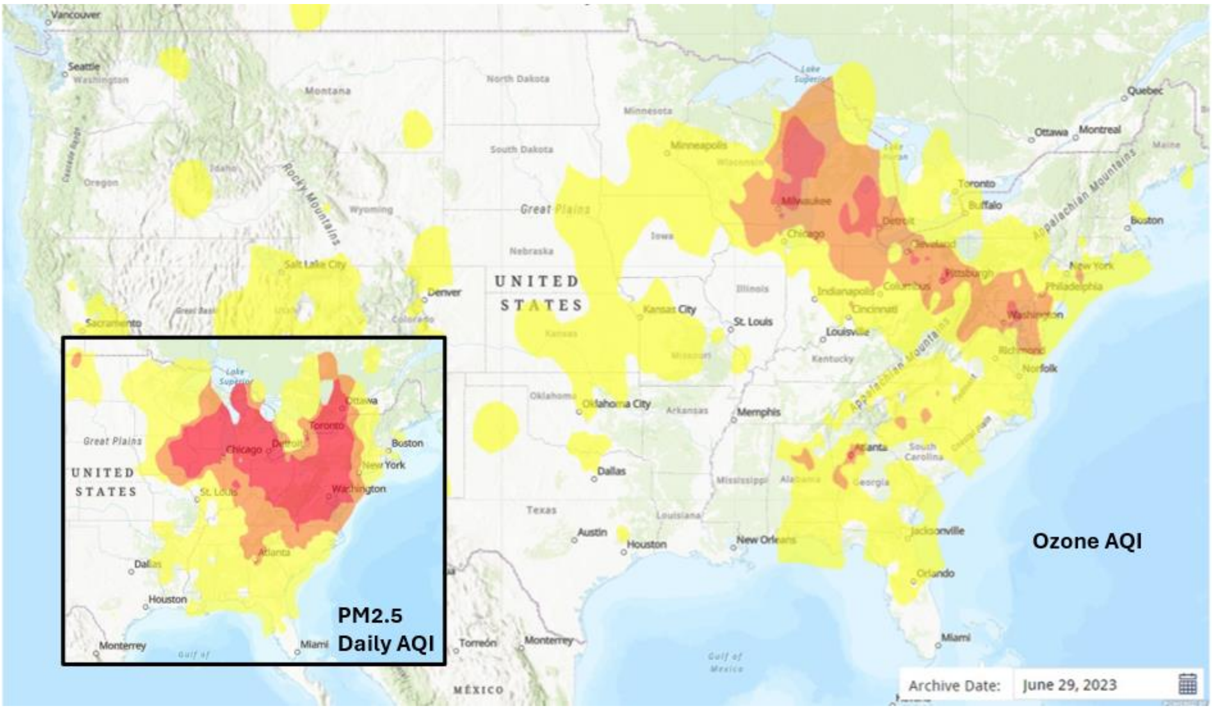
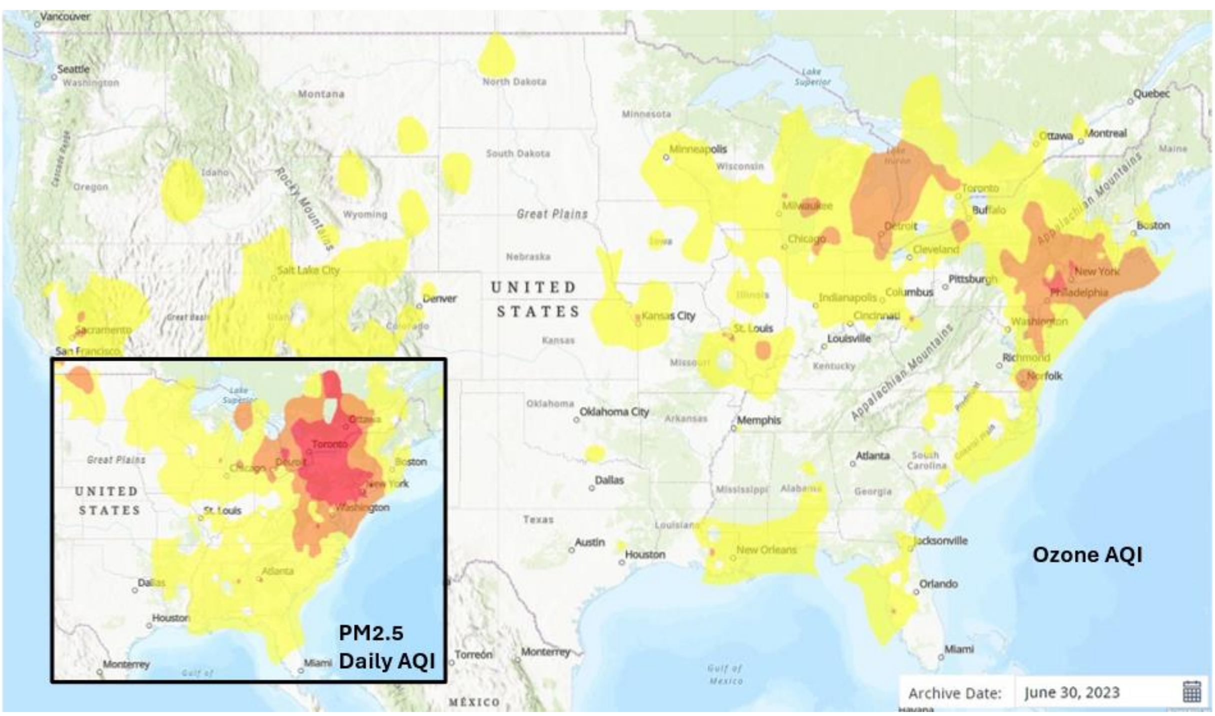


Figure 155: Daily AQI June 30, 2023



II. A Demonstration That the Event Affected Air Quality in Such a Way That There Exists a Clear Causal Relationship Between the Specific Event and the Monitored Exceedance or Violation

The Exceptional Events Rule demonstrations are required to address the technical element and implicit concept of CAA 319(b) that "the event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedance or violation"[159]. Demonstrations are required to support the clear causal relationship by a comparison of the ozone data requested for exclusion with historical concentrations at the air quality monitor. For a Tier 2 analysis, it needs to be demonstrated that the wildfire event's ozone influences are higher than non-event related concentrations, as well as consider the fire's distance from the affected monitor(s) to indicate a clear causal relationship.[160]

The June 2, 2023, event serves as an example of how smoke can affect air quality in the region. The evidence presented in this report compliments the conceptual model in section 1 and shows that smoke impacted air quality in New Jersey and caused higher-than-normal ozone concentration levels, which resulted in the ozone exceedances on June 29 and June 30, 2023.

The analyses presented in this section include the requirements of a Tier 2 analysis, as well as a Tier 3 weight of evidence component. The Tier 2 and Tier 3 analyses consist of comparisons to historical concentrations, Q/d analysis, analysis of the 99th percentile or higher of the 5-year distribution of ozone monitoring data, analysis of the four highest ozone concentrations within one year, trajectory analysis, satellite evidence, evidence of spatial/temporal patterns of ozone and/or NOx, changes in supporting ground level measurements, visibility impacts, and similar day analysis. These analyses demonstrate that smoke transport caused elevated levels of ozone which resulted in the exceedances at New Jersey monitors on June 29 and 30, 2023.

1. Comparison between ozone data requested for exclusion with historical concentrations.

The comparison of monitored concentrations with historical observations is used to demonstrate a clear causal relationship between ozone concentrations and a fire event. To do so, it is necessary to compare the event-related exceedance concentrations with historical concentrations measured at the affected monitor or at other monitors in the area during the same season.[161] According to USEPA Guidance, monitored observations at or above the 99th percentile in the past five years from the event-related ozone concentration can be used to establish statistical evidence that the event was likely influenced by

[159] 40 CFR 50.14(c)(3)(iv)(B)-(C).

[160] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[161] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

an exceptional event.[162] The NJDEP has officially certified the ozone data presented in this analysis, which includes the 2023 ozone season data.[163]

Scatter plots of the daily maximum 8-hour ozone concentrations at the four New Jersey monitors, Camden (340070002), Clarksboro (340150002), Colliers Mills (340290006), and Washington Crossing (340219991), included in the exclusion request for June 29 and 30, 2023, show that all four sites uncharacteristically exceeded the 70-ppb ozone NAAQS, highlighting the exceptional nature of the event. See Figure 156 through Figure 163. One of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area, Millville (340110007), recorded the daily maximum 8-hour average concentrations on June 29, the highest concentrations recorded by this station during the 5-year period. Rider University recorded the third highest daily maximum 8-hour average concentration in the Southern NJ-PA-DE-MD nonattainment area during the 5-year period (Figure 164 and Figure 165).

Each monitor's ozone data from March 1, 2019, through October 31, 2023, were plotted against that monitor's multi-season 99th percentile. The data for periods outside of the ozone season (November 1 through February 28/29) for the intervening years are not included in the plots. A dotted line indicates the level of the 99th percentile concentration for each plot. Concentrations from June 29 and 30, 2023, and the other Exceptional Event dates in 2023, are highlighted in each plot as a red mark.

Table 19 presents the ranking, from 2019 to 2023, of the data requested for exclusion on June 29 and 30, 2023, at each monitor.

Table 19: 2019 to 2023 Ranking of Data Requested for Exclusion on June 29 and 30, 2023, at Each Monitor

AQS Code	Site Name and Date	Ozone Concentration (ppb)	Annual Ranking (%)
340070002	Camden Spruce St (June 29)	71	99.3
340150002	Clarksboro (June 29)	78	99.6
340070002	Camden Spruce St (June 30)	78	99.7
340150002	Clarksboro (June 30)	77	99.5
340290006	Colliers Mills (June 30)	73	99.3
340219991	Washington Crossing (June 30)	89	99.9

[162] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf
[163] Certification Letter for 2023 Oozne Monitoring Data (December 18, 2023). See Appendix 3.

Figure 156: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Camden Monitor

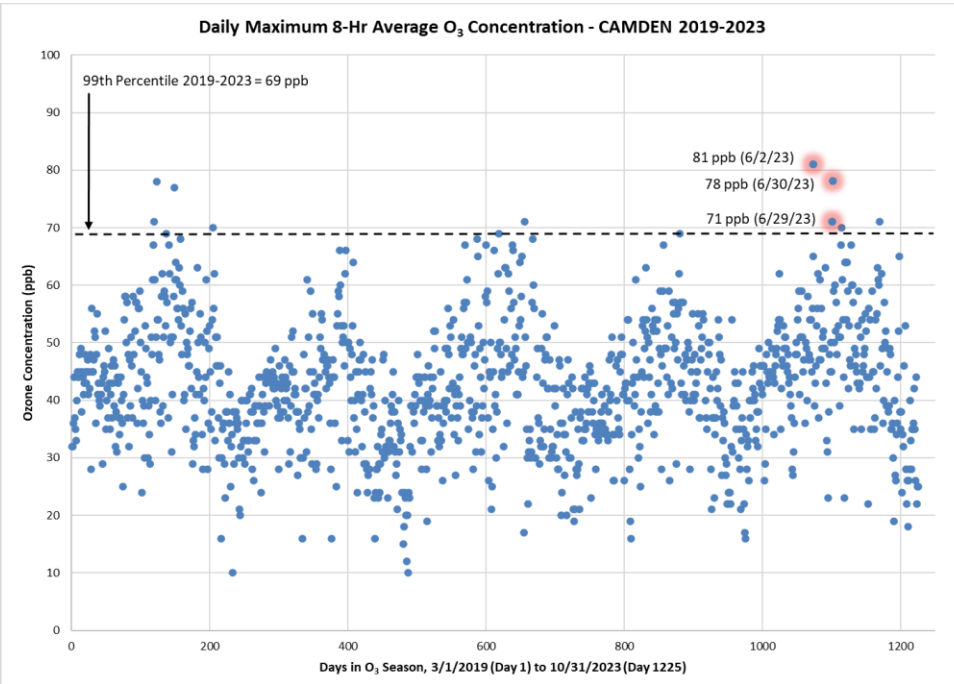


Figure 157: Camden Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

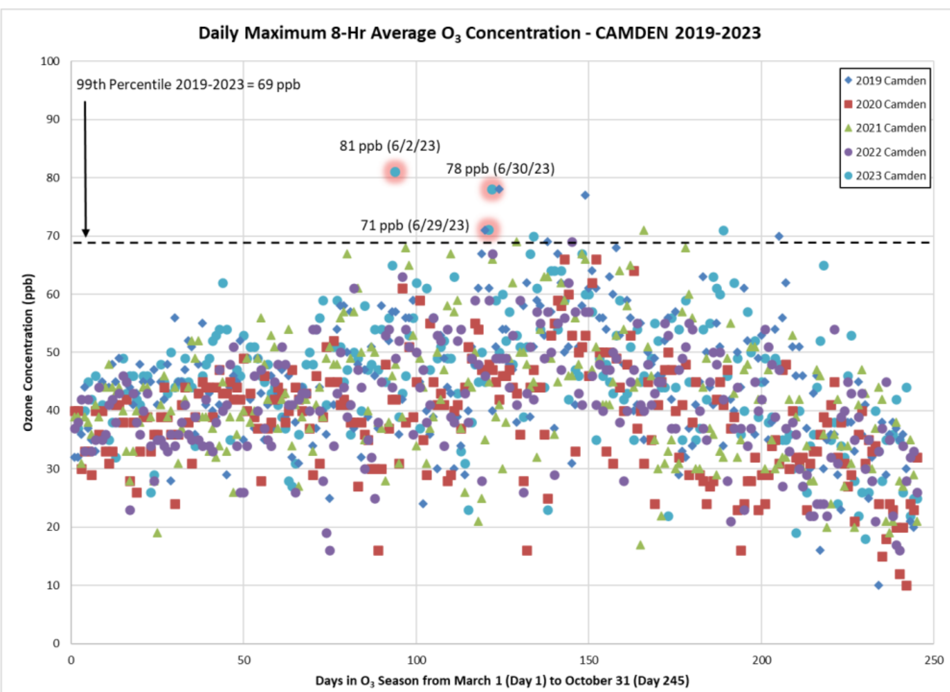


Figure 158: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Clarksboro Monitor

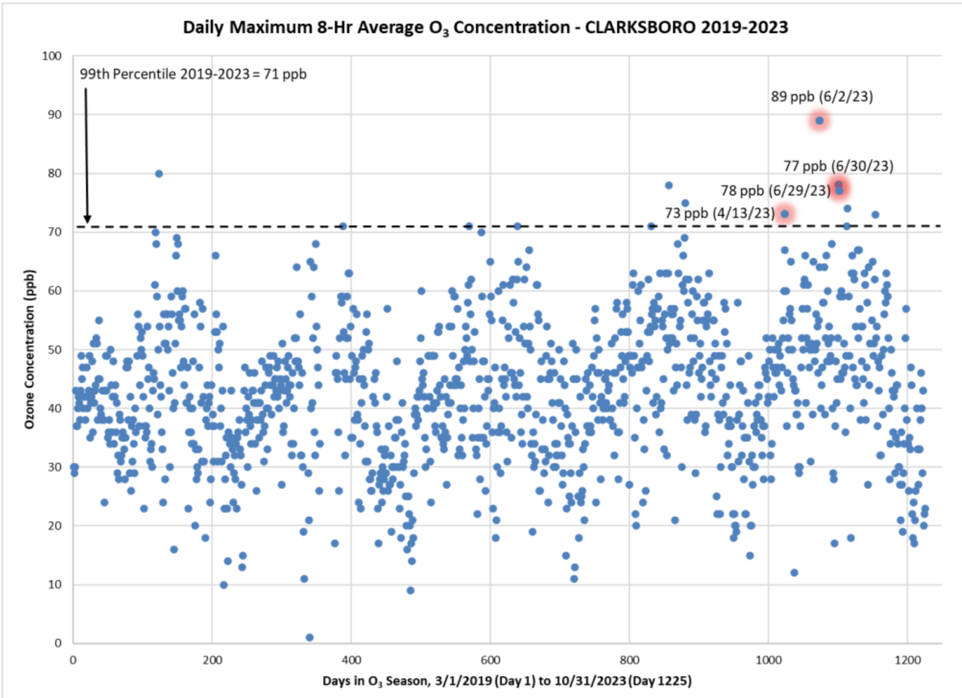


Figure 159: Clarksboro Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

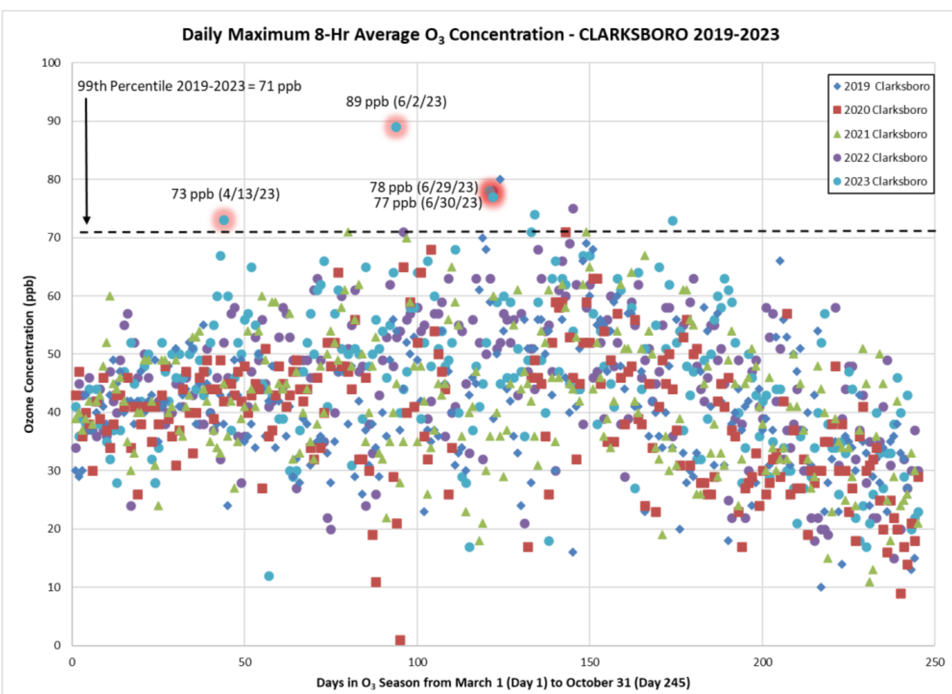


Figure 160: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Colliers Mills Monitor

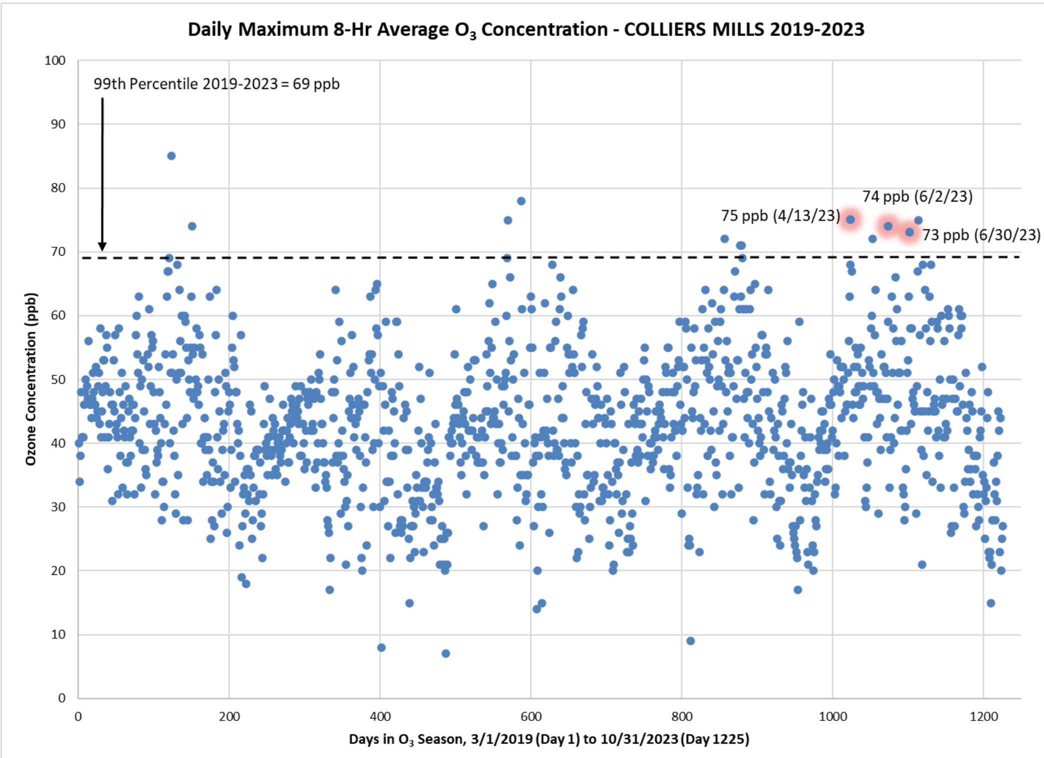


Figure 161: Colliers Mills Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

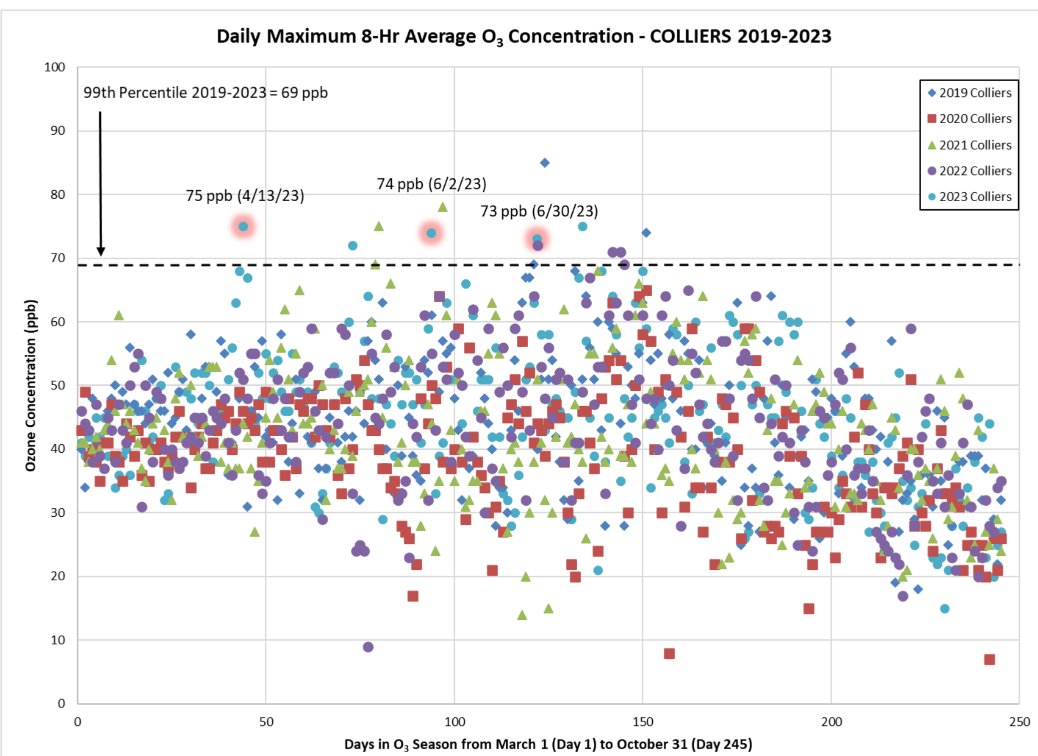


Figure 162: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Washington Crossing Monitor

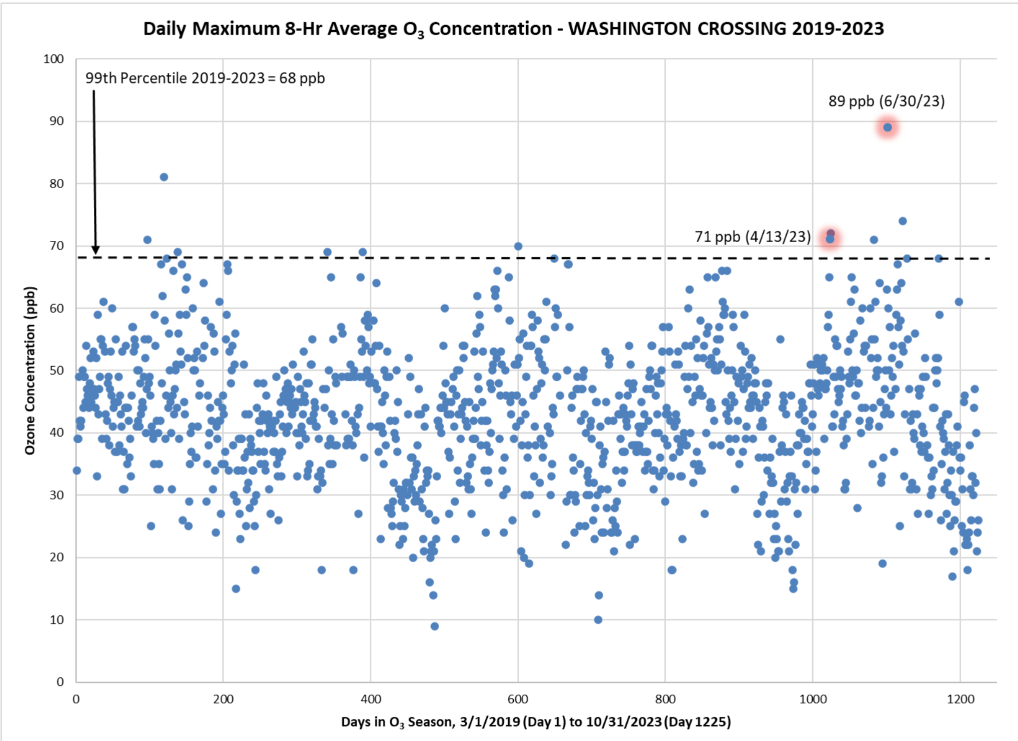


Figure 163: Washington Crossing Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations

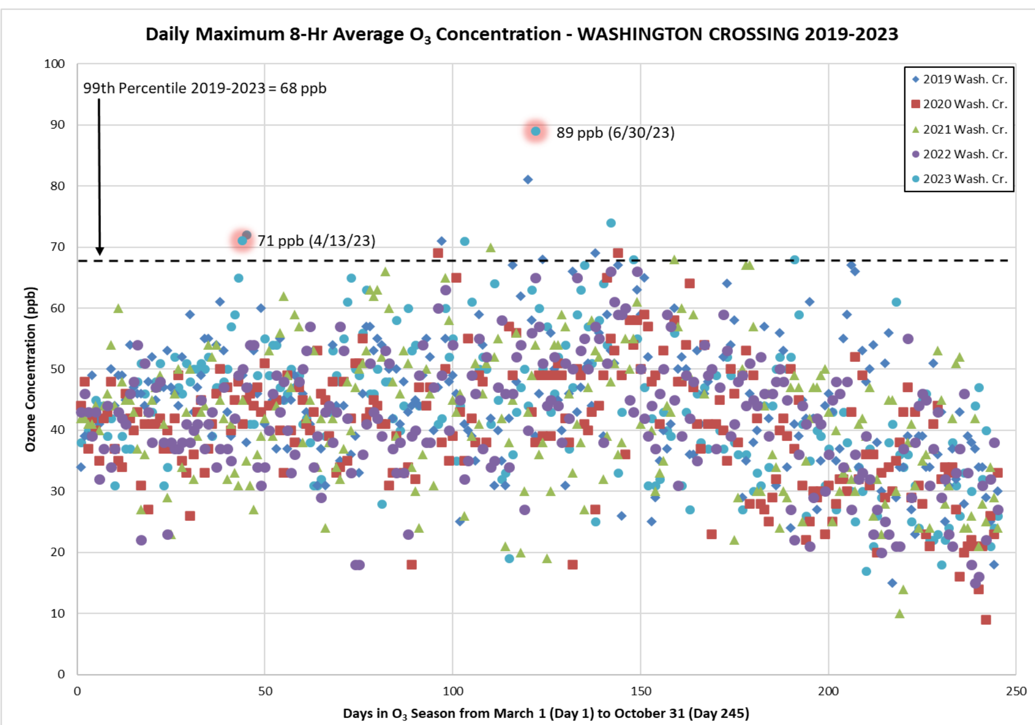


Figure 164: Daily Maximum 8-Hour Average Ozone Concentrations for 2019-2023 Ozone Season at the Rider Monitor

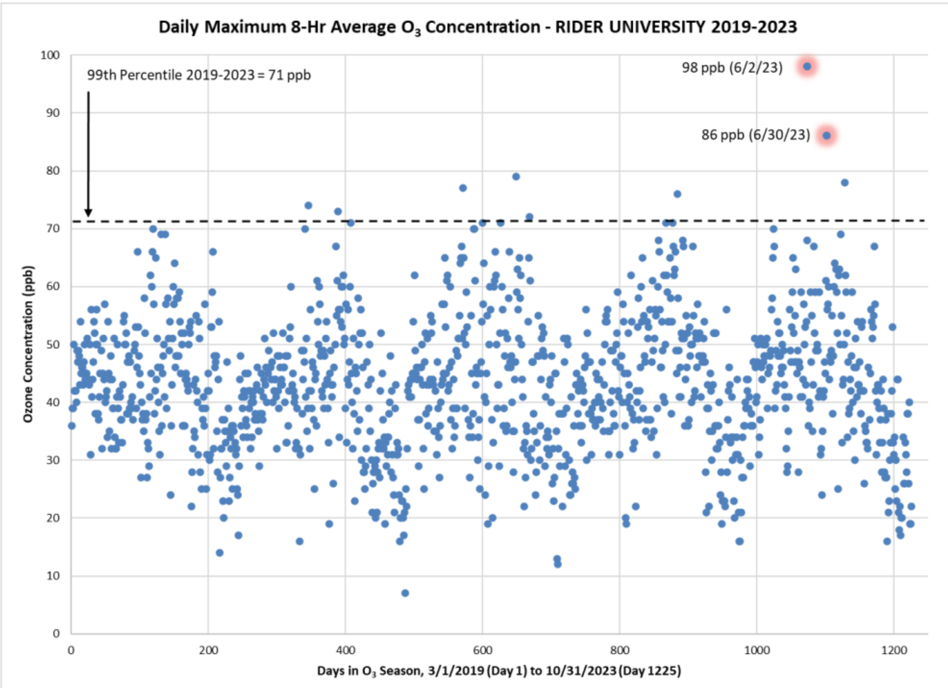
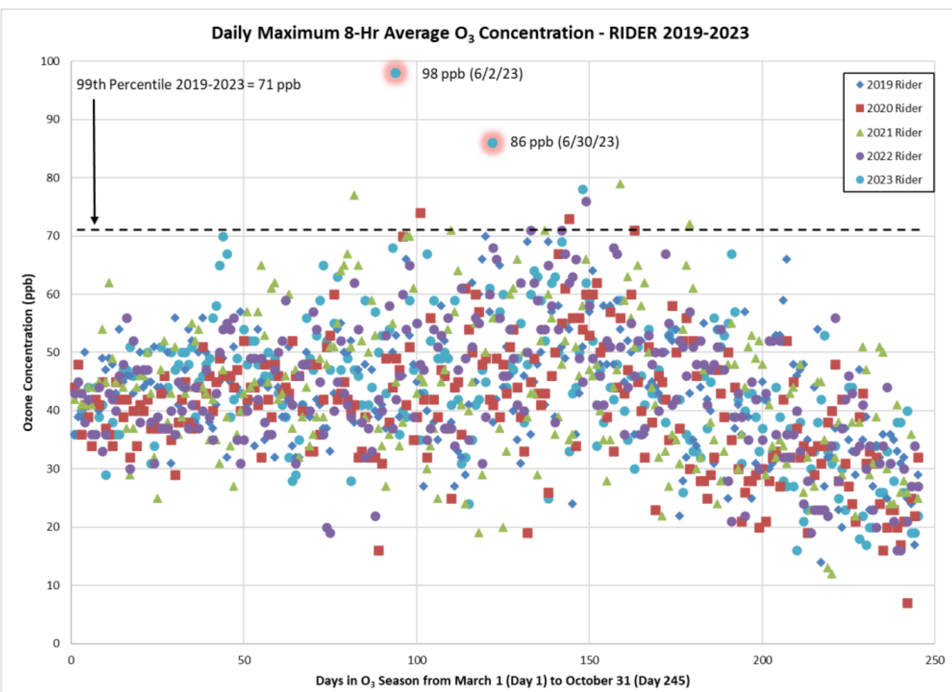


Figure 165: Rider Yearly Variation in Daily Maximum 8-Hour Average Ozone Concentrations



In accordance with the USEPA Exceptional Events Guidance documents, the 99th percentile was calculated for the monitors in the Southern NJ-PA-DE-MD nonattainment area based on the daily maximum 8-hour ozone values for March through October in the last five years, 2019-2023. The distinctive nature of the 2023 data is evident when comparing them to data from the previous four years, 2019-2022. On June 29 and 30, 2023, seven of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area recorded daily maximum concentrations greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period. For the remaining monitor, the daily maximum concentrations recorded on June 30, 2023, were greater than the 98th percentile concentration for the 5-year period. For this reason, the evidence presented in this section indicates a clear causal relationship and satisfies the comparison of the fire-influenced exceedance with historical concentration element of the Exceptional Events demonstration.

New Jersey also considered the ozone concentrations on the days preceding and following the June 29 & June 30 exceptional event. On Thursday and Friday, June 29 and 30, 2023, seven out of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area recorded exceedances of the 2015 70 ppb 8-hour ozone NAAQS. Two monitoring sites also exceeded the 2008 75 ppb 8-hour ozone NAAQS, and two sites exceeded the 1997 84 ppb 8-hour ozone NAAQS. The second highest daily maximum 8-hour ozone concentration recorded for the Southern NJ-PA-DE-MD nonattainment area in 2023 was 89 ppb at Washington Crossing, on June 30, 2023. Table 20 summarizes the daily maximum 8-hour average ozone concentrations recorded in Southern NJ-PA-DE-MD nonattainment area from June 25, 2023, through July 4, 2023, with the exceedances highlighted.

Table 20: Daily Maximum 8-hour Ozone Levels in the New Jersey Portion of the Southern NJ-PA-DE-MD Nonattainment Area from June 25, 2023, through July 4, 2023

AQS Code	Site Name	6/25	6/26	6/27	6/28	6/29	6/30	7/1	7/2	7/3	7/4
340071001	Ancora State Hospital	40	47	52	53	73	67	59	44	53	43
340010006	Brigantine	40	41	49	46	51	59	47	47	42	36
340070002	Camden Spruce St	48	45	50	45	71	78	59	50	60	52
340150002	Clarksboro	48	41	45	52	78	77	59	45	60	46
340290006	Colliers Mills	36	42	51	53	63	73	58	43	58	47
340110007	Millville	47	43	54	55	75	72	58	44	52	44
340210005	Rider University	41	42	47	45	61	86	56	57	60	44
340219991	Washington Crossing*	43	47	50	44	63	89	60	50	57	43

*Operated by USEPA

exceeds 70 ppb NAAQS of 2015
exceeds 75 ppb NAAQS of 2008
exceeds 84 ppb NAAQS of 1997

2. Evidence that The Event, Monitors, and Exceedance Meet the Key Factors for Tier 2 Clear Causal Analyses

Emissions from the burning of forests and vegetation have been shown to add several pollutants that enhance ozone formation to the ambient air including fine particle matter, non-methane hydrocarbons, black carbon, and carbon monoxide.[164] According to a study by the National Oceanic and Atmospheric Administration (NOAA), the effects of fire emissions on the atmosphere are even larger and far more

[164] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

widespread than previously believed, and substantially contribute to ozone, one of the most common and harmful constituents of air pollution.[165]

2.1 Emissions over Distance (Q/d) Analysis

According to the USEPA guidance, a Q/d analysis is recommended as a rough assessment of the ability of a wildfire to cause increased ozone concentrations.[166] The Q/d analysis is a simple comparison of the ratio of the emissions (Q), the daily tons of VOC and NOx emitted from the fire, to distance, (d), in kilometers, from the fire to the point of concern. The guidance indicates that a fire should have a Q/d in excess of 100 tons per day per kilometer of distance (tpd/km) in order to be considered to have a clear causal impact on ozone. This value was developed based on analyses of four fires that occurred in 2011.[167]

2.1.1 Estimate of Emissions, Q

According to the USEPA Guidance, the emissions from wildfires can be estimated using information from Section 13.1, Wildfires and Prescribed Burning, of USEPA's AP-42, Compilation of Air Emission Factors.[168] This section presents emission factors for various pollutants by fire and fuel configurations for the fire from AP-42. The emissions and emission factors are calculated using the following formulas:

$$F_i = P_i * L \quad \text{(Equation 1)}$$
$$E_i = F_i * A \quad \text{(Equation 2)}$$

Combining equations 1 and 2, we have:

$$E_i = P_i * L * A \quad \text{(Equation 3)}$$

where:
F_i = emission factor (mass of pollutant/unit area of forest consumed)
P_i = yield for pollutant "i" (mass of pollutant/unit mass of forest fuel consumed), where:
= 12 kg/Mg (24 lb/ton) for total hydrocarbon (as CH_4)
= 2 kg/Mg (4 lb/ton) for nitrogen oxides (NOx)
L = fuel loading consumed (mass of forest fuel/unit land area burned)
A = land area burned
E_i = total emissions of pollutant "i" (mass pollutant)

The values of P_i above are for total hydrocarbons and for nitrogen oxides. The fuel loading, L, provided in AP-42 for different regions of the United States ranges from 8 to 60 tons per acre.[169] This analysis will present a range of emissions, starting with a conservative estimate based on a low-end emission rate of

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[165] NOAA. (2022, January 10). *Smoke from wildfires influences ozone pollution on a global scale.* https://research.noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/

[166] USEPA. (2016). *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. https://www.USEPA.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[167] Ibid.

[168] USEPA. (1996). AP42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.1: Wildfires and Prescribed Burning. https://www.epa.gov/sites/default/files/2020-10/documents/13.1_wildfires_and_prescribed_burning.pdf

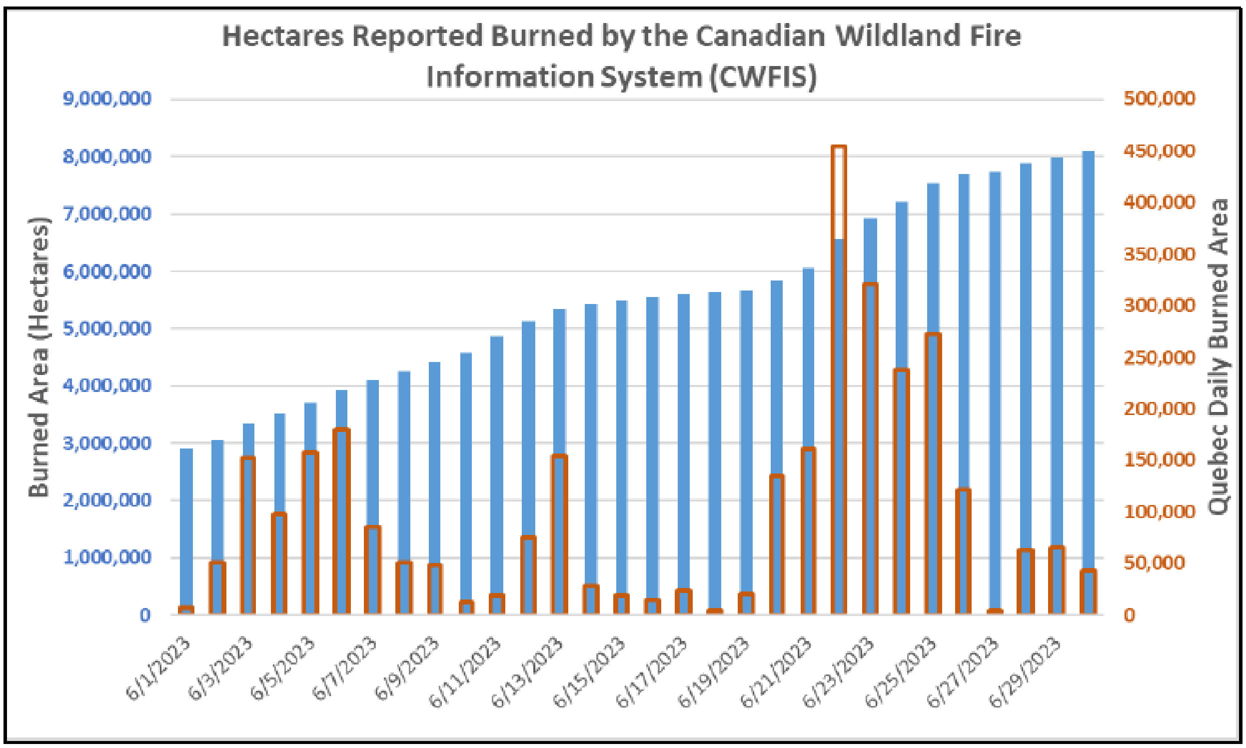
[169] USEPA. (1996). AP42, Fifth Edition, Volume I Chapter 13: Miscellaneous Sources, 13.1: Wildfires and Prescribed Burning. https://www.epa.gov/sites/default/files/2020-10/documents/13.1_wildfires_and_prescribed_burning.pdf

10 tons per acre associated with Central Canadian forests, and the results could increase by a factor of 6, if the high end of fuel loading is considered.

According to the Canadian Wildland Fire Information System (CWFIS), wildfires consumed 1,650,003 hectares (4,077,246 acres) across Canada from June 21, 2023, and June 26, 2023.[170] During this period, fires were most active in Quebec, with a peak daily burn area exceeding 450,000 hectares on June 22, 2023. Of the 1,650,000 hectares that burned across Canada, an extensive area of 1,570,081 hectares (3,879,755 acres) burned within Quebec. This is almost equivalent to the land area of Connecticut, which is approximately 1,435,700 hectares.

Figure 166 was plotted using data provided by CWFIS. The blue bars represent the cumulative burned area for all of Canada in June 2023, and the hallowed orange bars represent the daily area burned in Quebec, with the values on the right axis. A significant increase in emissions is observed from June 21, 2023, to June 26, 2023, due to intense fire activity in Quebec during that period.

Figure 166: Daily hectares of land burned across Canada May 1 - June 2, 2023



The Q/d for June 29 and 30, 2023 is calculated from June 21, 2023, through June 26, 2023, when the fire activity was intense in Quebec.

For the Quebec fires, the total hydrocarbon emissions over the entire period can be estimated to be:

$$E_{hc} = P_{hc} * L * A$$

= 24 lbs of HC / ton of forest fuel consumed * 10 tons fuel / acre * 3,879,755 acres

[170] Canadian Wildland Fire Information System. (n.d.). Government of Canada. https://cwfis.cfs.nrcan.gc.ca/home (check https://cwfis.cfs.nrcan.gc.ca/datamart as new reference)

= 931,141,200 pound of HC or
= **465,571 tons of HC emitted during the period from June 21 – 26, 2023**

If the high end of fuel loading is considered, the total hydrocarbon emissions become:

= 24 lbs of HC / ton of forest fuel consumed * 60 tons fuel / acre * 3,879, 755 acres
= 5,586,847,200 pounds of HC or
= **2,793,424 tons of HC emitted during the period from June 21 – 26, 2023**

Similarly for NOx:

$E_{NO_x} = P_{NO_x} * L * A$

= 4 lbs of NOx / ton of forest fuel consumed * 10 tons fuel / acre * 3,879,755 acres
= 155,190,200 pounds of NOx
= **77,595 tons of NOx emitted during the period from June 21 - 26, 2023**

If the maximum fuel load is considered, the total nitrogen oxides emissions become:

= 4 lbs of NOx / ton of forest fuel consumed * 60 tons fuel / acre * 3,879,755 acres
= 931,141,200 pounds of NOx
= **465,571 tons of NOx emitted during the period from June 21 – 26, 2023**

Q is the total daily emission rate in tons per day of reactive hydrocarbons and nitrogen oxides. USEPA recommends in the Exceptional Events Guidance,[171] that only 60% of the hydrocarbons from wildfires should be considered reactive. Therefore, the reactive hydrocarbon emissions become:

Q = rHC + NOx.
rHC = 0.6 * Ehc or
0.6 * 465,571 = **279,343 tons of reactive HC emitted daily during the period from June 21 – 26, 2023**.

If the maximum fuel load is considered, the reactive hydrocarbon emissions become:

0.6 * 2,793,424 = **1,676,054 tons of reactive HC emitted during the period from June 21 – 26, 2023**.

No adjustments are suggested for the NOx emissions to account for reactivity.

Therefore, the total rHC and NOx emissions over the period are **279,343 + 77,595, or 356,938 tons over the six days, or 1,676,054 + 465,571, or 2,141,625 tons over the six days,** if maximum fuel load is considered**.**

On average this results in a **daily emission rate, or Q, of 59,490 tons per day or 356,938 tons per day,** if maximum fuel load is considered.

[171] 42 U.S.C. 7619(b)(1)(iii), Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations. USEPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. https://www.USEPA.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

2.1.2 Estimate of Distance from the Fire, d.

New Jersey estimated the distance, d, from the approximate centroid of the fires (roughly 49.37°N, 76.61°W), to the Clarksboro monitor (39.800339, -75.212119), since this monitor is centrally located within the New Jersey portion of the Southern NJ-PA-DE-MD nonattainment area and experienced ozone violations during the Exceptional Event. Google maps was used to determine the straight-line distance between the approximate centroid of the fires and the Clarksboro monitor resulting in an approximate value of **665 miles (1,070 kilometers),** for d.[172]

2.1.3 Q/d Estimate

Using the values and days burned determined in the previous section for the Quebec fires, Q/d is calculated to be 55.6 tpd/km [59,490 tpd divided by 1,070 km](Table 21). If we assume that the single day on June 22 is representative of the smoke arriving in New Jersey from the out-of-control fires, when 1,124,529 acres burned, New Jersey's Q/d value becomes 96.7. At maximum fuel load, Q/d is calculated to be 333.6 tpd/km. If we consider only June 22, the value increases to 580 tpd/km. Standard Q/d values fall below the USEPA recommended level of 100 tpd/km but are within accepted levels in sample cases presented in USEPA guidance as conveying a clear causal relationship, while at maximum fuel load, Q/d value meets the USEPA threshold for a clear causal relationship.

Table 21: Q/d analysis, Quebec, Canada Fires

ACRES	Ehc (tons)	Enox (tons)	Q	No. days burning	d	Q/d	DESCRIPTION
3,879,755	**2,793,424**	**465,571**	**2,141,625**	**6**	**1,070**	**333.6**	**Fuel loading at maximum of 60 tons/acre instead of 10, June 21-26 only**
1,124,529	809,661	134,944	620,741	1	1,070	580	Fuel loading at maximum of 60 tons/acre instead of 10, June 22 only
1,124,529	134,944	22,491	103,457	1	1,070	96.7	Standard Q/d June 22 only
3,879,755	465,571	77,595	356,938	6	1,070	55.6	Standard Q/d, June 21-26 only

2.2 Discussion of 5-years of Ozone Data from 2019-2023- 99th Percentiles

Observations at monitors measuring at or above the 99th percentile in the past five years are considered statistical evidence that the values were likely influenced by an Exceptional Event. The Exceptional Events Guidance documents were used to calculate the 99th percentile for all the monitors in the Southern NJ-

[172] Map Developers. (n.d.). *Distance From To - Calculate distance between two addresses, cities, states, zipcodes, or locations*. Retrieved March 11, 2024, from https://www.mapdevelopers.com/distance_from_to.php?&from=49.37%C2%B0N%2C%2076.61%C2%B0W&to=39.800339%2C%20-75.212119

PA-DE-MD nonattainment area for all the days in March through October over the last five years (2019-2023). These percentiles are presented earlier in scatterplots in Figure 156-Figure 165 and summarized in section 1.

Table 22 summarizes the daily maximum 8-hour ozone concentrations measured by monitors in the Southern NJ-PA-DE-MD nonattainment area on June 29 and 30, 2023, along with each monitor's respective 99th percentile daily maximum 8-hour ozone concentrations for the 5-year period 2019-2023. The values highlighted in blue are over the 99th percentile for the 5-year period for each monitor, while the value highlighted in pink is over the 98th percentile. The last column highlights the monitors that exceeded their 99th percentile (YES) on June 2, 2023. Blanks indicate that the monitor did not exceed the 99th percentile.

Table 22: 5 years (2019-2023) of Daily Maximum 8-hour Average Ozone Concentrations for New Jersey Exceptional Event Monitors

	Daily Maximum 8-Hour O_3 (ppb)					2019-2023 Daily Max 8-Hr Avg		
	6/28/2023	6/29/2023	6/30/2023	7/1/2023	7/2/2023	99th %ile	98th %ile	Exceed 99th %ile (2019-2025) Level on June 29 and 30, 2023
Ancora State Hospital	53	73	67	59	44	66	61	**YES**
Brigantine	46	51	59	47	47	61	58	
Camden Spruce St	45	71	78	59	50	69	66	**YES**
Clarksboro	52	78	77	59	45	71	67	**YES**
Colliers Mills	53	63	73	58	43	69	67	**YES (June 30, 2023)**
Millville	55	75	72	58	44	68	62	**YES**
Rider University	45	61	86	56	57	71	68	**YES (June 30, 2023)**
Washington Crossing	44	63	89	60	50	68	66	**YES (June 30, 2023)**

> level of 99th Percentile > level of 98th Percentile

Table 22 shows that on June 29, 2023, four of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area, including the two monitors seeking an Exceptional Event exclusion, recorded daily maximum concentrations greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period. On June 30, 2023, seven out of the eight monitors in the Southern NJ-PA-DE-MD nonattainment area, including the four monitors seeking an Exceptional Event exclusion, recorded daily maximum concentrations greater than the 99th percentile of the daily maximum 8-hour ozone concentration for the 5-year period. For the remaining monitors, the daily maximum concentrations recorded on June 30, 2023, was greater than the 98th percentile concentration for the 5-year period. The daily maximum concentrations recorded on June 29, 2023, at Millville, and on June 30, 2023, at Washington Crossing were the highest concentrations recorded by these stations during this 5-year period.

2.3 Discussion of Highest Ozone Concentration Within 1 year

Key factor 2 compares event-related ozone concentration with non-event related high ozone concentrations. According to the USEPA Guidance, for a Tier 2 analysis, Key factor 2 can be satisfied if the exceedance due to an Exceptional Event is one of the four highest ozone concentrations within one year, or if an exceedance falls at the 99th percentile or higher over 5 years. New Jersey has exceeded the requirements for satisfying this key factor by conducting both the 99th percentile analysis and presenting the highest daily maximum ozone concentrations in 2023 in Table 23, showcasing the severity and widespread nature of June 29 and 30 event.

Table 23 compares the daily maximum 8-hour ozone concentrations measured during the Exceptional Event days with the five highest concentrations for the year. The overall maximums for 2023 ozone season at the New Jersey monitors, except Brigantine, occurred on an Exceptional Event Day, indicating the impact of the wildfires. Furthermore, all exceedances on an Exceptional Event Day at all Southern New Jersey's monitors were among the top fourth or fifth highest for the year.

Table 23: Ozone Daily Max Values Compared with Five Highest Daily Maximums in 2023

Site Name	Daily Max 8-Hr Ozone (ppb)				2023 Daily Maximum 8-Hr Ozone Concentrations (ppb)				
	4/13/2023	6/2/2023	6/29/2023	6/30/2023	1st Max	2nd Max	3rd Max	4th Max	5th Max
Ancora State Hospital	66	67	73	67	73	69	67	67	66
Brigantine	54	41	51	59	67	64	59	58	55
Camden Spruce St	62	81	71	78	81	78	71	71	70
Clarksboro	73	89	78	77	89	78	77	74	73
Colliers Mills	75	74	63	73	75	75	74	73	72
Millville	68	64	75	72	75	72	68	68	68
Rider University	70	98	61	86	98	86	78	70	69
Washington Crossing*	71	NA	63	89	89	74	72	71	71

*Site is operated by USEPA

1st Max	2nd Max	3rd Max	4th Max	5th Max	Exceedance Day

During the Exceptional Event periods in 2023, seven out of eight monitors in the Southern NJ-PA-DE-MD nonattainment area recorded their highest daily maximum 8-hour average ozone concentrations. One of the seven monitors recorded their highest values on June 30. The next most severe ozone event occurred on June 29 and 30, 2023, when seven monitors exceeded the 70 ppb 2015 8-hour ozone NAAQS, with one exceeding the 84 ppb 1997 8-hour ozone NAAQS. All of the ozone exceedances that occurred during the Exceptional Event periods exceed the 70 ppb 2015 ozone NAAQS and are among the highest 5 daily maximum 8-hour average for each of the monitors.

3. Evidence that Fire Emissions were Transported to New Jersey Monitors

A trajectory analysis can be used to show that the emissions from the fire were transported to the monitors, based on the methodology recommended in USEPA Guidance.[173] New Jersey presents trajectory modeling results in this section to show that emissions from west-central Canadian fires were transported to New Jersey.

3.1 Trajectory Analysis

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was employed to calculate backward trajectories arriving in New Jersey on June 29 and 30, 2023. The meteorological model that was used to compute the backward trajectories was obtained from the North American Mesoscale Forecast System, 12km, (NAM 12).

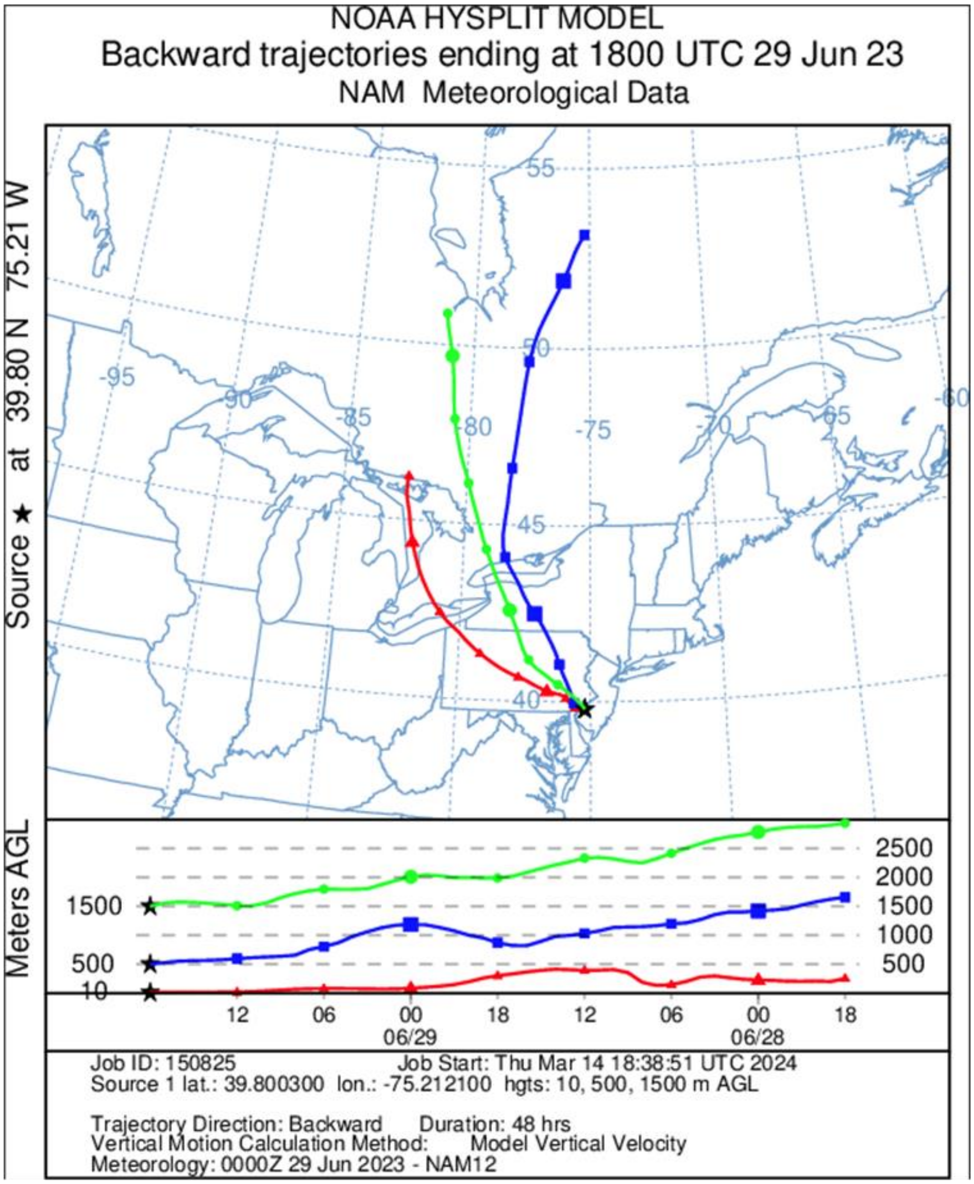
Figure 167-Figure 169 show trajectories at 3 different wind heights with an endpoint at the Clarksboro monitor in New Jersey on June 29 and 30, 2023. The figures illustrate where the air came from during the 48 hours preceding the 8-hour ozone standard exceedances on June 29 and 30, 2023. Figure 169 shows the combined transport pattern from June 29 and 30, along with 84-hour backward trajectories that end on June 30. The three wind heights above ground level (AGL) that are plotted in the figures below are 10m, 500m, and 1500m.

June 29

Back trajectories ending on June 29 (Figure 167) originated over various places across Quebec, Ontario, and Lake Huron. As mentioned previously, elevated PM2.5 levels were observed in this region due to the wildfire smoke plume, which allowed the trajectories to become heavily polluted with wildfire smoke from its origin. From here, trajectories moved in a southerly direction, influenced by the counterclockwise winds associated with an area of low pressure passing through this region. Trajectories made a turn toward the southeast and traversed over Pennsylvania and New York State. As trajectories drew closer to their endpoint in Clarksboro, they continued to transport high levels of aged wildfire smoke before arriving at their destination. Meanwhile, air at all levels experienced a gentle sinking motion through transit, allowing smoke to reach the surface and enhance ozone formation in New Jersey leading to above normal ozone exceedances.

[173] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

Figure 167: HYSPLIT 48hr Backward Trajectories on June 29, 2023 - Clarksboro – 10, 500, and 1500m AGL



June 30

Back trajectories ending on June 30 in Clarksboro, New Jersey show that air at the surface originated in nearby locations, such as Maryland, while mid- and upper-level trajectories originated near Lake Huron and upstate New York (Figure 168). During transit, dense plumes of wildfire smoke had migrated into the Great Lakes region by June 28, the starting time for trajectories in Figure 168. As low pressure passed over New England, and high pressure strengthened over the Mid-Atlantic, surface trajectories (red, Figure 168) showed signs of high-pressure overhead by the recirculation pattern. Upon the arrival of wildfire smoke into the Mid-Atlantic region, it was likely trapped under the influence of high pressure with little atmospheric ventilation leading to a build-up of wildfire smoke in New Jersey for a second day.

By evening on June 29, mid and upper-level trajectories arrived near the I-95 corridor where they encountered a wind shift due to high pressure advancing eastward causing the wind direction to shift out of the southwest. Throughout their path, the trajectories continued to carry wildfire smoke into the region as they had days prior. This aged wildfire smoke helped enhance ozone concentrations throughout the region and led to regionwide exceedances throughout the nonattainment area.

Figure 169 shows the 84hr backward trajectory for June 29 and 30. The purpose of including the 84-hour trajectory is that it provides a complete picture of the transport period and the two event days.

Figure 168: HYSPLIT 48hr Backward Trajectories on June 30, 2023, 10, 500, and 1500m AGL

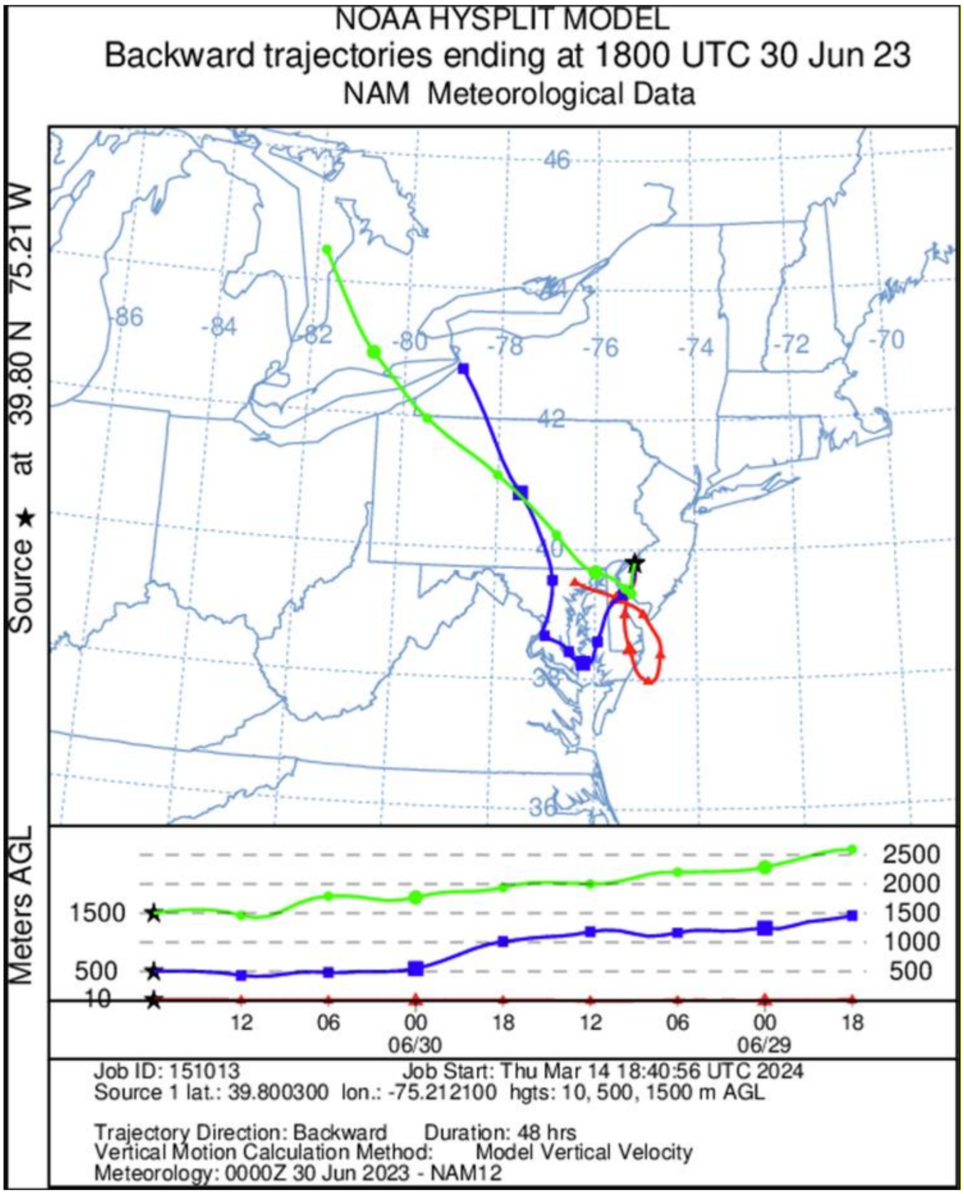
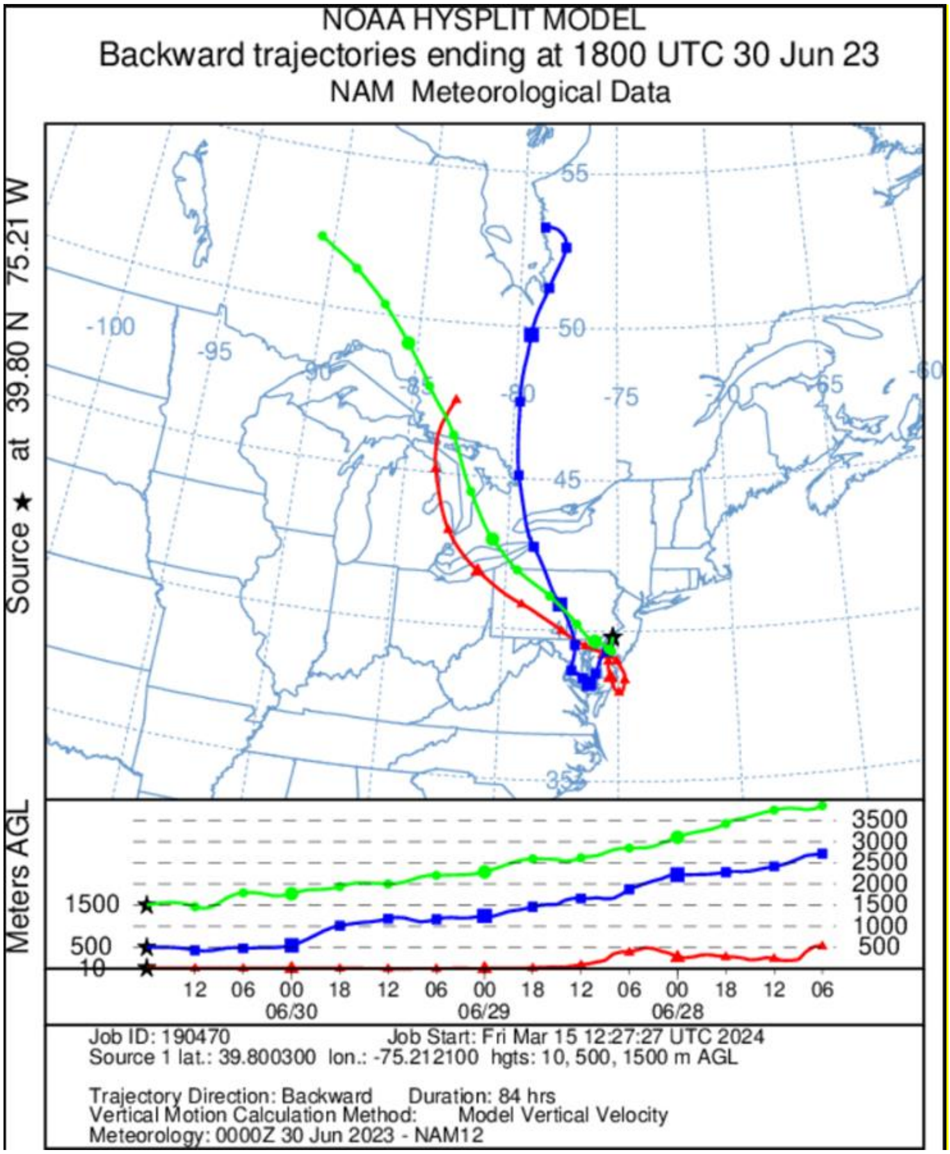


Figure 169: HYSPLIT 84hr Backward Trajectories on June 30, 2023, 10, 500, 1500m AGL



4. Evidence that Fire Emissions Affected New Jersey Monitors

This section adds to the weight of evidence that the emissions from the fires affected the monitored ozone concentrations at New Jersey monitors, as recommended by USEPA Guidance.[174]

The primary pollutants emitted from wildland fires include greenhouse gases, non-methane volatile organic compounds (NMVOC), NOx, and aerosol.[175] Wildland fires emit a variety of aerosols, including black carbon, organic carbon, and inorganic compounds.

[174] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

[175] Urbanski, S.P., Hao, W.M., & Baker, S. (2008). Chemical Composition of Wildland Fire Emissions. In Bytnerowicz, A, Arbaugh, M.J., Riebau, A.R., & Andersen, C. (Eds.), *Developments in Environmental Science* (Vol. 8, pp. 79-107).

The New Jersey monitoring network measures both total PM2.5 mass and speciated compounds such as ionic potassium (K^+) and organic carbon, as well as other pollutants such as CO, NOx and VOCs. Analyses of the various species that can be attributed to fires are presented in the following sections. The analyses show that the ozone exceedance in New Jersey was characterized by enhanced precursors attributable to wildfire species. The 2023 data concerning fine particulate matter, potassium, organic carbon, elemental carbon, black carbon, carbon monoxide, nitrogen dioxide, non-methane hydrocarbon and non-methane volatile organic compounds presented in this analysis is preliminary until certification by NJDEP.

4.1 Fine Particulate Matter (PM2.5)

PM2.5 emissions from wildfires can be transported across large distances. PM2.5 is one of the species that accounts for the next largest share of emissions from wildfire after CO_2 and CO and can be used as an indicator of the presence of wildfire smoke.[176] New Jersey monitors PM2.5 levels using filter-based continuous Federal Equivalent Method (FEM) monitors. The National Ambient Air Quality Standard (NAAQS) for 24-hour PM2.5 is 35 ug/m^3.

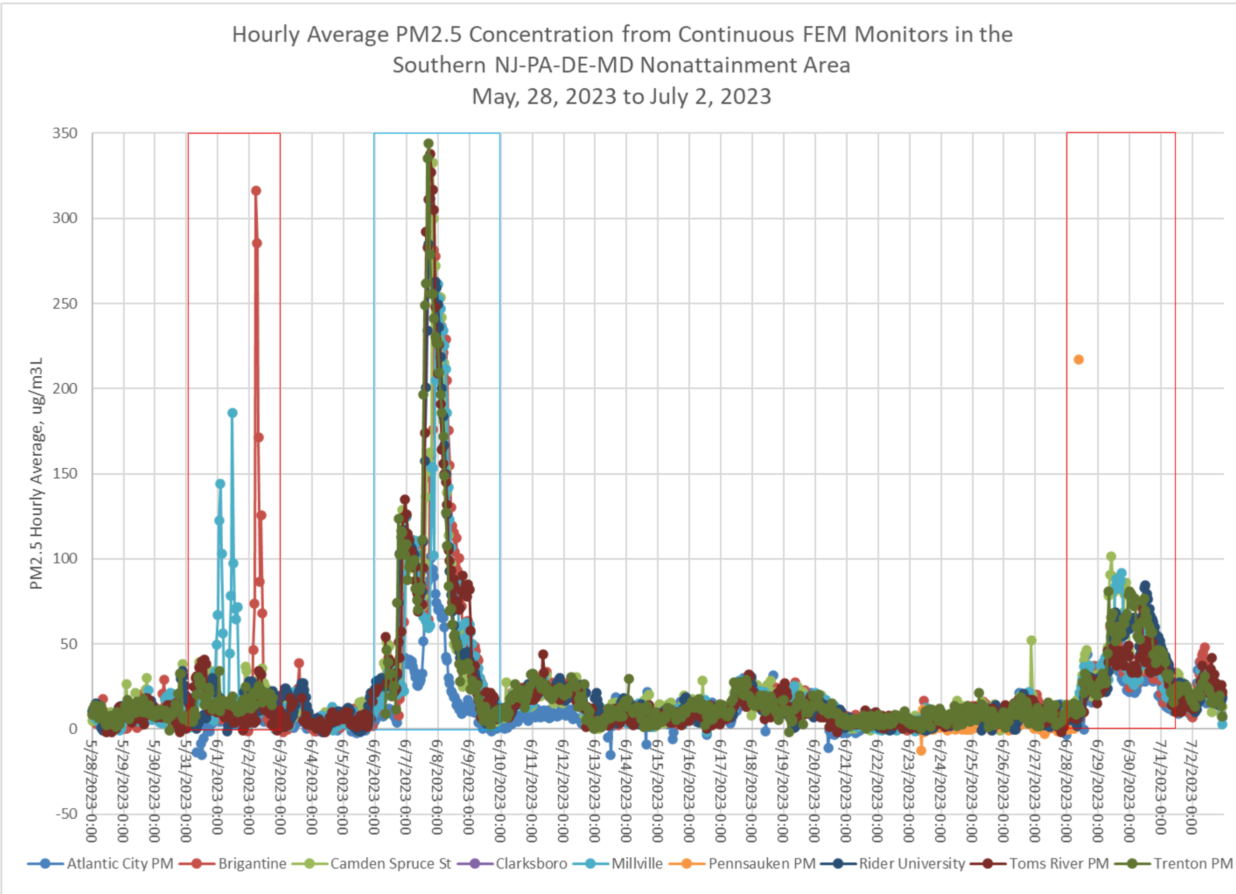
Hourly PM2.5 concentrations from May 28 - July 2, 2023, for monitors in the Southern NJ-PA-DE-MD nonattainment area, are presented in Figure 170. On June 29, PM2.5 levels recorded a peak hourly average of 101.6 ug/m^3, which is three times the 24-hour NAAQS. Similarly, on June 30, a peak hourly average of 84.7 ug/m^3 was recorded, which is almost two and a half times the 24-hour federal standard. The red and blue boxes in Figure 170 indicate periods of elevated PM2.5 concentrations. These elevated concentrations in the red boxes coincide with the June 2, and June 29 and 30 Exceptional Event dates. New Jersey is not seeking Exceptional Event exclusions for the period in the blue box because it does not have regulatory significance related to ozone for New Jersey.

Based on the analysis in this demonstration, the peak in PM2.5 concentration on June 29 and 30 is attributed to the smoke transport from the Quebec, Canada wildfires. Therefore, the elevated levels of PM2.5 in addition to other factors indicate the strong presence of wildfire in New Jersey during the June 29 and 30 ozone exceedances.

Elsevier. Retrieved January 24, 2024, DOI: 10.1016/S1474-8177(08)00004-1, https://www.fs.usda.gov/rm/pubs_other/rmrs_2009_urbanski_s001.pdf

[176] Ibid.

Figure 170: Hourly Average PM2.5 Concentration from Continuous FEM Monitors in the Southern NJ-PA-DE-MD Nonattainment Area from May 28, 2023, to July 2, 2023



4.1.1 Potassium and Organic Carbon

Biomass burning is a significant source of particle pollution, which is mainly composed of organic carbon (OC) and black carbon. These particles also contain potassium ions. Wildfire smoke can be traced using ionic potassium (K^+), which is a reliable indicator of wildfire emissions due to its scarcity in anthropogenic sources and its concentration above background levels.[177]

The presence of smoke from wildfires can be determined in the outside air by looking for elevated levels of certain pollutants, called markers, that are key components of wood smoke but are not usually found in outside air except in trace amounts. Primary markers for wood smoke emissions include potassium (K) and levoglucosan.[178] When there are high levels of potassium in the outdoor air, it is usually an indication

[177] Ma, Y., Weber, R.J., Lee, Y.N., Orsini, D.A., Maxwell-Meier, K., Thornton, D.C., Bandy, A.R., Clarke, A.D., Blake, D.R., Sachse, G.W., Fuelberg, H.E., Kiley, C.M., Woo, J.H., Streets, D.G., & Carmichael, G.R. (2003). Characteristics and influence of biosmoke on the fine-particle ionic composition measured in Asian outflow during the Transport and Chemical Evolution Over the Pacific (TRACE-P) experiment. *Journal of Geophysical Research: Atmospheres, 108*(D21), 37-1 – 37-16. DOI: 10.1029/2002JD003128, https://aerosols.eas.gatech.edu/papers/Ma%20ACE%20Asia%20Biomass%20Smoke.pdf

[178] Gibson, M.D., Haelssig, J., Pierce, J.R., Parrington, M., Franklin, J.E., Hopper, J.T., Li, Z, & Ward, T.J. (2015). A comparison of four receptor models used to quantify the boreal wildfire smoke contribution to surface PM2.5 in

that wood smoke is present and causing an increase in the outdoor air concentrations of other pollutants from wood smoke emissions as well. USEPA's PM2.5 Speciation Trends Network analyzes fine particle samples from sampling locations nationwide to monitor the levels of potassium and other parameters. The samplers generally operate on a three-day sampling schedule. However, some samplers operate on a six-day sampling schedule.

New Jersey has PM2.5 Speciation samplers located in the Camden Spruce Street and Rutgers University air monitoring stations. The Rutgers University sampler operates on a three-day sampling schedule, while the Camden Spruce Street sampler operates on a six-day sampling schedule. The potassium concentration at the Rutgers and Camden monitors is evidence of smoke impact on New Jersey monitors.

Figure 171 presents preliminary data obtained from June 2023. The data collected at the Camden and Rutgers monitors clearly show elevated levels of potassium in the air on June 29. Specifically, Camden recorded its highest potassium levels for the entire month on that day, suggesting the presence of smoke. No data was collected at either monitor on June 30. Higher PM2.5 concentrations were also observed within the Southern NJ-PA -DE-MD nonattainment area monitors on the same day.

The red boxes in The potassium concentration at the Rutgers and Camden monitors is evidence of smoke impact on New Jersey monitors.

Figure 171 indicate the two smoke periods that New Jersey is pursuing as Exceptional Events: June 2, and June 29 and 30. Although there appears to be a smoke event around June 7 and 8, New Jersey is not pursuing that episode because it was not identified to have regulatory significance related to ozone air quality for New Jersey. During this time period, organic and elemental carbon concentrations showed similar characteristics as potassium at the Camden and Rutgers monitors, as shown in Figure 172 and Figure 173.

The potassium concentration at the Rutgers and Camden monitors is evidence of smoke impact on New Jersey monitors.

Halifax, Nova Scotia during the BORTAS-B experiment. *Atmospheric Chemistry and Physics, 8*(2), 815-827. DOI: 10.5194/acp-15-815-2015

Figure 171: Preliminary Potassium (K) Concentrations Measured from PM2.5 Speciation Monitoring Sites at Rutgers and Camden, New Jersey in June 2023

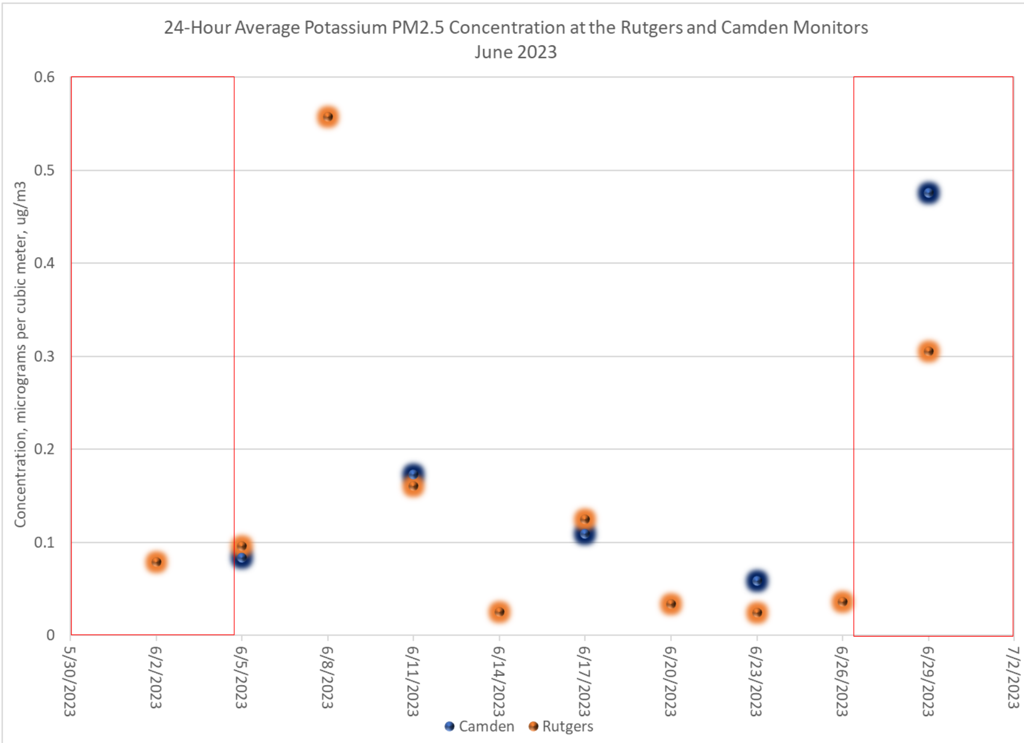


Figure 172: Preliminary Organic Carbon (OC) Concentrations Measured from PM2.5 Speciation Monitoring Sites at Rutgers and Camden, New Jersey in June 2023

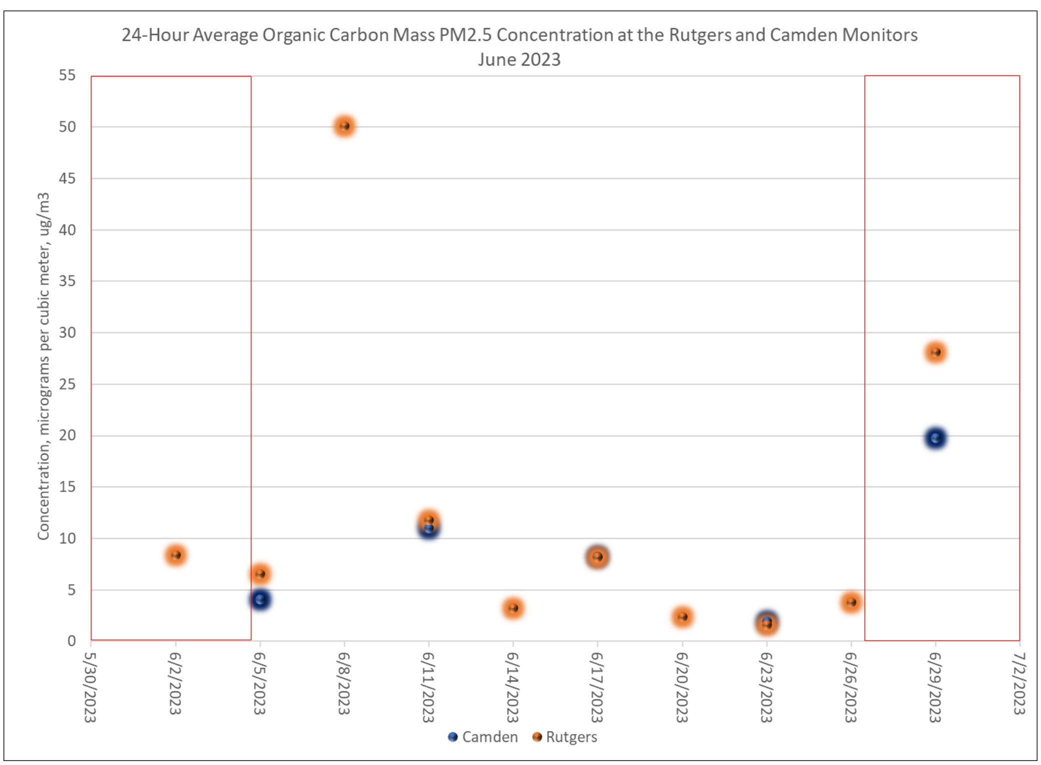
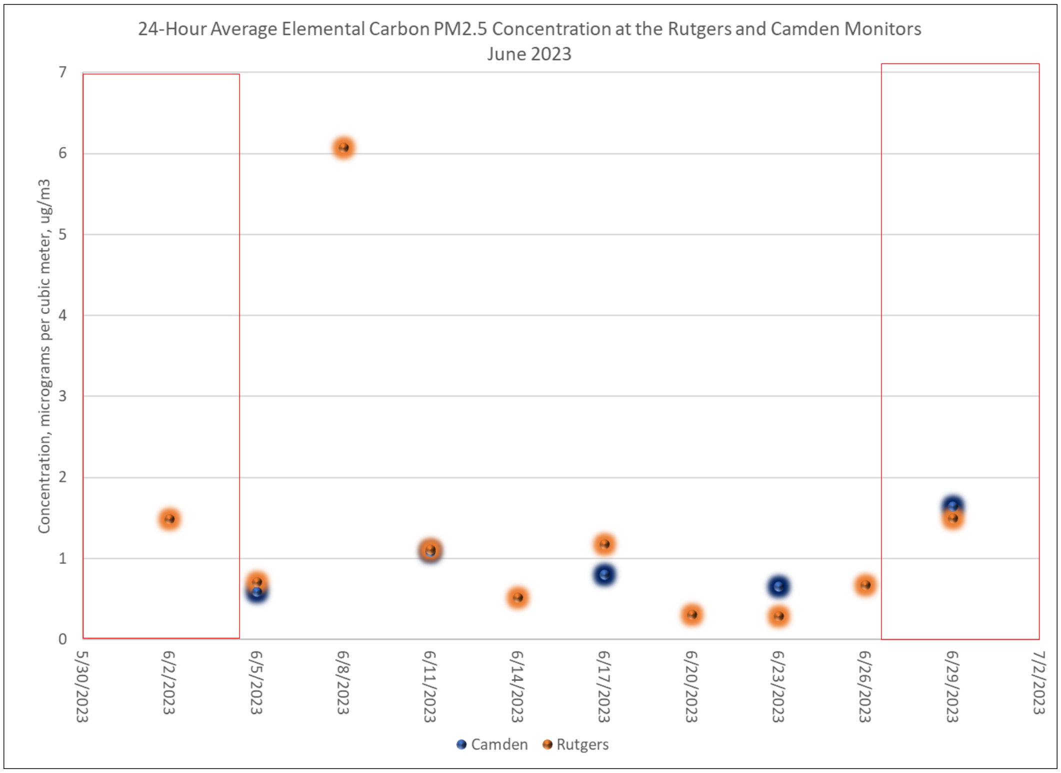


Figure 173: Preliminary Elemental Carbon (EC) Concentrations Measured from PM2.5 Speciation Monitoring Sites at Rutgers and Camden, New Jersey in June 2023



4.1.2 Black Carbon

The presence of black carbon (BC) is an indicator of smoke originating from biomass burning during wildfires. The detection of elevated levels of BC provides additional evidence of the impact of wildfire smoke on elevated ozone concentrations.[179] New Jersey measures near-real time black carbon in ambient air at five urban monitoring stations throughout the state.[180]

In addition, the average daily BC concentration on June 29, 2023, exceeded the long-term average for June over the past five years. Specifically, it was over 80% larger than the average from 2019 to 2013 (long-term average: 0.829 ug/m^3) in Bayonne, and over 40% larger at Elizabeth Trailer (long-term average: 1.278 ug/m^3). On June 30, 2023, the concentrations were even higher. The average daily BC concentration at Bayonne was over 190% greater than the long-term average and over 130% greater at Elizabeth Trailer.

Figure 174 presents the hourly BC concentrations at three NJ monitors from May 30 to July 3 in 2023. On June 29, a noticeable spike in BC concentrations begins, reaching a peak on June 30, as highlighted within the red box on the figure. There was no monitoring data for Camden Spruce St on June 29-30, 2023, to compare with the broader monthly and preceding year averages. However, as seen in In addition, the average daily BC concentration on June 29, 2023, exceeded the long-term average for June over the past five years. Specifically, it was over 80% larger than the average from 2019 to 2013 (long-

[179] NOAA. (2022, January 10). *Smoke from wildfires influences ozone pollution on a global scale.* https://research.Noaa.gov/2022/01/10/smoke-from-fires-influences-ozone-pollution-on-a-global-scale/

[180] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

term average: 0.829 ug/m^3) in Bayonne, and over 40% larger at Elizabeth Trailer (long-term average: 1.278 ug/m^3). On June 30, 2023, the concentrations were even higher. The average daily BC concentration at Bayonne was over 190% greater than the long-term average and over 130% greater at Elizabeth Trailer.

Figure 174 and Figure 175, the Camden Spruce St monitor follows a similar trend as the Bayonne and Elizabeth Trailer monitors located in New Jersey. These monitors are upwind of Camden Spruce St based on the trajectories seen earlier in this document in Figure 169. On June 29-30, the smoke plume originated in the north where these upwind areas experienced higher air pollutant concentrations along the smoke path before reaching the southern monitors. The BC levels monitored at Bayonne and Elizabeth Trailer increased as the days progressed indicating that increasing levels of BC can also be expected at the Camden monitor during this time due to transport. The increasing concentrations of BC can be seen in Figure 175 from May 30 to July 3 in 2023.

In June 2023, the average daily concentration of BC at the Bayonne monitor was 1.170 ug/m^3, while the Elizabeth Trailer monitor measures 1.412 ug/m^3. However, on June 29, the average daily BC concentration spiked to 1.529 ug/m^3, with the hourly concentrations reaching as high as 3.167 ug/m^3 in Bayonne and 4.295 ug/m^3 in Elizabeth Trailer. The very next day, June 30, the average daily BC concentration spiked to 2.408 ug/m^3 in Bayonne and 2.991 ug/m^3 in Elizabeth Trailer, with the hourly concentrations reaching as high as 4.136 ug/m^3 and 4.173 ug/m^3, respectively.

In addition, the average daily BC concentration on June 29, 2023, exceeded the long-term average for June over the past five years. Specifically, it was over 80% larger than the average from 2019 to 2013 (long-term average: 0.829 ug/m^3) in Bayonne, and over 40% larger at Elizabeth Trailer (long-term average: 1.278 ug/m^3). On June 30, 2023, the concentrations were even higher. The average daily BC concentration at Bayonne was over 190% greater than the long-term average and over 130% greater at Elizabeth Trailer.

Figure 174: Hourly Black Carbon Concentration at New Jersey Monitors from May 30 to July 3 in 2023

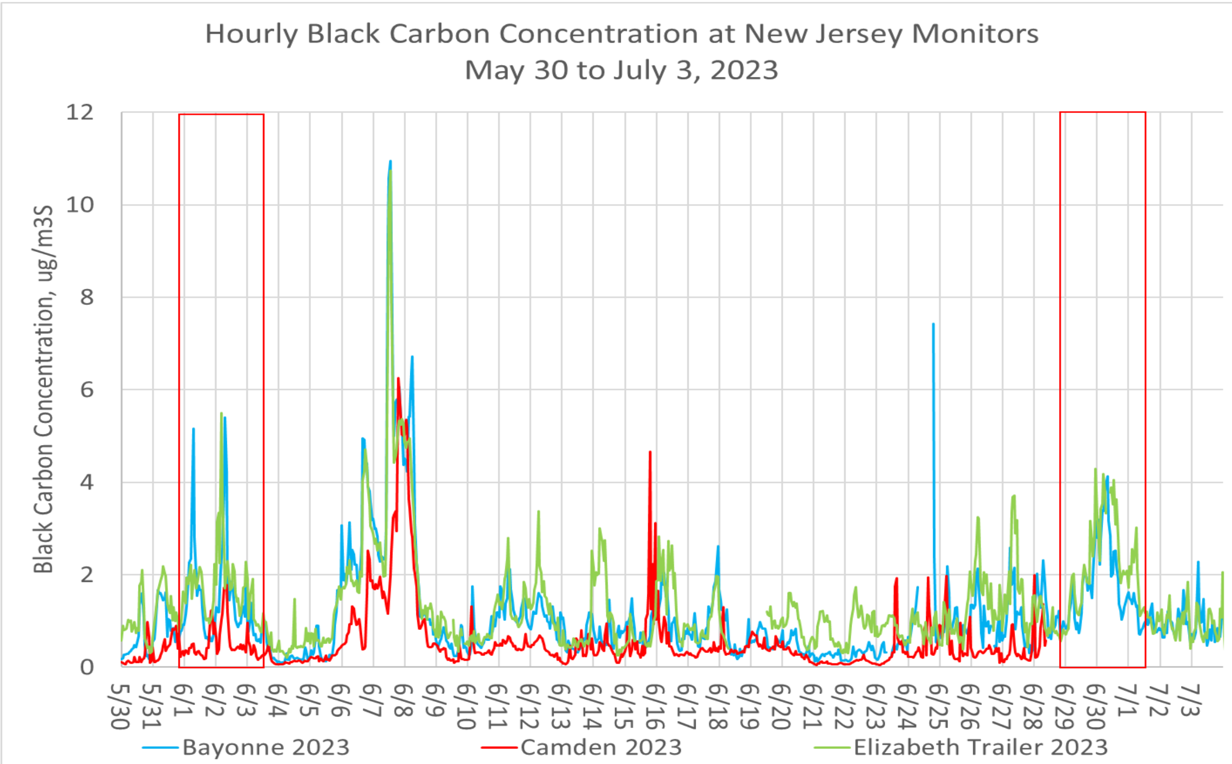
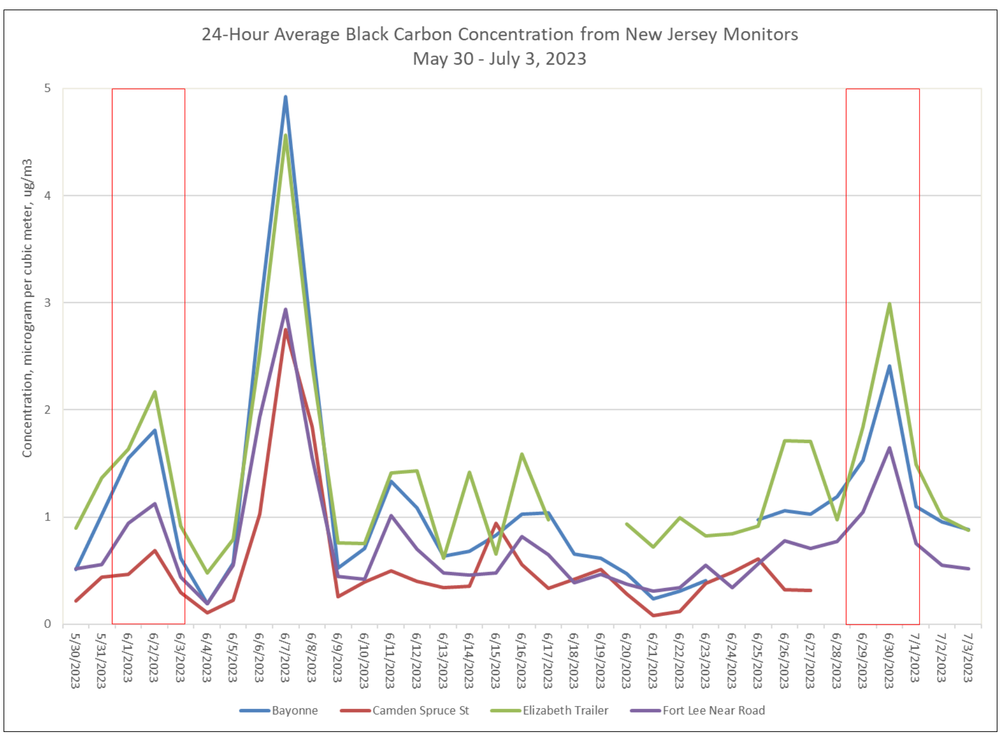


Figure 175: Daily Average Black Carbon Concentration at New Jersey Monitors, May 30 – July 3, 2023



4.2 Carbon Monoxide (CO)

Several research studies have investigated the impact of wildfires in Canada's boreal forests on trace gases and particles. One study determined that an intense wildfire event in northwestern Canada in June 1995 resulted in increased concentrations of carbon monoxide (CO) and ozone (O_3) concentrations in the midwestern and eastern United States. Therefore, a significant increase in carbon monoxide, in addition to other pollutants in the ambient air may signal a wildfire event.[181] New Jersey measures near-real time CO levels in the ambient air at five monitoring stations throughout the state.[182]

In June 2023, the average hourly CO concentration at the Camden Spruce St monitor was 0.33 ppm, while the maximum hourly concentration on June 29 and 30 were 1.03 and 1.16 ppm, respectively. The average hourly concentration at Camden Spruce St for the period, April 1 to July 31, was 0.26 ppm. The June 29 and 30 concentrations of CO significantly exceed the seasonal averages normally seen in New Jersey, indicating elevated CO levels during the time of the exceptional event. This trend holds true for all monitors, with the June 29 and 30 maximum concentrations consistently surpassing the average concentrations.

Figure 176 displays the hourly concentrations of CO between May 28 and July 2, 2023, while Figure 177 displays the daily average CO concentrations from May 31 to July 2, 2023. On June 29 and 30, elevated levels of CO are observed across all monitors, as highlighted within the red box.

[181] Yang, Z., Demoz, B., Delgado, R., Sullivan, J., Tangborn, A., & Lee P. (2022). Influence of the transported Canadian wildfire smoke on the ozone and particle pollution over the Mid-Atlantic United States. *Atmospheric Environment, 273*. Retrieved February 7, 2024, DOI: https://doi.org/10.1016/j.atmosenv.2022.118940

[182] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

Figure 176: Hourly Carbon Monoxide Concentrations at New Jersey Monitors from May 28 to July 2, in 2023

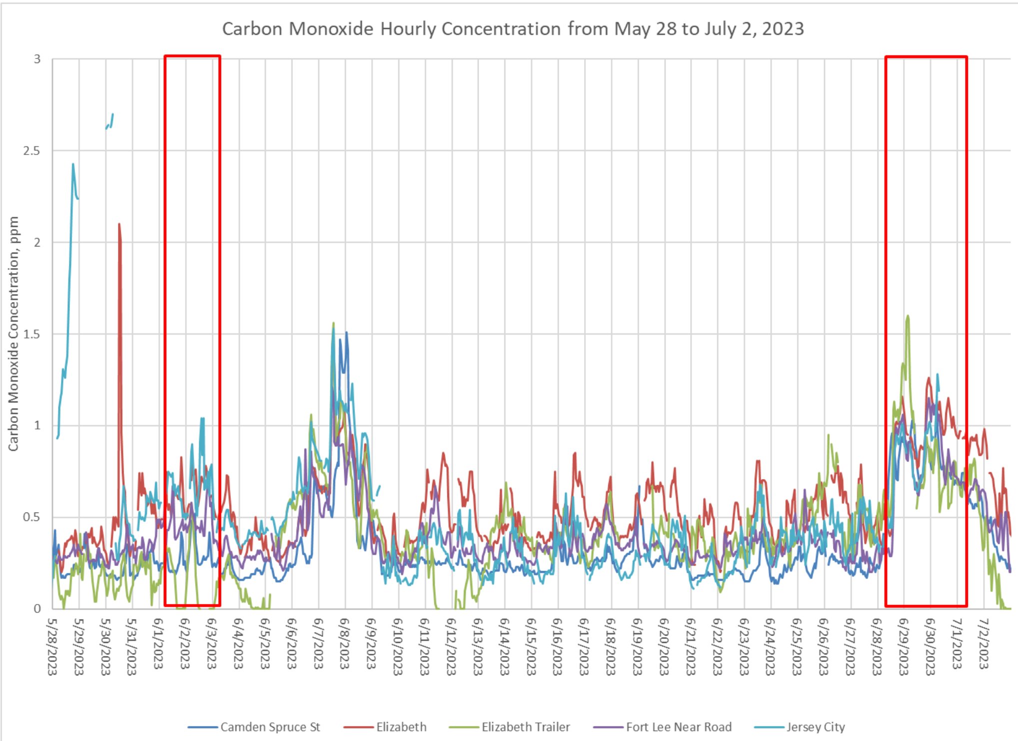
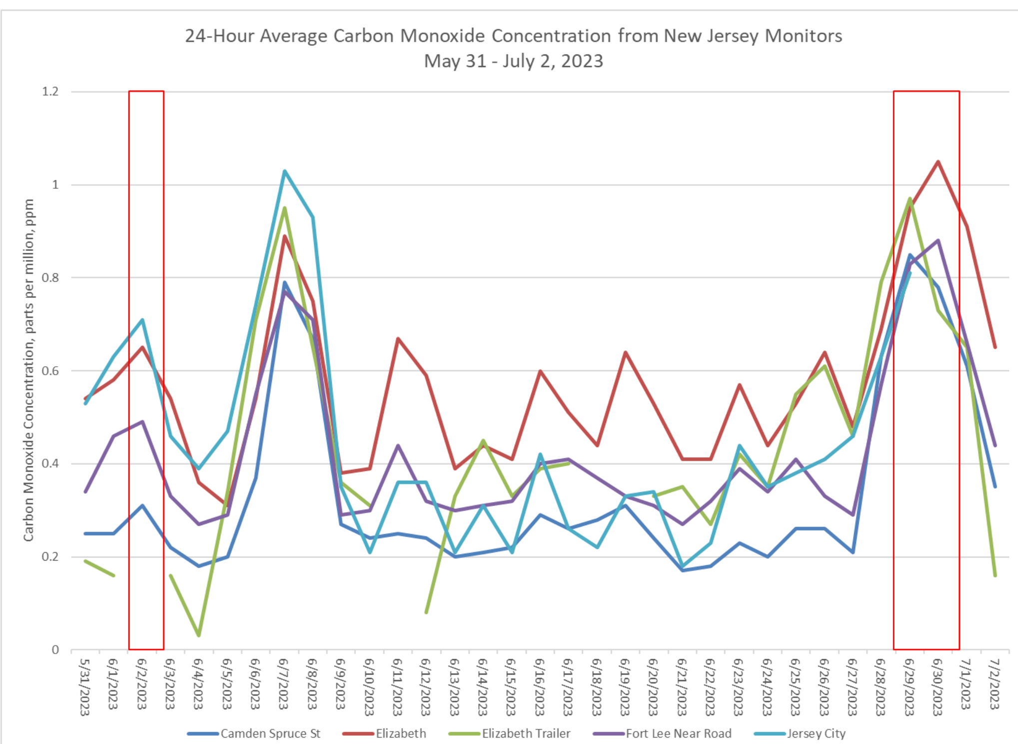


Figure 177: Daily Average Carbon Monoxide Concentrations at New Jersey Monitors from May 31 to July 2 in 2023



4.3 Nitrogen Dioxide (NO_2)

Nitrogen oxides (NOx) are emitted from wildfires and are precursors to ozone formation. Analyzing NOx trends can provide additional evidence that the ozone exceedances on June 29 and 30 qualify as exceptional events. Two of the most common NOx compounds are nitrogen oxide (NO) and nitrogen dioxide (NO_2). Nitrogen oxide oxidizes in the atmosphere to form NO_2. According to the USEPA, NO_2 can serve as an indicator for NOx levels.[183] New Jersey measures near-real time NO_2 levels in the ambient air at five monitoring stations throughout the state.[184]

In the days leading up to June 29 and 30, noticeable spikes of NO_2 concentrations were observed at the monitors, suggesting the presence of smoke in the atmosphere. On the day of June 29, the maximum hourly NO_2 concentration reached 9.4 ppb, and on June 30 measured 23.7 ppb. These values are significantly greater than the average hourly NO_2 concentration for June 2023 of 5.37 ppb, and the hourly average for June 2021-2023 of 4.65 ppb.

The elevated levels of NO_2 on June 29 and 30, 2023 above historical average trends are consistent with the presence of wildfire smoke and provide evidence that the ozone exceedances on June 29 and 30 were the result of an exceptional event.

Figure 178 displays the hourly NO_2 concentrations measured at the Rutgers University monitor in June 2023. Figure 179 displays the corresponding daily average NO_2 concentrations in June 2023. On June 29 and 30, elevated levels of NO_2 values are observed, as highlighted within the red boxes.

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[183] USEPA. (2023, July 25). *Basic Information about NO_2*. Retrieved February 7, 2024, from https://www.epa.gov/no2-pollution/basic-information-about-no2

[184] NJDEP. (2023). *2022 New Jersey Air Quality Report*. https://www.nj.gov/dep/airmon/pdf/2022-nj-aq-report.pdf

Figure 178: Hourly Concentration of NO_2 at the Rutgers monitor in June 2023

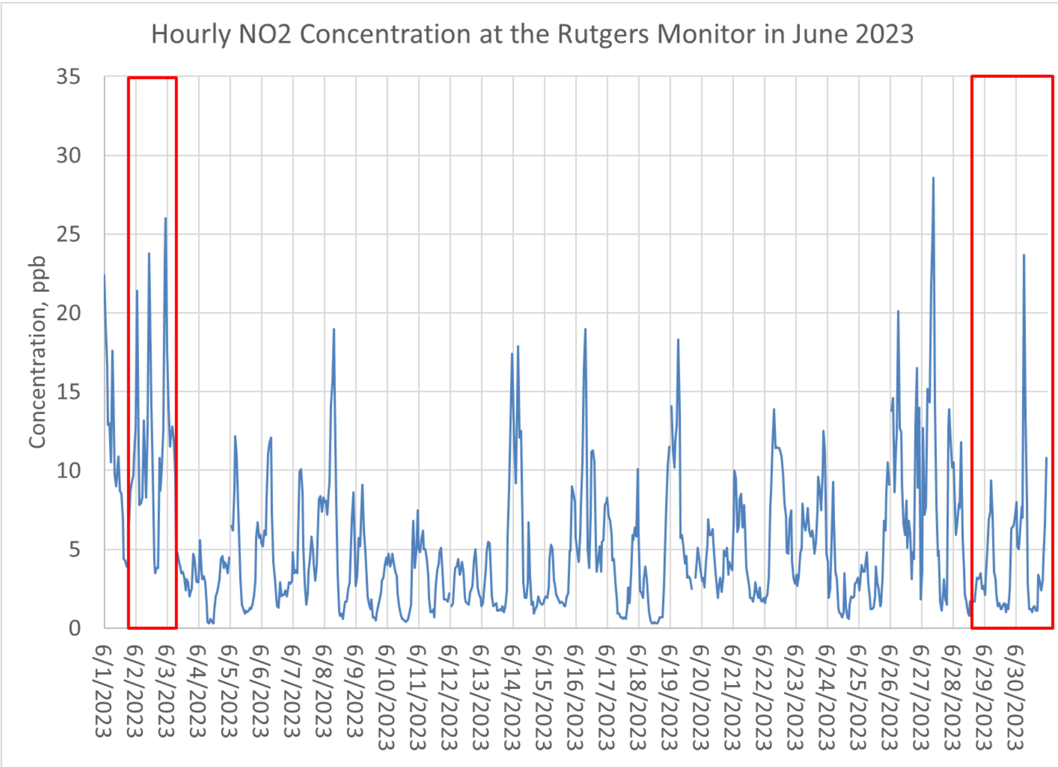
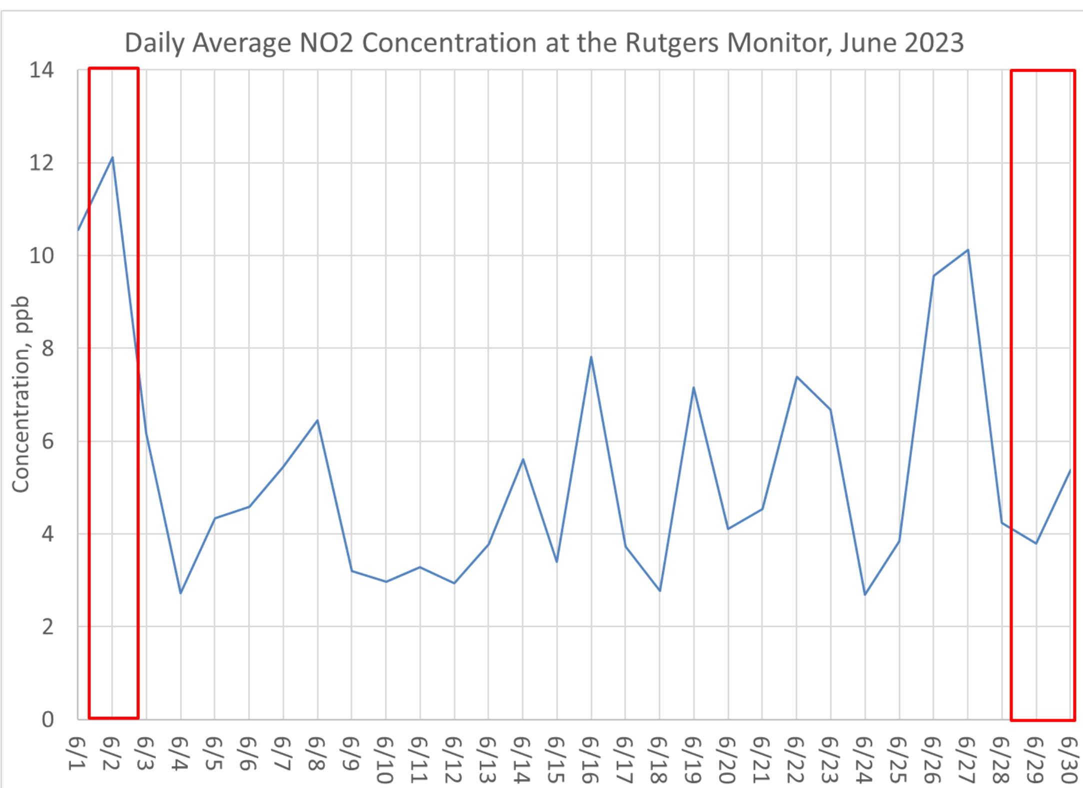


Figure 179: Daily Average Concentration of NO_2 at the Rutgers monitor in June 2023



4.4 Non-Methane Volatile Organic Compounds (NMVOCs)

Non-methane volatile organic compounds (NMVOC) are considered one of the primary pollutants emitted from wildland fires, along with greenhouse gases, NOx, and aerosol.[185] In New Jersey, the Rutgers University monitor measures non-methane VOCs as part of the national Photochemical Assessment Monitoring Station (PAMS) program.

4.4.1 Formaldehyde (HCHO)

Formaldehyde (HCHO), one of the most abundant NMVOCs emitted by fires, is formed in fire plumes via VOC oxidation.[186] In this analysis, elevated formaldehyde levels are considered potential indicators of wildfire smoke presence.

The typical average hourly concentration of formaldehyde at Rutgers is 2.11 per million by volume (ppbv). However, the hourly maximum concentrations on June 29 and June 30 measured significantly higher at 3.74 ppbv and 5.07 ppbv, respectively., The maximum concentration on June 29 was over 75 percent larger and on June 30 was over 140 percent larger than the typical hourly levels observed throughout the month. Similarly, the daily average concentration shows a similar peak in concentration on June 29 and 30, with levels consistently higher than those on the surrounding days.

Figure 180 and Figure 181 illustrate the hourly and daily average concentration of formaldehyde at the Rutgers monitor, with June 29 and 30 highlighted. Both graphs display elevated concentrations on June 29 and 30. These elevated levels are consistent with the conclusion that the ozone exceedances on June 29 and 30 were exceptional events.

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[185] Urbanski, S.P., Hao, W.M., & Baker, S. (2008). Chemical Composition of Wildland Fire Emissions. In Bytnerowicz, A, Arbaugh, M.J., Riebau, A.R., & Andersen, C. (Eds.), *Developments in Environmental Science* (Vol. 8, pp. 79-107). Elsevier. Retrieved January 24, 2024, DOI: 10.1016/S1474-8177(08)00004-1, https://www.fs.usda.gov/rm/pubs_other/rmrs_2009_urbanski_s001.pdf

[186] Liao, J., Wolfe, G.M., Hannun, R.A., St. Clair, J.M., Hanisco, T.F., Gilman, J.B., Lamplugh, A., Selimovic, V., Diskin, G.S., Nowak, J.B., Halliday, H.S., DiGangi, J.P., Hall, S.R., Ullmann, K., Holmes, C.D., Fite, C.H., Agastra, A., Ryerson, T.B., Peischl, J., … Neuman, J.A.. (2021). Formaldehyde evolution in US wildfire plumes during the Fire Influence on Regional to Global Environments and Air Quality experiment (FIREX-AQ). *Atmospheric Chemistry and Physics, 21*(24), 18319-18331. Retrieved December 3, 2023, DOI: 10.5194/acp-21-18319-2021, https://airbornescience.nasa.gov/content/Formaldehyde_evolution_in_US_wildfire_plumes_during_the_Fire_Influence_on_Regional_to_0 (Also see report in Non-methane VOC folder)

Figure 180: Hourly Concentration of Formaldehyde at the Rutgers University Monitor from May 22 to June 30, 2023

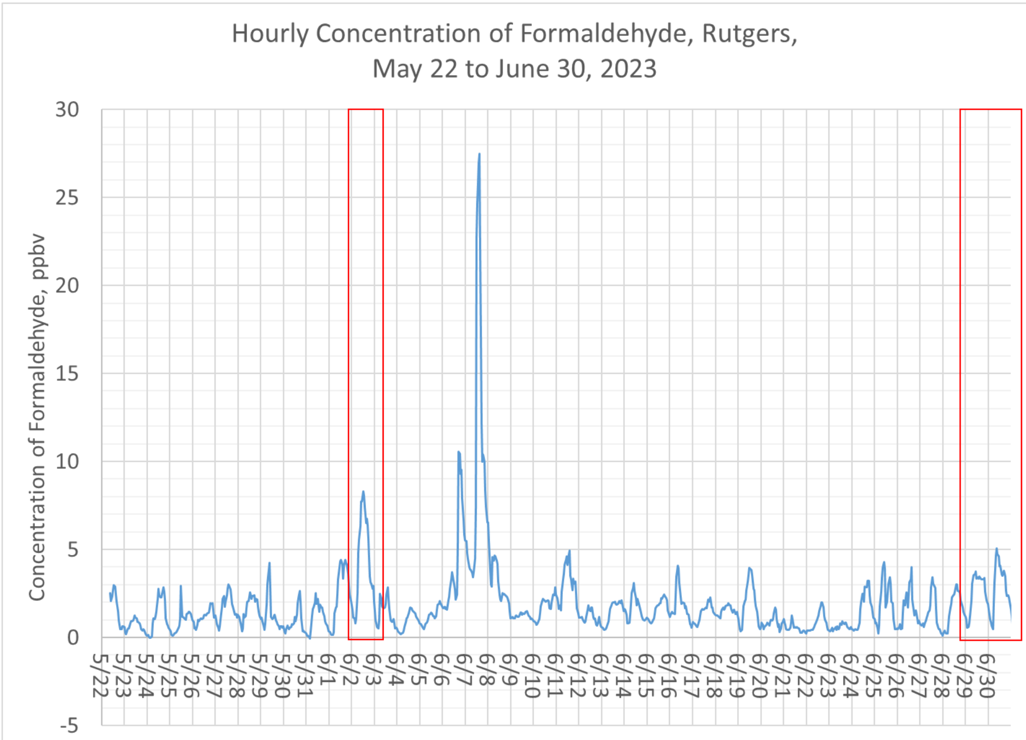
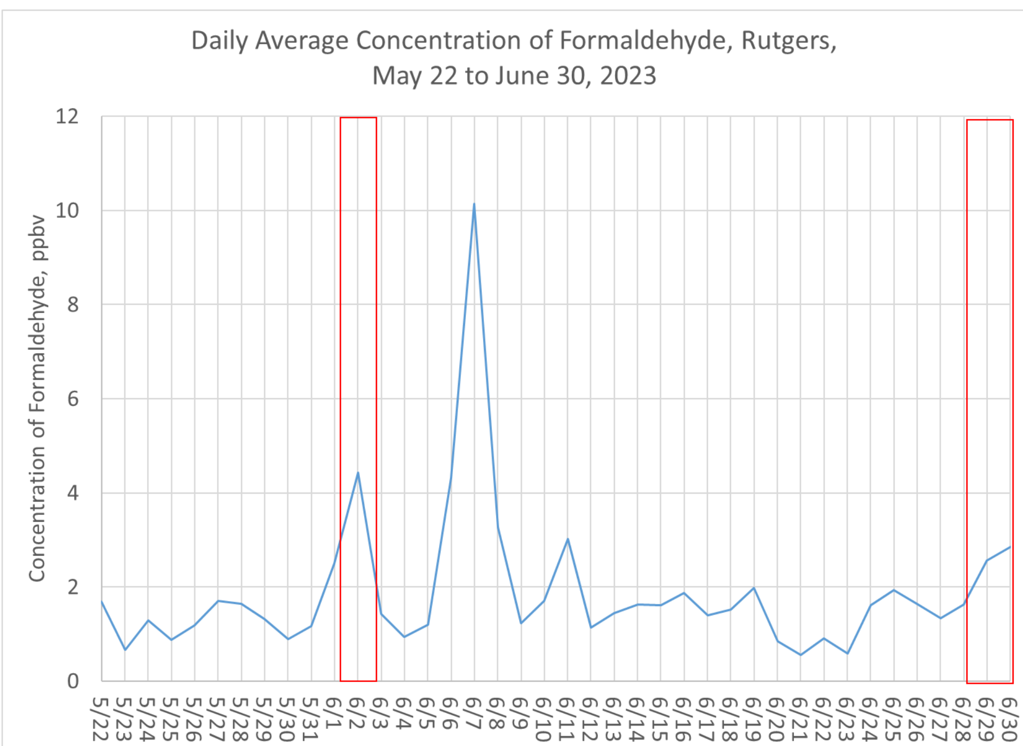


Figure 181: Daily Average Concentration of Formaldehyde at the Rutgers University Monitor from May 22 to June 30, 2023



4.4.2 Benzene (C_6H_6)

Wildfire smoke has also been documented to contain toxic carcinogens such as benzene.[187,188] Benzene is classified as an aromatic hydrocarbon, and research indicates that aromatic hydrocarbons constitute approximately 8 percent of emissions from wildfire.[189] In this analysis, we will interpret elevated benzene levels as potential indicators of wildfire smoke, while acknowledging that benzene is a trace component and other factors may also contribute to its presence.

Figure 182 presents a comparison between benzene concentrations at the Rutgers PAMS monitor for daily average concentrations and hourly concentrations in June from 2021 to 2023. The benzene values were consistently higher in 2023 compared to the preceding years. This trend is particularly evident in the daily average concentration graph but also evident in the hourly concentration graph. In summary, benzene concentrations exhibited elevated levels in June 2023.

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187 Gould, C.F., Heft-Neal, S., Prunicki, M., Aguilera, J., Burke, M., & Nadeau, K. (2024). Health Effects of Wildfire Smoke Exposure. *Annual Review of Medicine, 75*(1), 227-292. Retrieved February 8, 2024, DOI: 10.1146/annurev-med-052422-020909, https://web.stanford.edu/~samhn/papers/Gould%20et%20al%202023%20-%20ARM.pdf (pdf in NMVOC folder)

188 Kormacher, M. & Moore, A. (2023, July). *The Health Effects of Wildfire Smoke.* University of Washington Interdisciplinary Center for Exposures, Diseases, Genomics and Environment. Retrieved February 8, 2024, from https://deohs.washington.edu/edge/sites/deohs.washington.edu.edge/files/2023-09/Wildfire%20Smoke%20Fact%20Sheet%20JH%20VB%20EDITS.pdf (pdf saved in NMVOC folder)

189 Urbanski, S.P., Hao, W.M., & Baker, S. (2008). Chemical Composition of Wildland Fire Emissions. In Bytnerowicz, A, Arbaugh, M.J., Riebau, A.R., & Andersen, C. (Eds.), Developments in Environmental Science (Vol. 8, pp. 79-107). Elsevier. Retrieved February 8, 2024, DOI: 10.1016/S1474-8177(08)00004-1, https://www.fs.usda.gov/rm/pubs_other/rmrs_2009_urbanski_s001.pdf

Figure 182: Benzene Concentrations (ppbC) at the Rutgers PAMS Monitor: Daily Average (top) and Hourly (bottom) in June 2021-2023

4.5 Non-Methane Hydrocarbons (NMHC)

Non-methane hydrocarbons are produced from wildfires and contribute to the enhancement of ozone formation to the ambient air.[190] In this analysis, we will interpret elevated levels as potential indicators of wildfire smoke presence, while acknowledging that these pollutants are trace components and other factors may also contribute to their presence.

The hydrocarbons examined include ethylene, propylene, ethane, propane, and n-butane. Figure 183 presents hourly concentrations of ethylene, ethane, and n-butane in June 2021, 2022, and 2023, with June 29 and 30 highlighted in the red box. For ethylene, a peak occurs on June 29, 2023, followed by a smaller one on June 30, 2023. For ethane, concentrations gradually increased in the days leading up to

[190] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

June 29 and 30, 2023, and remained at an elevated level on those dates. For n-butane, there is a noticeably large spike on June 28, 2023, followed by a smaller one on June 29, 2023.

Additionally, the graphs reveal that non-methane hydrocarbon concentrations were consistently higher on June 29 and 30, 2023, compared to the preceding years. This trend is particularly evident in the daily average concentration graphs of these hydrocarbons including propylene and propane during June in 2021, 2022, and 2023, as shown in Figure 184. Elevated levels within the red boxes in the graphs indicate the exceptional event on June 29 and 30.

Figure 183: Hourly concentration of non-methane hydrocarbons in June 2021, 2022, and 2023 – a) Ethylene, b) Ethane, and c) n-Butane

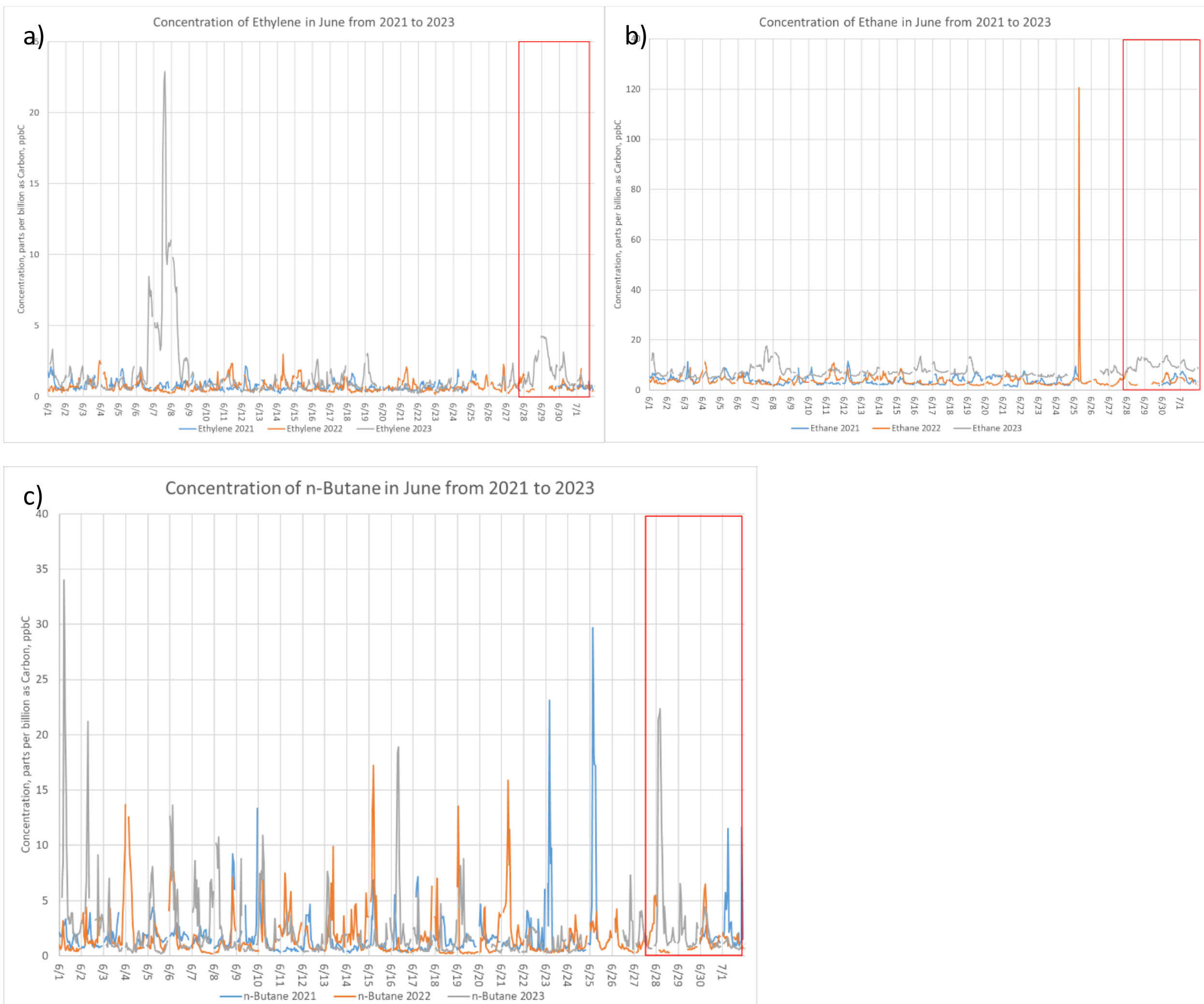
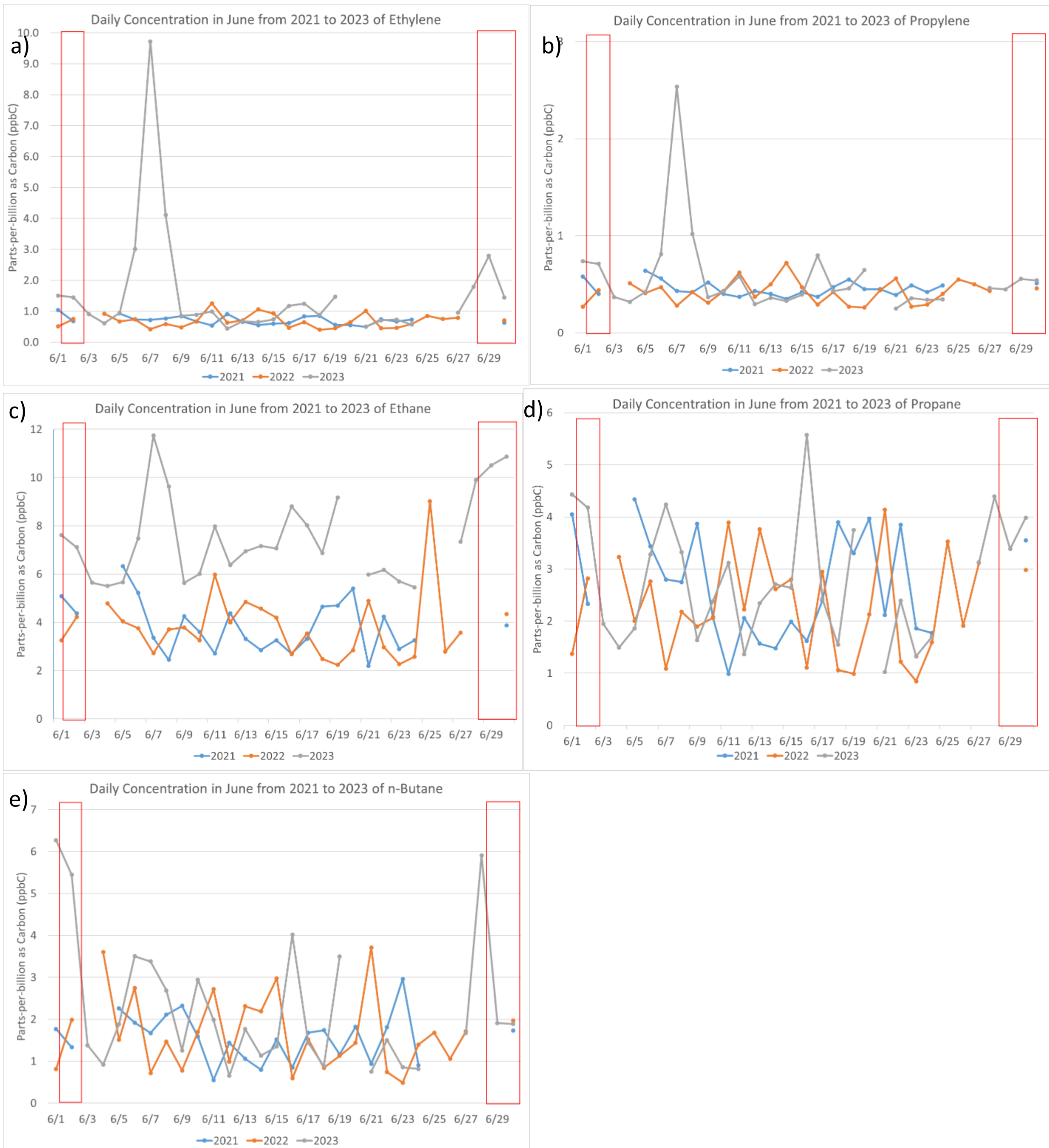


Figure 184: Daily concentration of non-methane hydrocarbons in June 2021, 2022, and 2023 – a) Ethylene, b) Propylene, c) Ethane, d) Propane, and e) n-Butane



4.6 Light Extinction

According to the USEPA Guidance, elevated light extinction measurements at or near the ozone monitoring site that cannot be explained by emissions from other sources and are consistent with wildfire impact can be used as evidence to support the impact of fire emissions on affected monitors.[191]

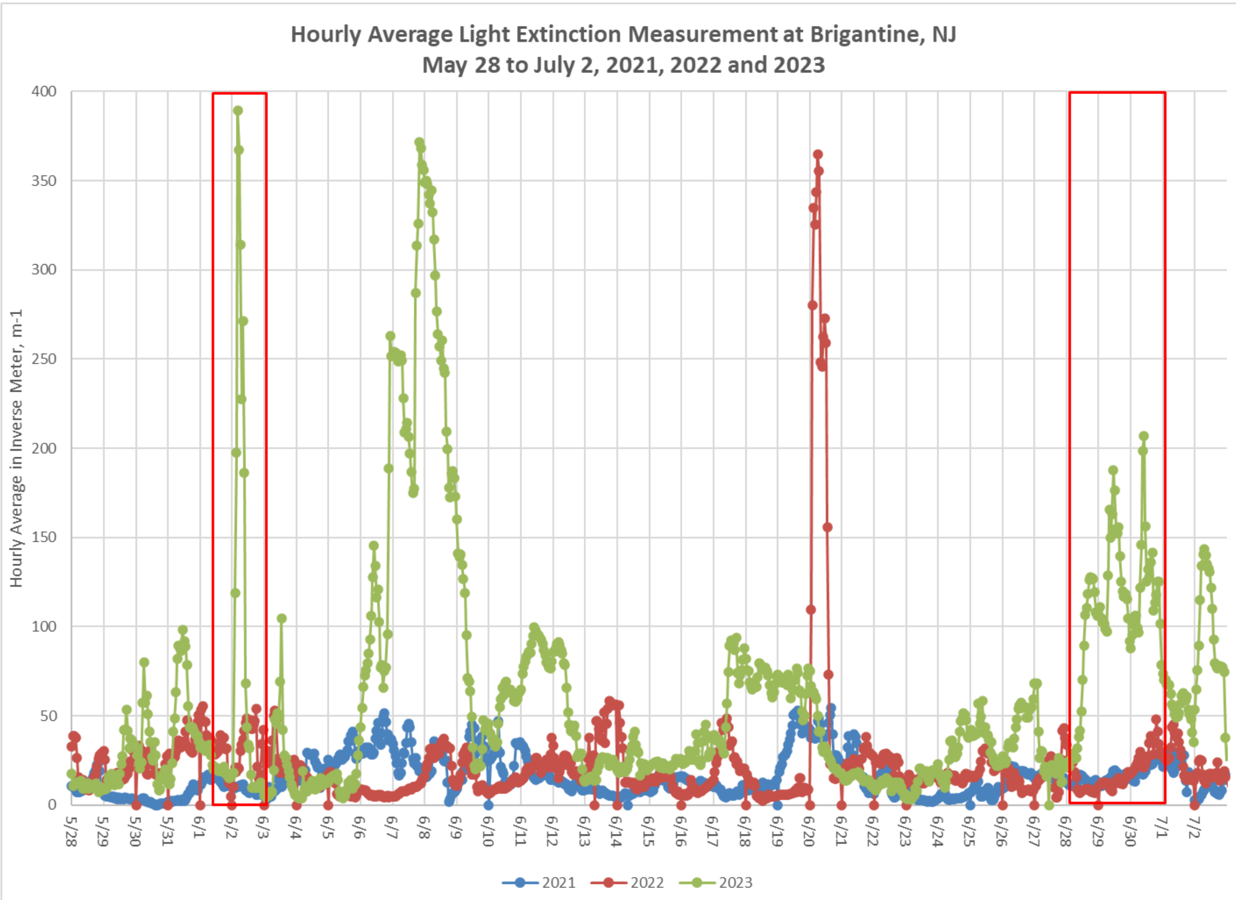
New Jersey measures visibility using a nephelometer at the Brigantine monitor. Brigantine is located in a rural area, and usually does not experience elevated light extinction levels, however, on June 29 and 30, 2023, the light extinction levels at Brigantine were higher-than-normal. Light extinction levels were also generally higher throughout June 2023 than at the same period in previous years, indicating the presence of smoke in the atmosphere due to the wildfires.

Figure 185 presents light extinction data measured at Brigantine from May 28 to July 2, in 2021, 2022 and 2023. A visible peak can be seen on June 29 and 30, 2023. As shown on the chart, the light extinction levels at Brigantine were generally low in 2021 and 2022, while 2023 had higher levels during this period. This peak can be attributed to the smoke from Quebec wildfires.

Brigantine is located in a rural area, and usually does not experience elevated light extinction levels, however, on June 29 and 30, 2023, the light extinction levels at Brigantine were higher-than-normal. Light extinction levels were also generally higher throughout June 2023 than at the same period in previous years, indicating the presence of smoke in the atmosphere due to the wildfires.

[191] NJDEP. (2017). *Exceptional Event Demonstration Analysis For Ozone During May 25-26, 2016.* https://www.epa.gov/sites/default/files/2017-12/documents/final_ee_for_nj.pdf

Figure 185: Hourly Average Visibility Light Extinction Measurement at the Brigantine, NJ Monitor from May 28 to July 2, in 2021, 2022, and 2023



4.7 Evidence of Changes in Spatial/Temporal Patterns of Ozone and NOx

This section presents satellite evidence of smoke and ozone precursors to demonstrate changes in the spatial and temporal patterns of ozone and NO_2 and the impacts on New Jersey monitors. Videos (See Appendix …) of ozone and smoke patterns from satellite imagery were generated using the Remote Sensing Information Gateway (RSIG) application and RSIG3D.[192] The videos also included hourly monitoring data for nitrogen dioxide and ozone from USEPA AirNow and Air Quality System (AQS) data inventories. Smoke information was obtained from the National Aeronautics and Space Administration (NASA) Hazard Mapping System (HMS) Fire and Smoke Product data inventory.

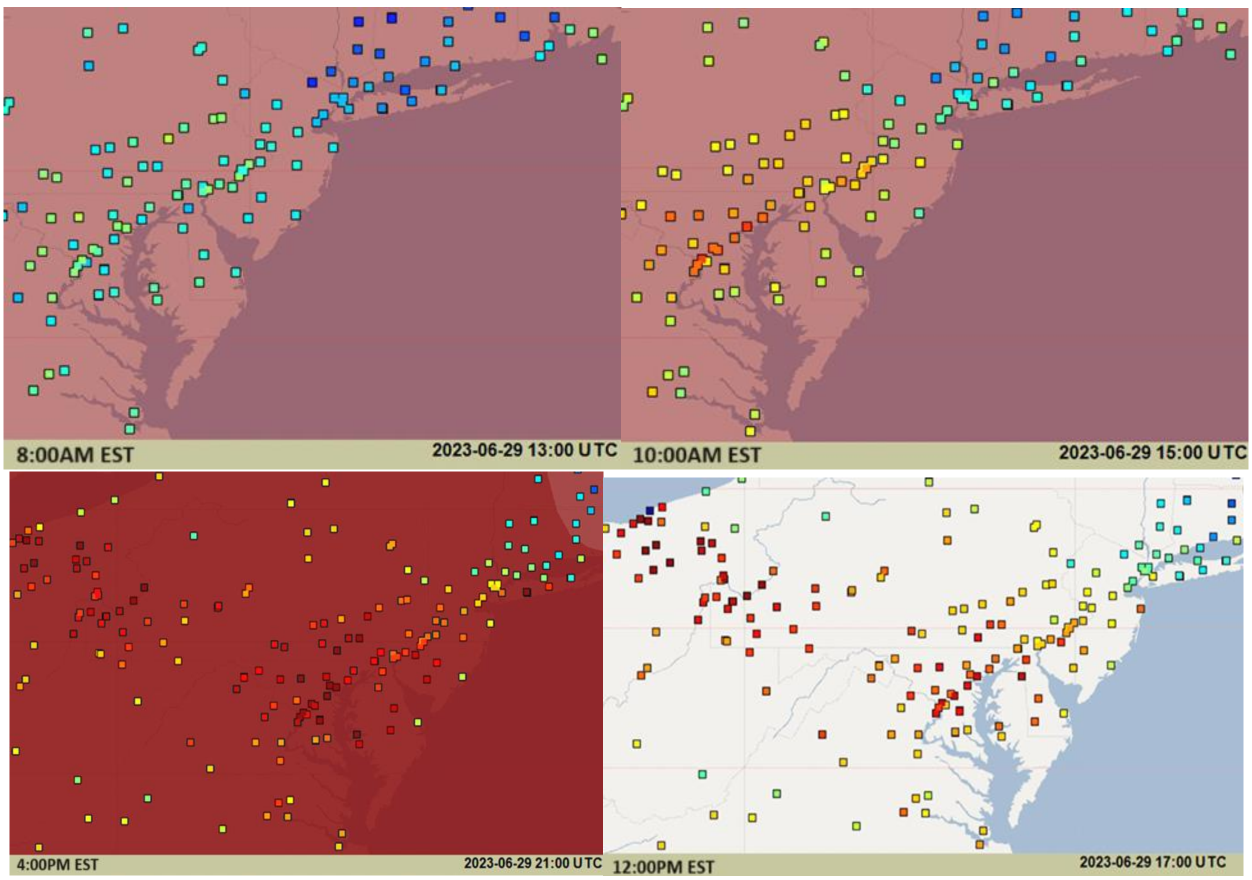
Figure 186 presents screenshots from the videos with the location of the smoke plume indicated by dark red shading and the ozone measurements in ppb at monitors indicated by dots where red represents higher ozone values and blue represents lower ozone values. While the hourly data is reported in Coordinated Universal Time (UTC), the local Eastern Standard Time (EST) is provided in the chart for reference.

[192] USEPA. (2024). *Remote Sensing Information Gateway (RSIG)* (Version 20231206). Retrieved January 25, 2024, from https://www.epa.gov/hesc/remote-sensing-information-gateway

4.7.1 Analysis of Changes in Spatial/Temporal Patterns of Ozone Using RSIG3D

Figure 186 presents screenshots from a video generated using RSIG3D. The video presents the ozone monitoring data with a smoke overlay for June 29, 2023. Before 8:00AM EST (13:00 USC), ozone levels at the monitors began to rise. By 10:00AM EST, the smoke levels began to increase as indicated by a slightly darker shading, and several monitors began to exceed the 70 ppb 2015 8-Hour ozone NAAQS. The highest ozone concentrations (ranging from 78 to 108 ppb) occurred between 12:00PM and 6:00 PM, coinciding with the denser smoke plume indicated by the darker shading. At 4:00 PM, the highest ozone values were observed in neighboring states west of New Jersey, including Pennsylvania and Ohio, and monitors with extremely elevated ozone levels can be seen extending southward into the state.
After 6:00 PM, the values at the southern New Jersey monitors started to decrease, and by 9:00 PM, many had fallen below the NAAQS threshold, as observed in Figure 186.

Figure 186: Ozone Monitoring and HMS Smoke Patterns on June 29, 2023



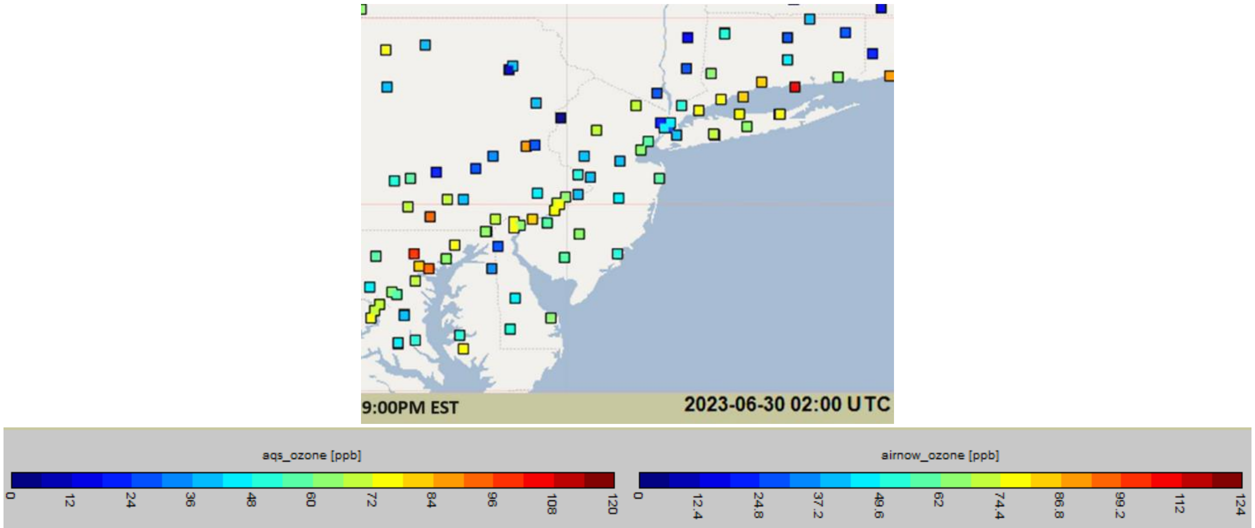
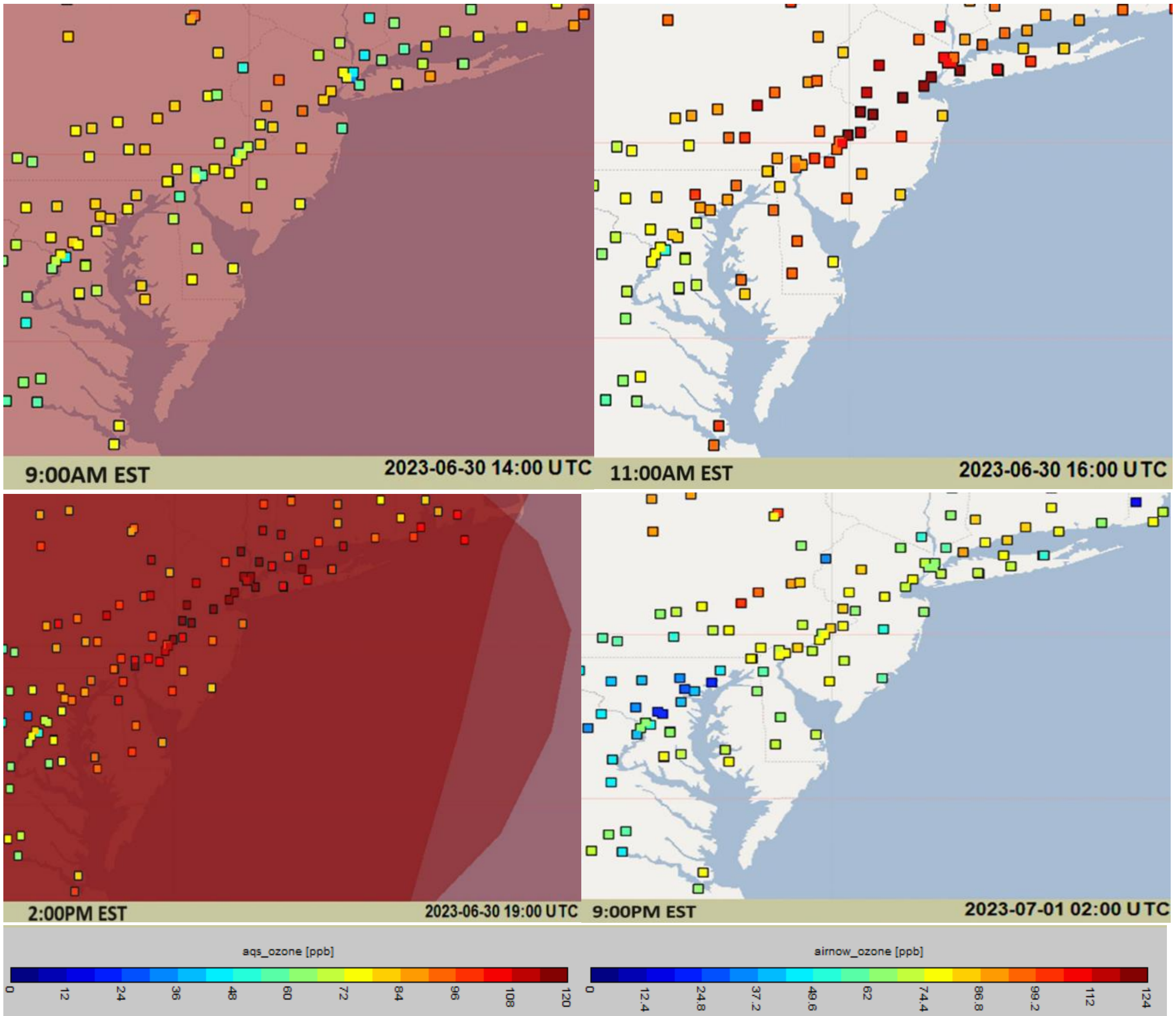


Figure 187 presents screenshots from an RSIG3D-generated video that presents ozone monitoring data with a smoke overlay for June 30, 2023. At 9:00 AM, the smoke levels are elevated and several monitors in the Southern NJ-PA-DE-MD nonattainment area began to exceed the 70 ppb 2015 8-Hour ozone NAAQS. The highest ozone concentrations (ranging from 102 to 120 ppb) occurred between 11:00AM and 3:00 PM, coinciding with the dense smoke overlay which appeared at 2:00PM. Around 3:00 PM, the values at the southern New Jersey monitors started to decrease, and by 9:00 PM, some had started to decrease to below the NAAQS. The monitors stayed at these slightly elevated levels until the end of the day.

Figure 187: Ozone Monitoring and HMS Smoke Patterns on June 30, 2023



4.7.2 Analysis of Changes in Spatial/Temporal Patterns of Nitrogen Dioxide (NO_2) Using RSIG3D

Figure 188 presents screenshots from a video generated using RSIG3D that presents nitrogen dioxide monitoring data with a smoke overlay for June 29, 2023. At the beginning of June 29, the nitrogen dioxide levels were low. Between 2:00AM and 9:00AM, there was a slight increase in nitrogen dioxide, resulting in a light blue color. A thin smoke cloud appears at 6:00 AM. The density of the smoke plume increased as the day progressed between 1:00 PM and 5:00 PM. The conditions on June 29, 2023, were similar to June 2, 2023, where the areas upwind of the monitors under consideration had higher concentrations that followed the pathway of the smoke plume before reaching the monitors in the Southern NJ-PA-DE-MD nonattainment area. Around 9:00 PM, elevated levels were noticed in states south of New Jersey, such as Maryland and North Carolina.

Figure 188: Nitrogen Dioxide Monitoring and HMS Smoke Patterns on June 29, 2023

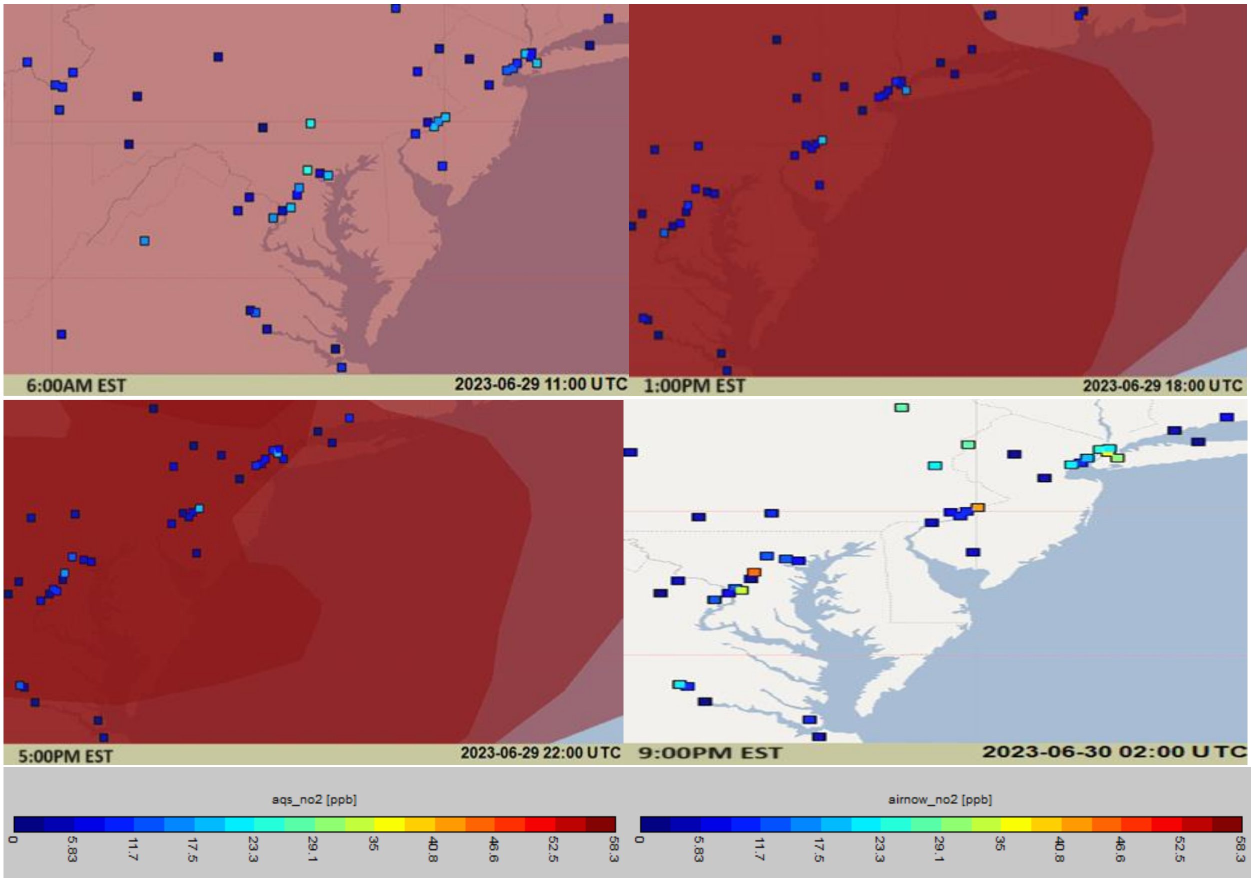
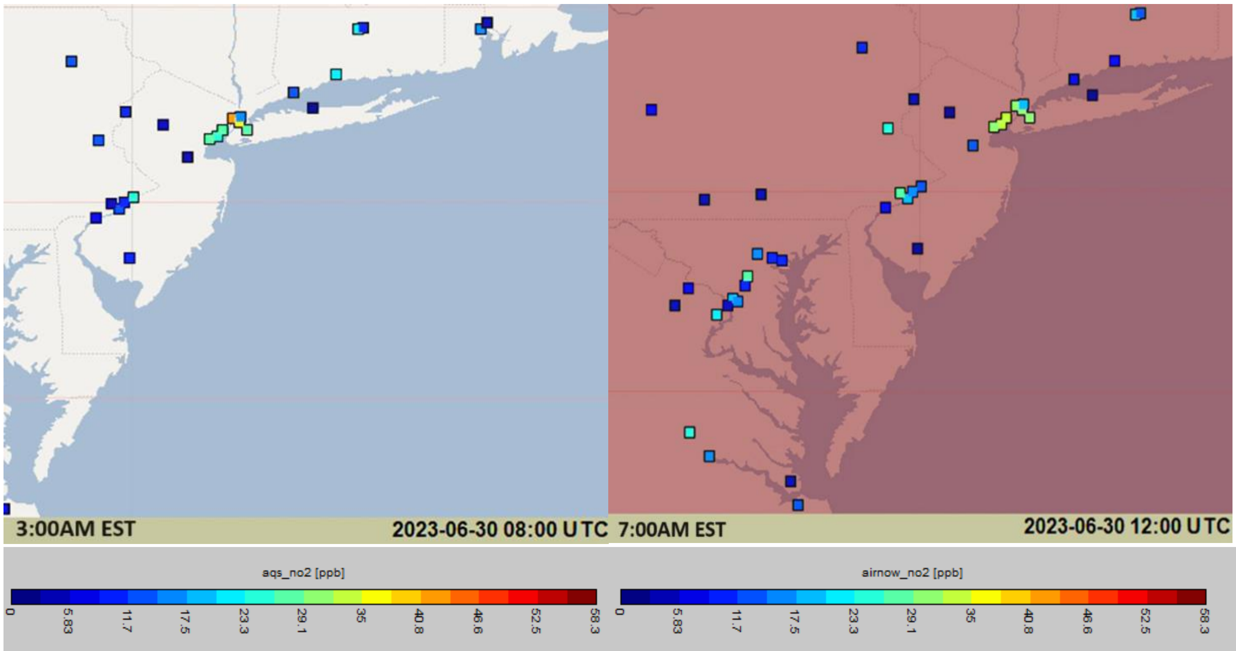


Figure 189 presents screenshots from a video generated using RSIG3Dof nitrogen dioxide monitoring data with a smoke overlay for the morning of June 30, 2023. At the beginning of the day, slightly elevated nitrogen dioxide levels were seen at New Jersey monitors, with higher levels in the Northern NJ-NY-CT nonattainment area. This pattern continued until a less dense smoke overlay appeared around 6:00 AM. The density of the smoke increased as the day progressed as displayed by the conditions at 7:00 AM. The conditions on June 30, 2023, followed the same pattern as on June 29, 2023, where the areas upwind of the monitors under consideration had a higher concentration and followed the pathway of the smoke plume before reaching the monitors in the Southern NJ-PA-DE-MD nonattainment area. Towards the end of the day, the values began to increase again.

Figure 189: Nitrogen Dioxide Monitoring and HMS Smoke Patterns on June 30, 2023



4.8 Visual Photographic Evidence of Ground-level Smoke at the Monitor (HazeCam Pictures from Brigantine)

New Jersey uses remote cameras at Brigantine, NJ, to evaluate visibility conditions throughout the year.[193] Figure 190-Figure 192 show pictures taken during and after the exceptional event that occurred in New Jersey on June 29 and 30, 2023. On June 29 and 30, the skylines of Atlantic City were obscured, discolored, and hazy in appearance. However, on July 10, days after the exceptional event, when the smoke plume moved out of the southern parts of the state, a noticeable improvement in visibility and haze conditions occurred.

[193] Camnet (n.d.). Visibility HazeCam. https://hazecam.net/

Figure 190: HazeCam Picture from Brigantine, NJ on June 29, 2023, 11:00 AM EST.

Figure 191: HazeCam Picture from Brigantine, NJ on June 30, 2023, 10:00 AM EST.

Figure 192: HazeCam Picture from Brigantine, NJ on July 10, 2023, 2:00 PM EST

III. Analyses Comparing the Claimed Event-influenced Concentrations to Concentrations at the Same Monitoring Site at Other Times

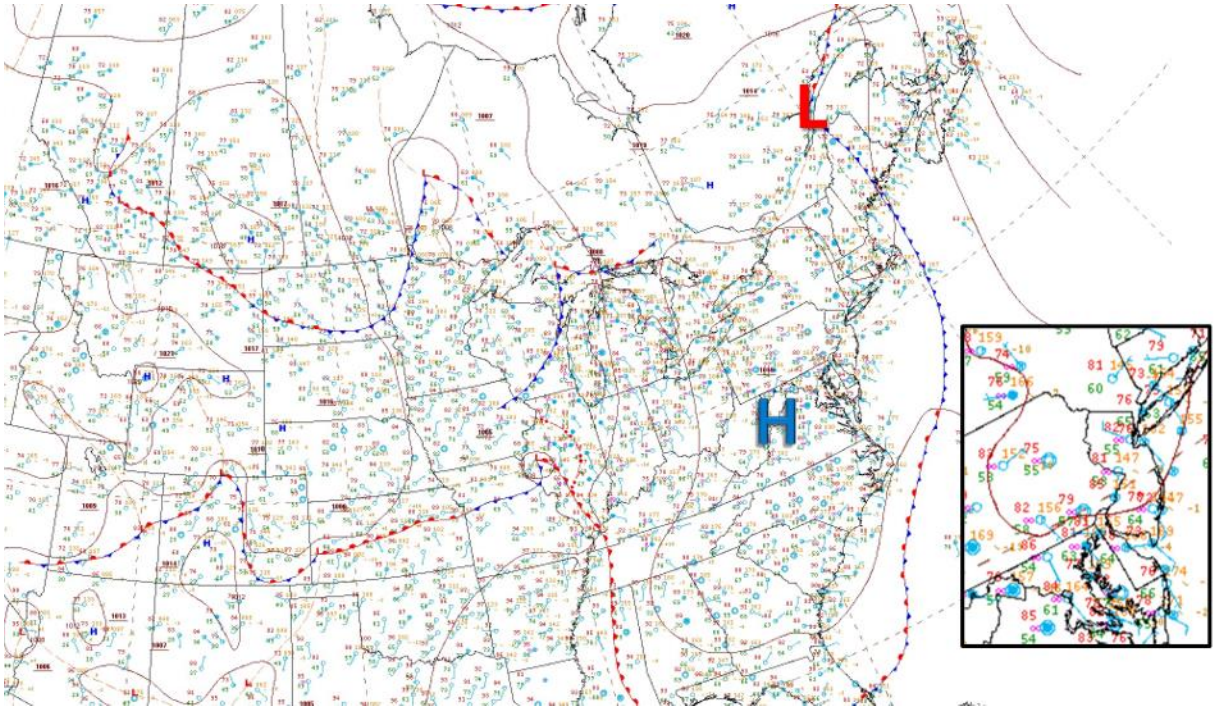
A similar day analysis identifies specific meteorological conditions observed on the exceptional event day (in this case June 29 and 30, 2023) and compares those conditions to other days with the same conditions in past history but did not yield unusually elevated ozone concentrations. Therefore, days with similar meteorology when no smoke is present should not produce ozone exceedances of the same magnitude. No data from the year 2020 was used in the similar day analysis due to the unusual anthropogenic emissions conditions caused by the pandemic.

The parameters/criteria that were used for the reference day meteorology include the following:

- Surface analysis & upper air (850mb) showing high pressure over Mid-Atlantic US;
- Departing area of Low pressure near southwestern Canada;
- High temperature at KPHL 85° F or higher;[46]
- 0.00” precipitation;
- General surface wind direction light/variable and out of the west-southwest/west;
- No ozone exceedances (or 1 questionable, isolated exceedance);
- Length of day;

Figure 193 presents surface analysis for the reference day, June 29, 2023.

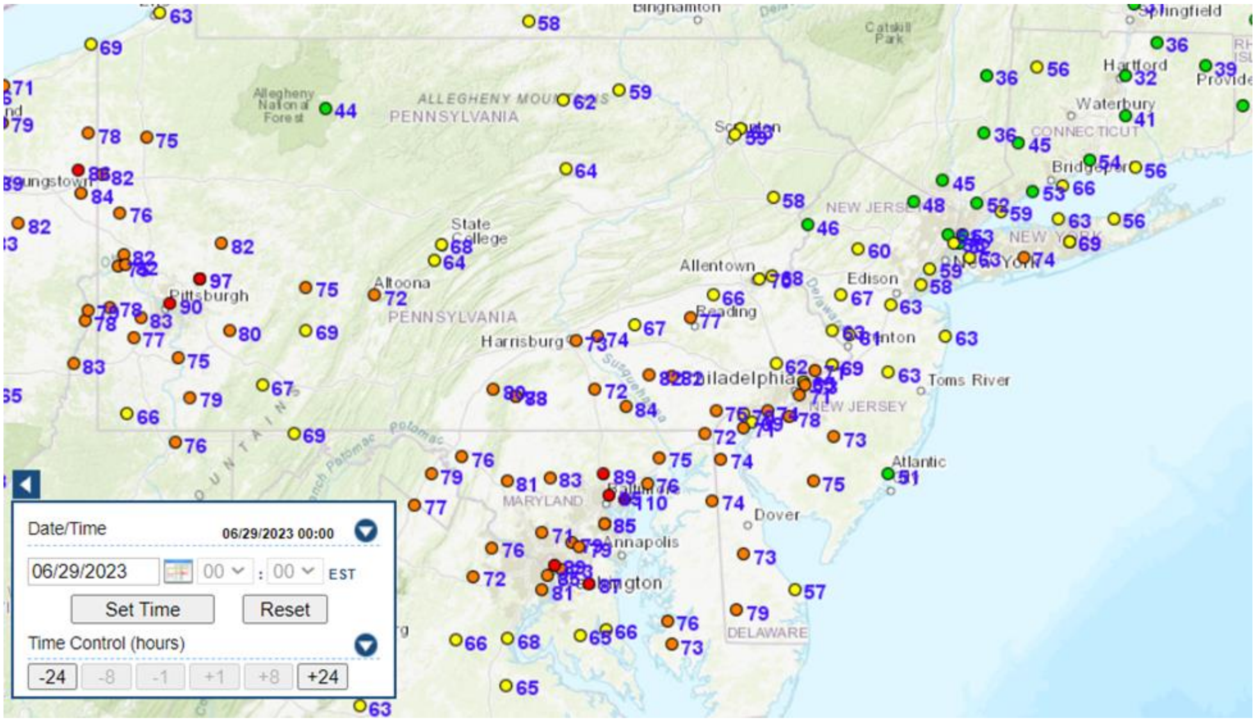
Figure 193: Reference Day Surface Analysis– June 29, 2023, 12UTC



Note: Surface high pressure marked with blue "H" located over the Mid-Atlantic region of the United States. Red "L" indicating departing area of low pressure over southwestern Canada. Surface temperatures indicated by red numbers showing nearby range from approximately 78-85 degrees F. Mostly sunny skies indicated by blue wind barbs with hollow circles. Pink infinity (∞) symbol indicates haze was present.

Figure 194 presents the maximum 8-hour ozone concentration on the reference day, June 29, 2023.

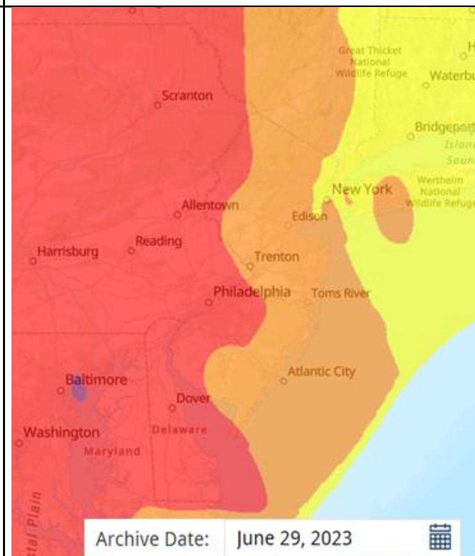
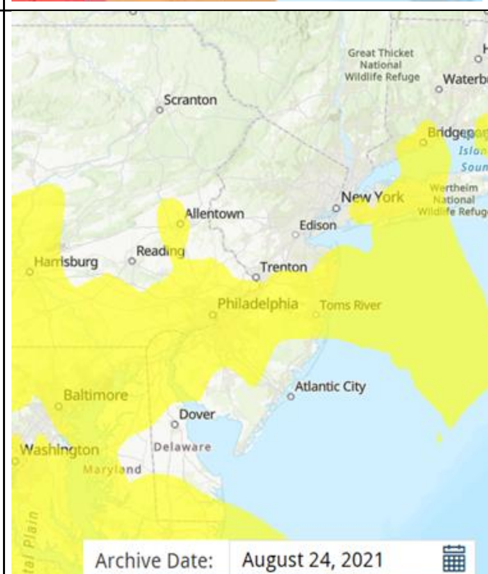
Figure 194: Reference Day 8hr Max Ozone Concentrations on June 29, 2023

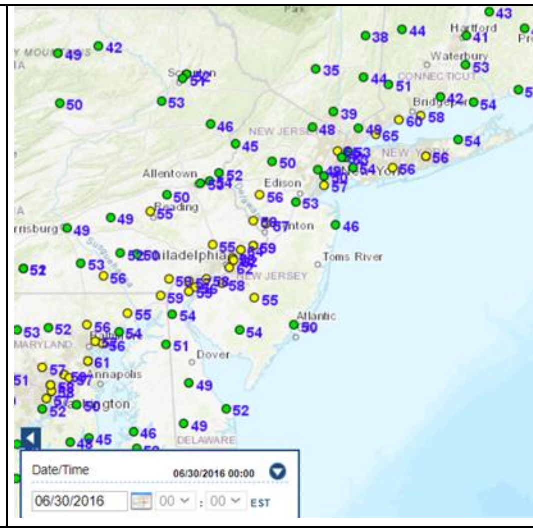


Based on the surface analysis and ozone concentrations represented in Figure 193 and Figure 194, Table 24 presents dates that were chosen as similar days for June 29, 2023, because they were characterized by similar meteorological conditions. As noted in Table 24, while the meteorological conditions were similar, the ozone levels on these days were not elevated as seen on June 29, 2023. Therefore, the widespread ozone exceedance concentrations on June 29, 2023, can be attributed to an exceptional event due to wildfire smoke.

Table 24: Similar Day Comparison of Max Ozone Concentration, Max Temperature, and AQI Map for June 29, 2023

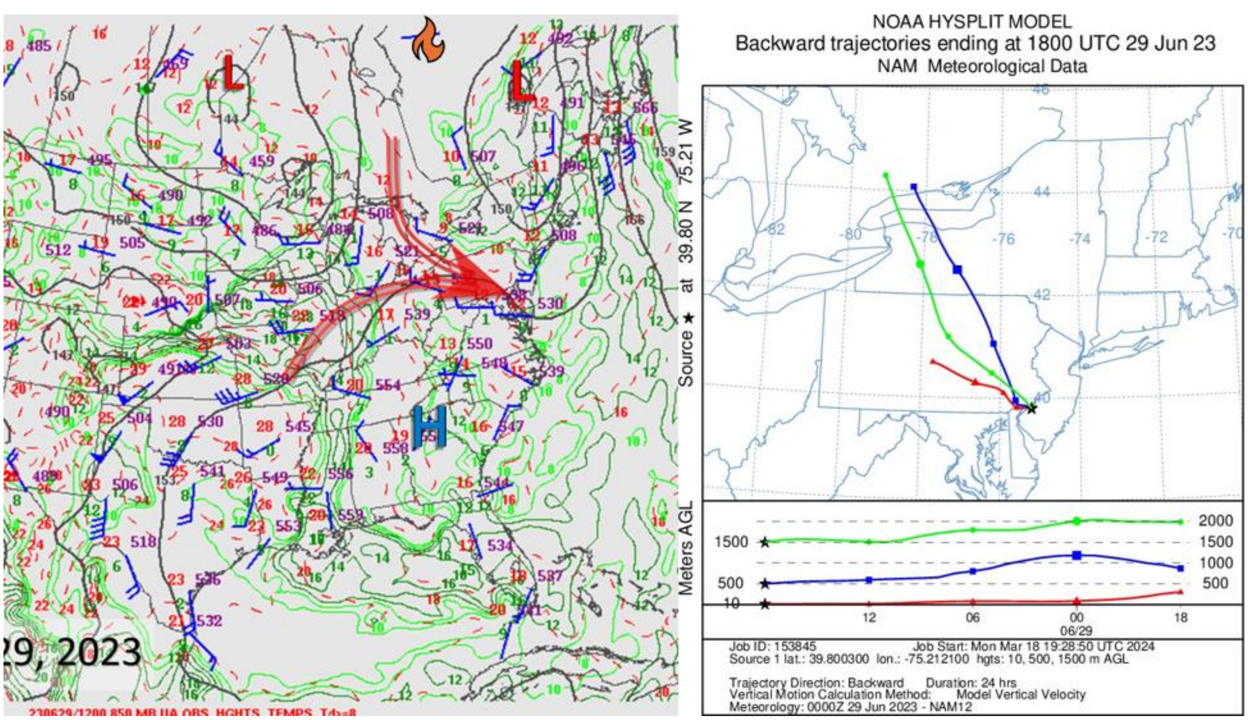
Note: Ozone (ppb) represents the monitor that recorded the highest observed ozone concentration on the specified day in the New Jersey portion of the Southern NJ-PA-DE-MD nonattainment area. Temperature represents the highest recorded temperature on specified date at KPHL.

Date	Ozone (ppb)	Temp (F)	AQI Map
June 29, 2023 Reference Day	78 - Clarksboro	85	
August 24, 2021	61 - Clarksboro	92	

June 30, 2016	62 – Camden Spruce Street	86	

The following image (Figure 195) shows the 850mb map and backward trajectories for the reference day, June 29, 2023. The features of importance for the similar day comparison are high pressure located over the Mid-Atlantic United States and a departing area of low pressure near southwestern Canada. These features should be accompanied by a similar backward trajectory with average wind direction at KPHL out of the west-southwest/west.

Figure 195: 850mb Map and 24hr Backward Trajectories for Reference Day: June 29, 2023



Based on the above criteria for the reference day, the following figures (Figure 196 and Figure 197) show a comparison of the matching meteorological criteria for the similar day analysis.

Figure 196: 850mb Map and 24hr Backward Trajectories for August 24, 2021

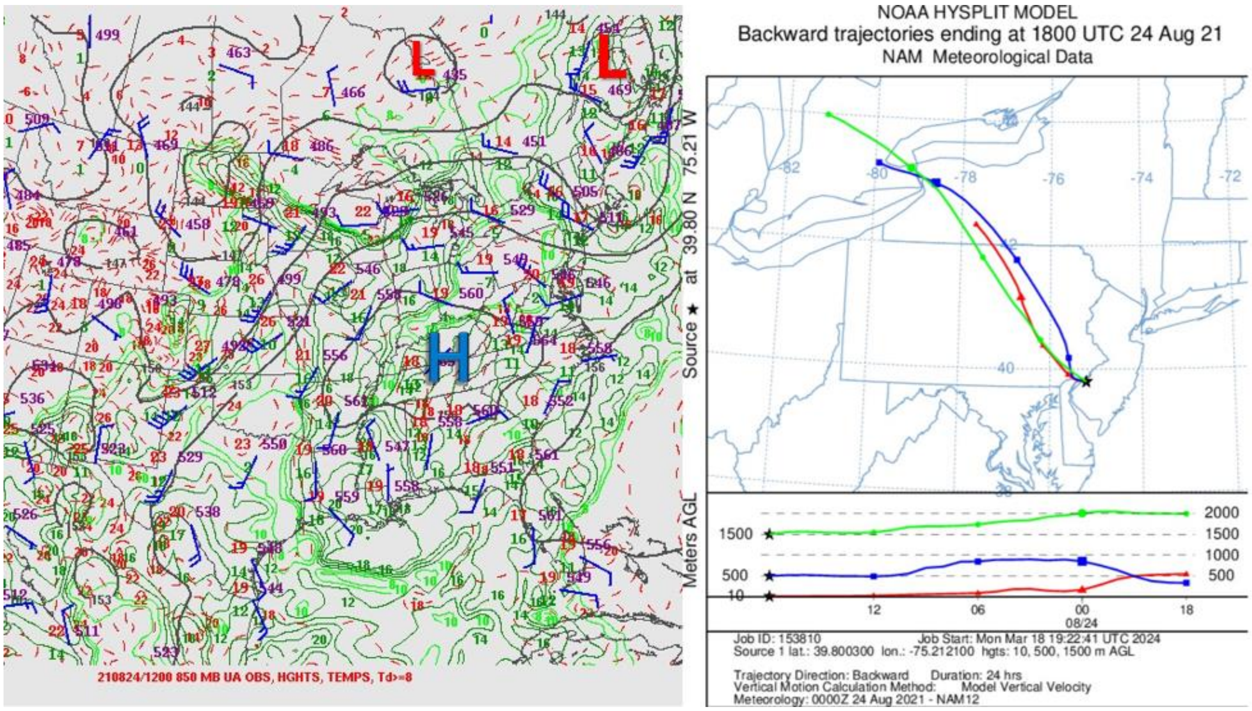


Figure 197: 850mb Map and 24hr Backward Trajectories for June 30, 2016

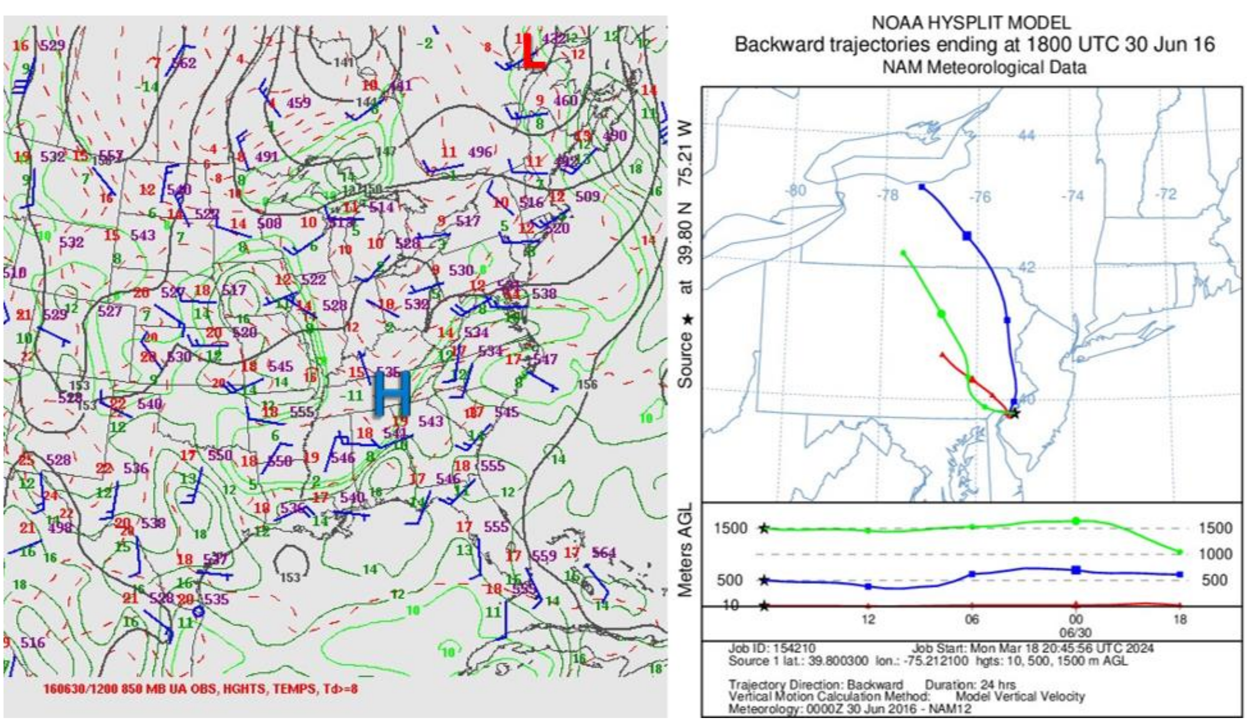
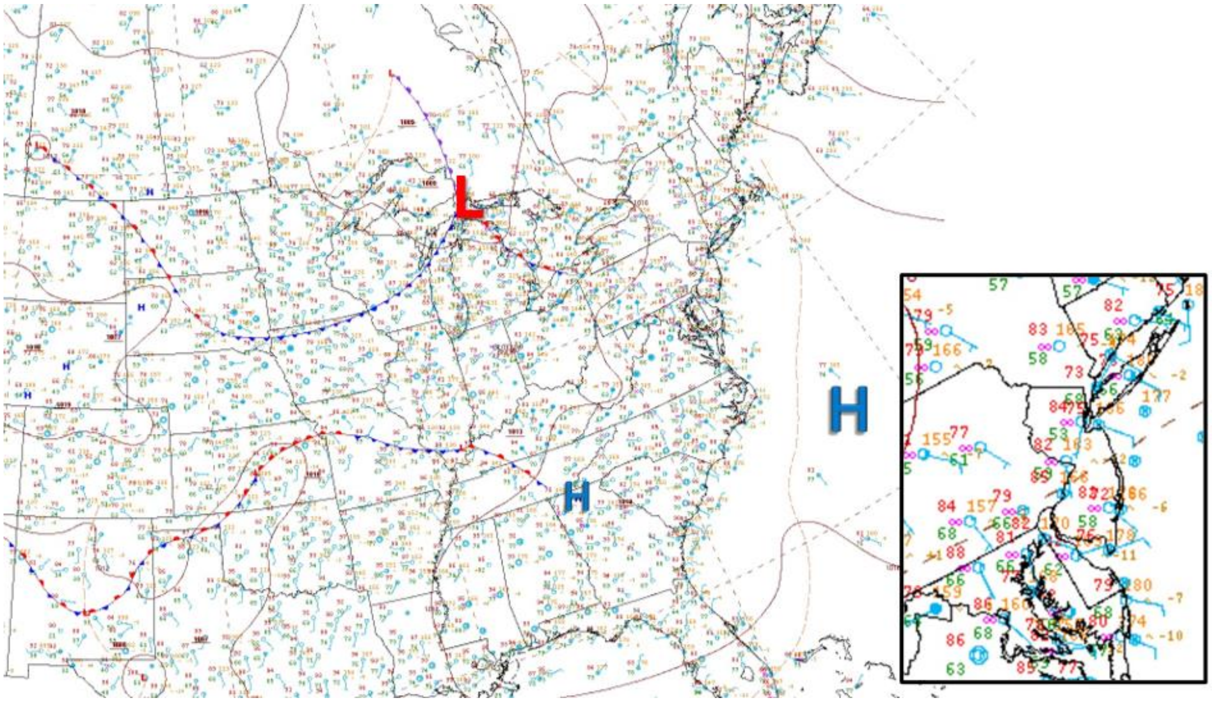


Figure 198 presents surface analysis for the reference day, June 30, 2023.

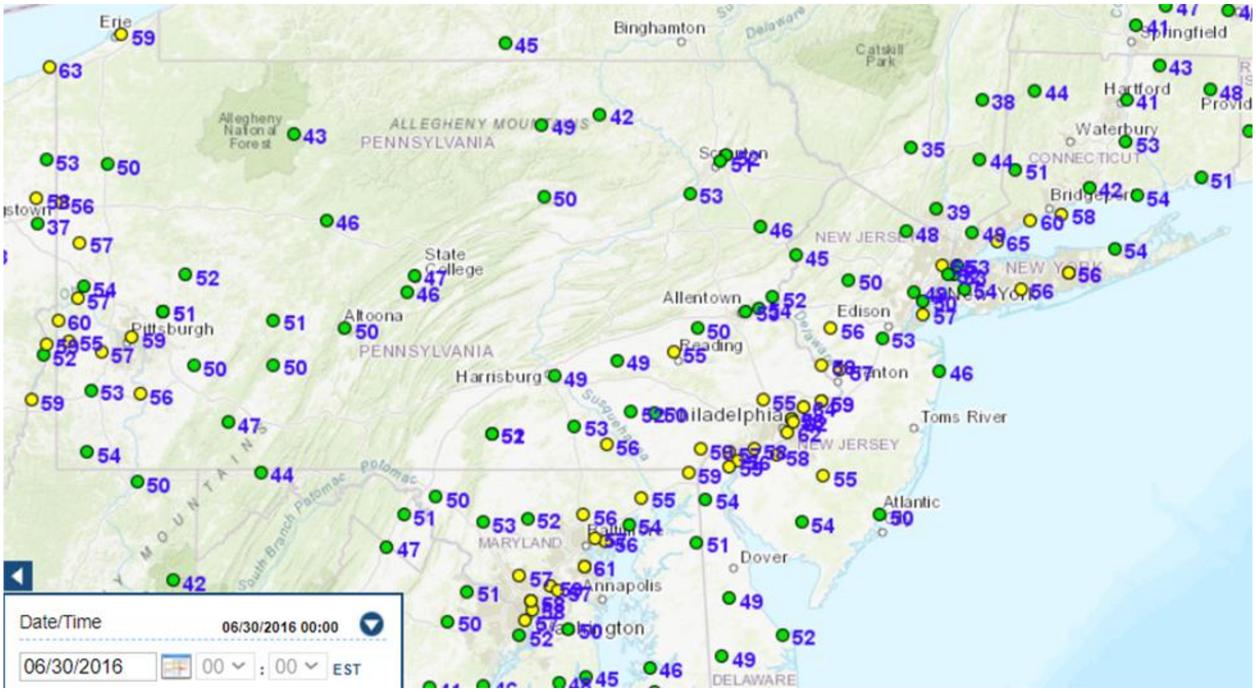
Figure 198: Reference Day Surface Analysis– June 30, 2023, 18UTC



Note: Broad area of surface high pressure marked with blue “H” located off the Carolina coast of United States. Red “L” indicating approaching area of low pressure over Great Lakes. Surface temperatures indicated by red numbers showing nearby range from approximately 76-85 degrees F. Mostly sunny skies indicated by blue wind barbs with hollow circles.

Figure 199 presents the maximum 8-hour ozone concentration on the reference day, June 30, 2023.

Figure 199: Reference Day 8hr Max Ozone Concentrations on June 30, 2023

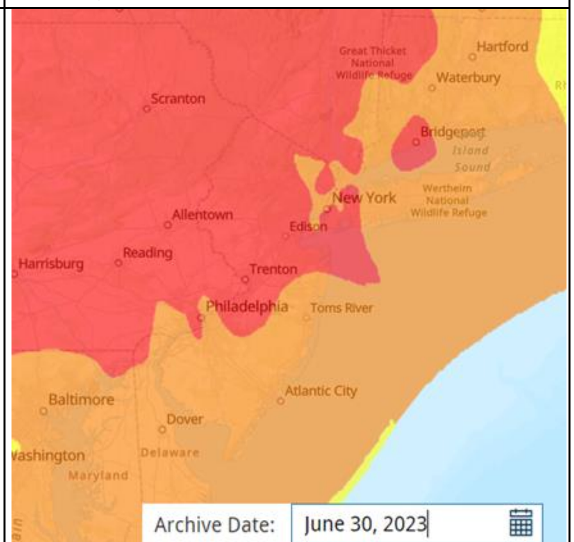
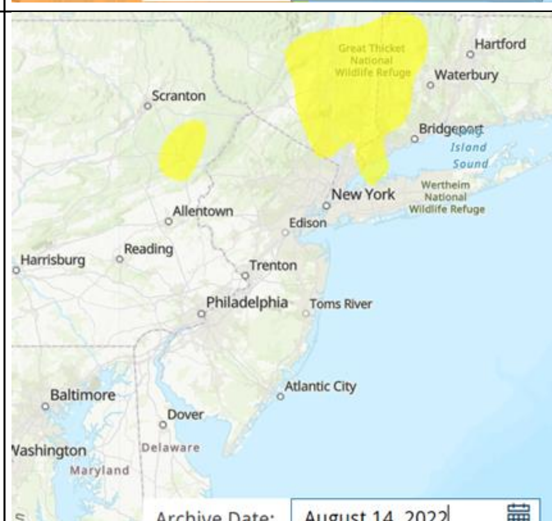


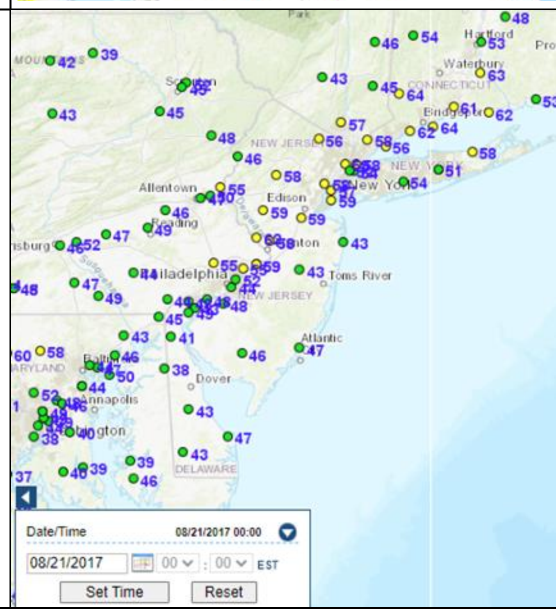
Based on the above criteria, the dates in

Table 25 were chosen as similar days for June 30, 2023. These dates were chosen because they observed all of the similar meteorological conditions listed above but lacked widespread ozone exceedance concentrations. Therefore, the widespread ozone exceedance concentrations on June 30, 2023, can be attributed to an exceptional event due to wildfire smoke.

Table 25: Similar Day Comparison of Max Ozone Concentration, Max Temperature, and AQI Map for June 30, 2023

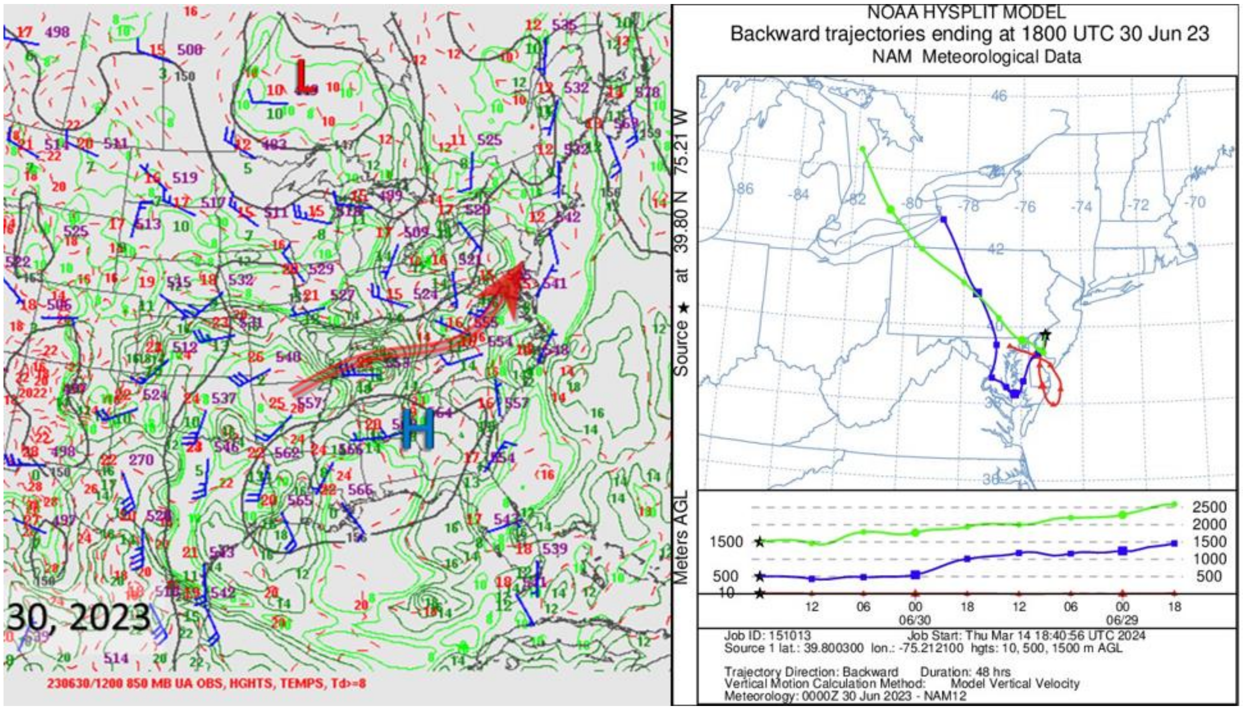
Note: Ozone (ppb) represents the monitor that recorded the highest observed ozone concentration on the specified day in the New Jersey portion of the Southern NJ-PA-MD-DE nonattainment area. Temperature represents the highest recorded temperature on specified date at KPHL.

Date	Ozone (ppb)	Temp (F)	AQI Map
June 30, 2023 Reference Day	78 – Camden Spruce Street	84	
August 14, 2022	51 - Clarksboro	85	

July 24, 2021	56 – Camden Spruce Street	86	
August 21, 2017	48 - Clarksboro	88	

The following image (Figure 200) shows the 850mb map and backward trajectories for the reference day, June 30, 2023. The features of importance for the similar day comparison are high pressure located over the southeastern United States, extending off the coast and an approaching area of low pressure near the Great Lakes. These features should be accompanied by a similar backward trajectory with average wind direction at KPHL out of the south/southwest.

Figure 200: 850mb Map and 24hr Backward Trajectories for Reference Day: June 30, 2023



Based on the above criteria for the reference day, the following figures (Figure 201-Figure 203) show a comparison of the matching meteorological criteria for the similar day analysis.

Figure 201: 850mb Map and 24hr Backward Trajectories for August 14, 2022

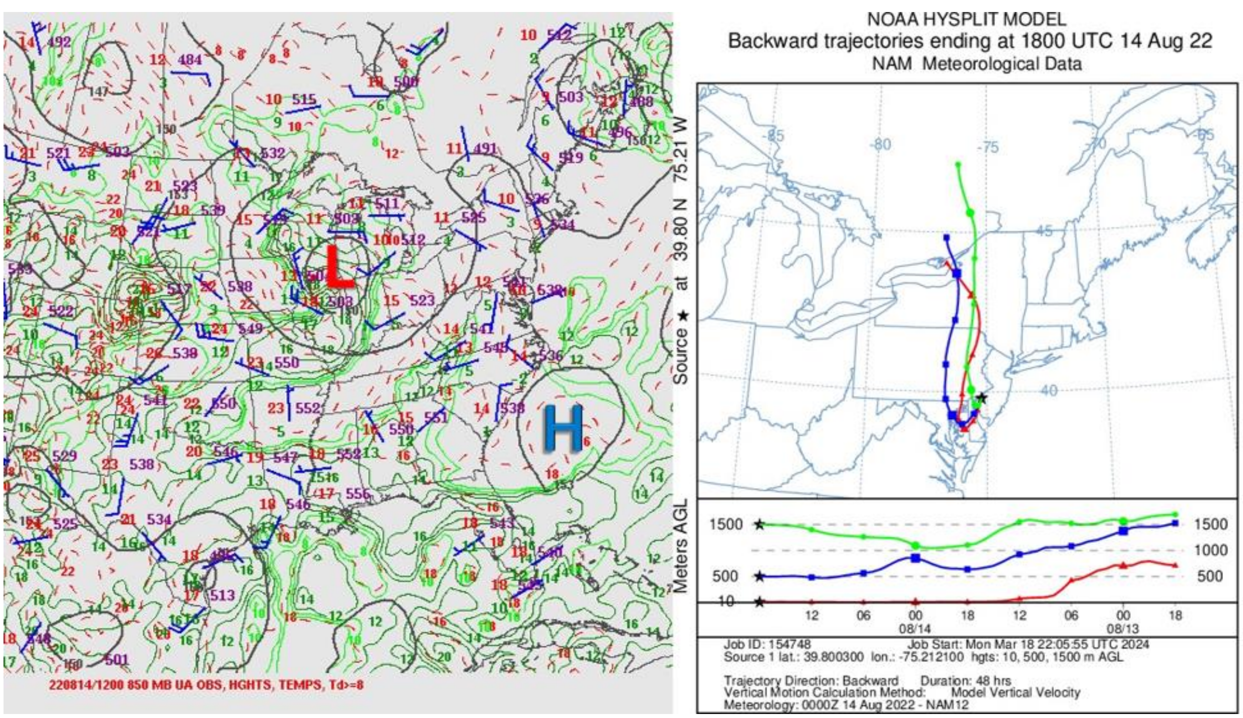


Figure 202: 850mb Map and 24hr Backward Trajectories for July 24, 2021

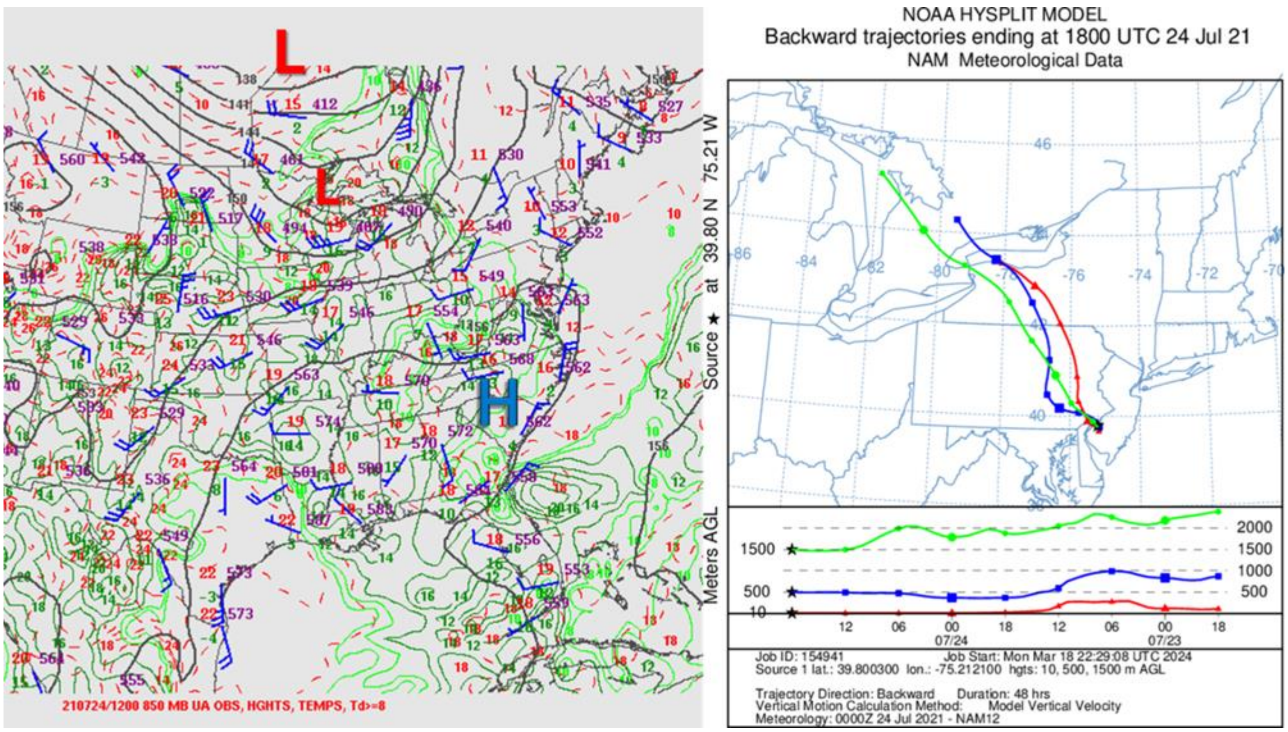
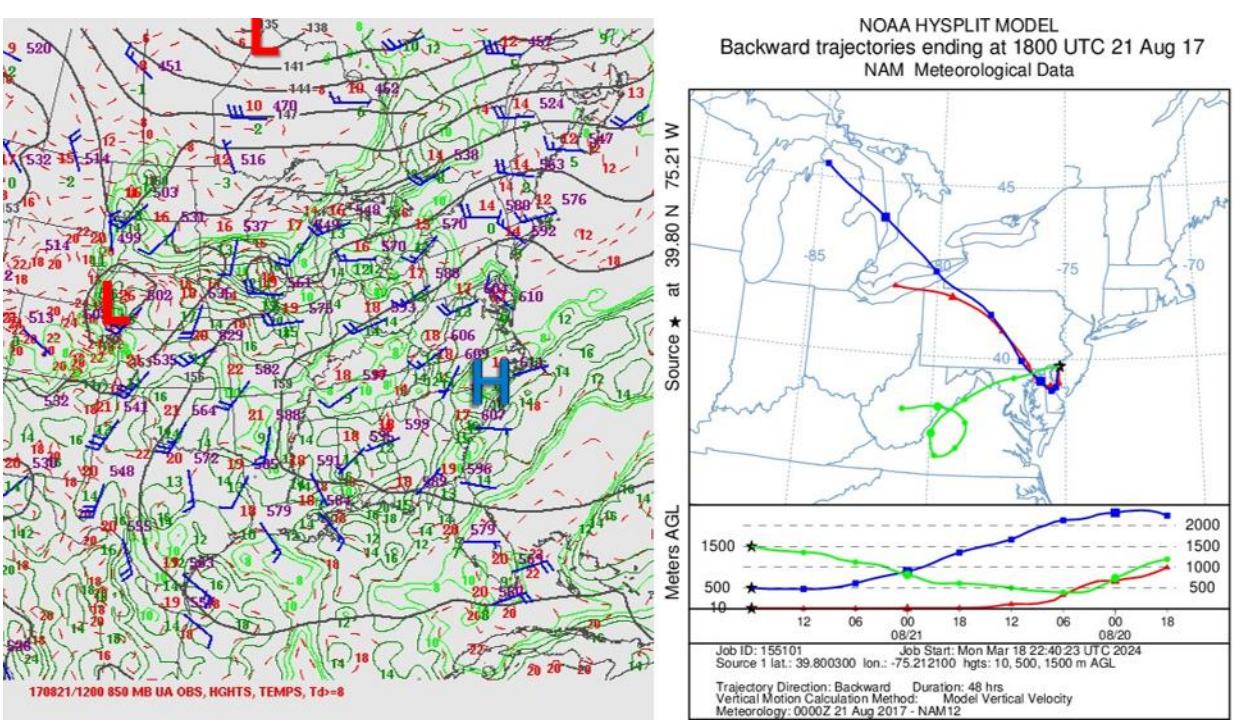


Figure 203: 850mb Map and 24hr Backward Trajectories for August 21, 2017



IV. A Demonstration that the Exceptional Event was Both Not Reasonably Controllable and Not Reasonably Preventable

According to the Clean Air Act and the Exceptional Events Rule, an exceptional event must be "not reasonably controllable or preventable."[194,195] In its July 2018 "Update to Frequently Asked Questions" for the 2016 Revisions to the Exceptional Events Rule the USEPA states, "it is presumptively assumed that if evidence supports that a wildfire occurred on wildland, such a wildfire event will satisfy both factors of the "not reasonably controllable or preventable' criterion, provided the Administrator determines that there is no compelling evidence to the contrary in the record."[196] The USEPA Exceptional Event Guidance also states that wildfire events on wildland are not generally reasonable to control or prevent.[197]

As previously stated in this document and reported in news articles, the Quebec fires pertinent to this exceptional event, were ignited by lightning, accidental human activities, or unknown sources, and occurred in wildland areas.[198,199,200,201] The Quebec wildfires, which occurred outside of the United States can be considered not reasonably controllable or preventable by New Jersey. Therefore, emissions from these wildfires were not reasonably controllable or preventable and meet the criterion for an exceptional event.

V. Caused by Human Activity that is Unlikely to Recur at a Particular Location or a Natural Event

According to the CAA and the Exceptional Events Rule, an exceptional event must be "an event caused by human activity that is unlikely to recur at a particular location or a natural event"[202,203] The Exceptional Events Rule's definition of wildfire is "… any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a

[194] 42 U.S.C. 7401 et seq.
[195] 40 CFR 50.14
[196] USEPA. (2018, July). *2016 Revisions to the Exceptional Events Rule: Update to Frequently Asked* Questions.
[197] 42 U.S.C. 7619(b)(1)(iii), *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations*. EPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. Page 30: https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf
[198] Korte, C. (2023, June 27). How did the Canadian wildfires start? A look at what caused the fires that are sending smoke across the U.S. *CBS News*. https://www.cbsnews.com/news/how-did-wildfires-in-canada-start-spread-to-europe-midwest/
[199] Reuters. (2023, August 19). Canada wildfires: what are the causes and when will it end. https://www.reuters.com/world/americas/canadas-record-wildfire-season-whats-behind-it-when-will-it-end-2023-08-17/
[200] Yousif, N. (2023, June 1). Nova Scotia battles its largest wildfire on record. *BBC*. https://www.bbc.com/news/world-us-canada-65755795
[201] Ignudo, T. (2023, June 20). Lightning strikes caused 2 different New Jersey wildfires, officials say. *CBS News*. https://www.cbsnews.com/philadelphia/news/new-jersey-wildfires-acron-hill-flatiron-burlington-county/
[202] 42 U.S.C. 7401 et seq.
[203] 40 CFR 50.14

prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event." [204,205]

The Quebec fires examined in this analysis are categorized as wildfires. Sections I and II of this demonstration provide detailed descriptions and visual representations, demonstrating that these fires meet the criteria for being considered a "natural event". The unplanned fires were ignited by lightning in wildland areas or due to unknown causes. The USEPA generally considers the emissions of ozone precursors from wildfires on wildland to meet the regulatory definition of a natural event at 40 CFR 50.1(k), defined as one 'in which human activity plays little or no direct causal role.' As such, NJDEP has demonstrated that these events qualify as natural occurrences and may be considered for treatment as exceptional events.

[204] 42 U.S.C. 7619(b)(1)(iii), *Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentration*s. EPA-HQ-OAR-2015-0229-0130, U.S. Environmental Protection Agency. Page 30: https://www.epa.gov/sites/default/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf

[205] 40 CFR 50.1(n)

Conclusion

The 2023 burn season in Canada was unprecedented. By the end of September 2023, wildfires had ravaged an estimated 18 million hectares – an area roughly the size of North Dakota. This surpassed the previous record set in 1989, when 7.6 million hectares were charred.[206] The fires started in the spring and raged continuously in various regions of Canada throughout the summer, releasing billowing waves of smoke across the United States. The smoke influenced by meteorological conditions was transported to New Jersey.

The Canadian wildfires, the Midwest United States fires, and to a small extent local fires in New Jersey, generated pollutants including volatile organic compounds, black carbon, fine particulate matter, carbon monoxide, nitrogen oxides, potassium, and haze. These emissions resulted in elevated ozone concentrations at certain ambient air monitors in New Jersey, surpassing the 99th percentile concentrations recorded over the past five years. Additionally, the meteorological conditions observed during these events were not consistent with the meteorological conditions typically observed with other historically high ozone days in New Jersey. Additional analyses beyond the Tier 2 demonstration requirements were conducted to provide a weight of evidence demonstration. This demonstration establishes that the 8-hour ozone concentrations exceeding 70 ppb during the exceptional event days in New Jersey qualify for data exclusion as an exceptional event. The meteorological conditions favored the transport of smoke from Canada, Kansas, and New Jersey fires to the New Jersey monitors. There is a clear causal relationship between the specific events and the monitored exceedances of the ozone NAAQS in New Jersey on April 13, June 2, June 29 and 30, 2023. Therefore, these ozone measurements should be excluded from the 2023 ozone monitoring data and the calculation of the 2023 ozone design value.

[206] NASA Earth Observatory. (2023, June 1 – July 23). *Tracking Canada's Extreme 2023 Fire Season*. Retrieved February 6, 2024, from https://earthobservatory.nasa.gov/images/151985/tracking-canadas-extreme-2023-fire-season

Appendices

Appendix 1: New Jersey Initial Notification of Potential Exceptional Event to USEPA, October 24, 2023

Initial Notification of Potential Exceptional Event

Davis, Sharon [DEP] <Sharon.Davis@dep.nj.gov>
Tue 10/24/2023 8:48 AM

To:wieber.kirk@epa.gov <wieber.kirk@epa.gov>
Cc:Gorgol, John [DEP] <John.Gorgol@dep.nj.gov>;Wenstrup, Victoria [DEP] <Victoria.Wenstrup@dep.nj.gov>;Oluwaseun-Apo, Stella [DEP] <Stella.Oluwaseun-Apo@dep.nj.gov>;Ratzman, Kenneth [DEP] <Kenneth.Ratzman@dep.nj.gov>;Steitz, Francis [DEP] <Francis.Steitz@dep.nj.gov>;Lim, Luis [DEP] <Luis.Lim@dep.nj.gov>;Fradkin, Kenneth <Fradkin.kenneth@epa.gov>

Dear Kirk,

The New Jersey Department of Environmental Protection (NJDEP) observed ozone exceedances at multiple ambient air quality monitors on April 13, June 2, June 29, and June 30, 2023. New Jersey believes that the ozone exceedance events were influenced by a combination of the Quebec and Nova Scotia wildfires in Canada, Mid-Western United States wildfires, and local wildfires. New Jersey monitoring data for ozone on these days has been accordingly flagged in the United States Environmental Protection Agency's (EPA) Air Quality System (AQS) as being an exceptional event.

In accordance with 40 CFR 50.14(c)(2) of the "Exceptional Events Rule", this email serves to provide EPA with an initial notification of New Jersey's intent to request exclusion of ambient air quality data due to the exceptional events noted above.

If you have any questions, please contact me or Stella Oluwaseun-Apo, of my staff, at Stella.Oluwaseun-Apo@dep.nj.gov

Sincerely,
Sharon

Sharon Davis, Chief
Bureau of Evaluation and Planning
NJDEP| Air Planning | Air Quality Evaluation and Planning
(609) 292-6722 (office)

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Appendix 2: EPA Region 2 Exceptional Events Initial Notification Summary Information, December 14, 2023

EPA Region 2 Exceptional Events Initial Notification (IN) Summary Information

Directions: For Initial Notifications for attainment date extensions, please fill out **A, D**, and **E**. For all other requests, please fill out **A, B, C, F**.

Submitting Agency: NJDEP

Agency Contact: Stella Oluwaseun-Apo, Stella.Oluwaseun-Apo@dep.nj.gov, Victoria Wenstrup, Victoria.Wenstrup@dep.nj.gov

Date Submitted: 12/14/2023

Applicable NAAQS (e.g. 2015 8-Hour Ozone): 2015 8-hour Ozone Standard (70 ppb)

Affected Regulatory Decision[1]: Attainment date extension
(for classification decisions, specify level of the classification with/without EE concurrence)

Area Name/Designation Status: Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE – New Jersey Only

Design Value Period (list three year period): (2023 DV year) 2021, 2022, 2023
(where there are multiple relevant design value periods, summarize separately)

[1] designation, classification, attainment determination, attainment date extension, or finding of SIP inadequacy leading to SIP call
[2] Provide additional information for types of event described as "other"

A) Information Specific to Each Flagged Monitor Day *(or attach separate spreadsheet)*

Date of Event	Type of Event (high wind, intrusion, wildfires/ prescribed fire, other[2])	AQS Flag	Monitor AQS ID (and POC)	Site Name	Exceedance Concentration	Units	Event Name	Notes (e.g. links to other events)
4/13/2023	Wildfire	Y	340150002	Clarksboro	73	ppb	Flint Hills Kansas Wildfire	
4/13/2023	Wildfire	Y	340290006	Colliers Mils	75	ppb	Flint Hills Kansas Wildfire	
4/13/2023	Wildfire	Y	34029991	Washington Crossing	71	ppb	Flint Hills Kansas Wildfire	
6/2/2023	Wildfire	Y	340070002	Camden	81	ppb	NW Canada, Nova Scotia Canada, & NJ Wildfires	
6/2/2023	Wildfire	Y	340150002	Clarksboro	89	ppb	NW Canada, Nova Scotia Canada, & NJ Wildfires	
6/2/2023	Wildfire	Y	340290006	Colliers Mills	74	ppb	NW Canada, Nova Scotia Canada, & NJ Wildfires	
6/2/2023	Wildfire	Y	340210005	Rider	98	ppb	NW Canada, Nova Scotia Canada, & NJ Wildfires	
6/29/2023	Wildfire	Y	340070002	Camden	71	ppb	Quebec Canada Wildfires	
6/29/2023	Wildfire	Y	340150002	Clarksboro	78	ppb	Quebec Canada Wildfires	
6/30/2023	Wildfire	Y	340070002	Camden	78	ppb	Quebec Canada Wildfires	
6/30/2023	Wildfire	Y	340150002	Clarksboro	77	ppb	Quebec Canada Wildfires	
6/30/2023	Wildfire	Y	340290006	Colliers Mills	73	ppb	Quebec Canada Wildfires	
6/30/2023	Wildfire	Y	34029991	Washington Crossing	89	ppb	Quebec Canada Wildfires	
6/30/2023	Wildfire	Y	340210005	Rider	86	ppb	Quebec Canada Wildfires	

[1] designation, classification, attainment determination, attainment date extension, or finding of SIP inadequacy leading to SIP call
[2] Provide additional information for types of event described as "other"

B) Violating Sites Information

(listing of all violating sites in the planning area, regardless of operating agency, and regardless of whether or not they are impacted by EEs)

Site/monitor	AQS ID	Design Value (without EPA concurrence on any of the events listed in Section A)	Design Value (with EPA concurrence on all events listed in Section A)

C) Summary of Maximum Design Value (DV) Site Information (Effect of EPA Concurrence on Maximum Design Value Site Determination)

(Two highest values from Table B)

Maximum DV site (AQS ID) **without EPA concurrence** on any of the events listed in attached spreadsheet	Design Value	Design Value Site	Comment
Maximum DV site (AQS ID) **with EPA concurrence** on all events listed in attached spreadsheet	Design Value	Design Value Site	Comment

D) Highest 4th High Monitors that Exceed the Standard *(or attach separate spreadsheet)*

(listing of all "highest 4th high" exceeding sites in the planning area, regardless of operating agency, and regardless of whether or not they are impacted by EEs)

Site/monitor	AQS ID	4th High (4th high without EPA concurrence on any events listed in section A)	4th High (4th high with EPA concurrence on all events listed in section A)
Camden – NJ	340070002	71	67
Colliers Mills – NJ	340290006	73	68
Clarksboro – NJ	340150002	74	68
Washington Crossing – NJ	34029991	71	68
BCSP - DE	100031010	70	N/A
Lums Pond - DE	100031007	72	N/A
Fair Hill – MD	240150003	70	N/A
LAT/LON IS OF CORNER OF TRAILER - PA	420910013	70	N/A
Bristol – PA	420170012	79	N/A
Chester – PA	420450002	74	N/A
New Garden – PA	420290100	70	N/A
North East Airport (NEA) – PA	421010024	72	N/A
North East Waste (NEW) – PA	421010048	71	N/A

[1] designation, classification, attainment determination, attainment date extension, or finding of SIP inadequacy leading to SIP call

[2] Provide additional information for types of event described as "other"

E) Summary of Highest 4th High Site Information (Effect of EPA Concurrence on Highest 4th High Site Determination)
(Two highest values from Table D)

Maximum 4th high site (AQS ID) **without EPA concurrence** on any of the events listed in section A	4th High	4th High Site	Comment
Clarksboro	**74**	**340150002**	**Two highest maximum 4th high sites in the New Jersey portion of the Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE, are listed.**
Colliers Mills	**73**	**340290006**	
Maximum 4th high site (AQS ID) **with EPA concurrence** on all events listed in section A	4th High	4th High Site	Comment
Clarksboro	**68**	**340150002**	**With EPA concurrence on all events listed in section A, three sites tied with a maximum 4th high of 68.**
Colliers Mills	**68**	**340290006**	
Washington Crossing	**68**	**340219991**	

F) List of any sites (AQS ID) within planning area with invalid design values (e.g., due to data incompleteness)

[1] designation, classification, attainment determination, attainment date extension, or finding of SIP inadequacy leading to SIP call
[2] Provide additional information for types of event described as "other"

Appendix 3: Certification Letter for 2023 Ozone Monitoring Data (December 18, 2023)

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

DIVISION OF CLIMATE CHANGE MITIGATION AND MONITORING

401 East State Street
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www.nj.gov/dep

PHILIP D. MURPHY
Governor

TAHESHA L. WAY
Lt. Governor

SHAWN M. LATOURETTE
Commissioner

December 18, 2023

Kirk Wieber, Branch Chief
Air Programs Branch
U.S. Environmental Protection Agency Region 2
290 Broadway
Mail Code: 25th FL
New York, NY 10007-1866

Dear Mr. Wieber:

As per 40 CFR Part 58.15, enclosed please find a signed copy of the 2023 AMP600 Certification Evaluation and Concurrence Report, for data from all New Jersey ozone monitors listed in the AMP600 report for PQAO Code 0764 and collected from January 1, 2023 to October 31, 2023. Electronic copies of the following are being sent to Gavin Lau of your staff: the AMP600; the 2023 AMP256 QA Data Quality Indicator Report for all ozone monitors; and the 2023 AMP450 Quicklook Criteria Parameters Report for all ozone monitors. The ozone data is being certified early to support NJDEP's 2023 exceptional event demonstration.

I certify that the 2023 ozone data and the ozone quality assurance data collected from January 1, 2023 to October 31, 2023 are complete, accurate to the best of my knowledge and have been submitted to AQS by the New Jersey Department of Environmental Protection. If you have any questions regarding the data, please call me at 609-462-7266.

Sincerely,

Luis Lim

Luis Lim, Chief
Bureau of Air Monitoring

Enclosures

c: Sharon Davis
Peg Hanna
Gavin Lau, EPA Region 2 (electronic mail)

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Appendix 4: Remote Sensing Information Gateway Videos

1. RSIG3D Ozone Video on April 13, 2023
2. RSIG3D Nitrogen Dioxide Video on April 13, 2023
3. RSIG3D Ozone Video on June 2, 2023
4. RSIG3D Nitrogen Dioxide Video on June 2, 2023
5. RSIG3D Ozone Video on June 29-30, 2023
6. RSIG3D Nitrogen Dioxide Video on June 29-30, 2023