Exceptional Events Demonstration Addressing the 2015 8-Hour Ozone (O_3) National Ambient Air Quality Standard (NAAQS)

Lake and Porter Counties, Indiana

Developed By:

The Indiana Department of Environmental Management (IDEM)

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1.0 INTRODUCTION

1.1 Background on Ozone Standard

The Clean Air Act required National Ambient Air Quality Standards (NAAQS) to be established and routinely reviewed for six criteria pollutants; ground level ozone (O_3) is one of the six criteria pollutants. Ground-level ozone is not emitted directly into the air but instead is created by a chemical reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOC). These pollutants, emitted by different types of sources such as vehicular traffic, power plants, industrial boilers, refineries, chemical plants, and residential sources, chemically react in the presence of sunlight to form ozone. Ozone is most likely to reach unhealthy levels on hot, sunny, non-windy days in urban environments. Once formed, ozone can be transported long distances during which rural areas can experience high ozone concentrations.

Breathing ozone can cause respiratory problems for anyone. Sensitive groups, such as the very young, the elderly, or people with asthma or chronic respiratory problems may be particularly vulnerable to ill health effects. Elevated, prolonged exposure to ozone can also have secondary impacts on sensitive vegetation and ecosystems, including forests, parks, wildlife refuges and wilderness areas.

The United States Environmental Protection Agency (U.S. EPA) continues to conduct 5-year reviews of all criteria pollutants, including ozone. These reviews include related health studies and assessments from science and health experts. The initial ozone standard was established in 1971, with revisions to the standard in 1979, 1997 (which revised the threshold and time-averaging form of the standard from 1-hour to the annual fourth highest daily maximum 8-hour average concentration averaged over three years), 2008 and 2015. U.S. EPA's 2015 review resulted in the strengthening of the primary standard to from 0.075 parts per million (ppm) to 0.070 ppm and an extension of Indiana's ozone monitoring season to March 1 through October 31.

1.2 Exceptional Event (EE) Rule and Guidance

U.S. EPA promulgated the Exceptional Events Rule in 2007 (73 FR 13560) to address Clean Air Act (CAA) section 319(b), which allows for the exclusion of air quality monitoring data influenced by exceptional events from use in determinations of exceedances or violations of the NAAQS, including the ozone standard. U.S. EPA revised the 2007 Exceptional Events Rule in 2016[1] based on implementation experiences with the exceptional events data exclusion process. The revised Exceptional Events Rule at 40 CFR 50.14(c)(3) clarifies that an exceptional events demonstration must include the following elements:

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

1) A narrative conceptual model that describes the event(s) causing the exceedance or violation and a discussion of how emissions from the event(s) led to the exceedance or violation at the affected monitor(s);
2) 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;
3) Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times. The Administrator shall not require a State to prove a specific percentile point in the distribution of data;
4) A demonstration that the event was both not reasonably controllable and not reasonably preventable;
5) A demonstration that the event was caused by human activity that is unlikely to recur at a particular location or was a natural event; and
6) Documentation that the submitting air agency followed the public comment process. Events in this demonstration include:

- Section 3.3.1 May 23, 2023
- Section 3.4 May 30, 2023
- Section 3.5 June 2 – 3, 2023
- Section 3.6 June 10, 2023
- Section 3.7 June 18 – 19, 2023
- Section 3.8 June 21, 2023
- Section 3.9 July 4, 2023
- Section 3.10 July 23 and July 25, 2023
- Section 3.11 August 3, 2023
- Section 3.12 June 11 – 12, 2025
- Section 3.13 June 16, 2025
- Section 3.14 July 2, 2025
- Section 3.15 July 14, 2025

Emissions from wildfires are presumed to meet the standards in 40 CFR 50.14(c)(3)(iv)(D): “Provided the Administrator determines there is no compelling evidence to the contrary in the record, the Administrator will determine every wildfire occurring predominantly on wildland to have met the requirements identified…regarding the not reasonably controllable or preventable criterion.” 40 CFR 50.14(b)(4).

Indiana has reviewed the EE rule and guidance and has prepared this ozone EE demonstration request in accordance with each document. Included in this demonstration model are information such as maps, figures, and tables of the wildfire events that impacted Indiana, descriptions of the ozone monitors in Lake and Porter counties, examples of media coverage of the wildfire event, meteorological analysis, monitoring trends and smoke forecasts from the requested days to determine transport of smoke and ozone conducive conditions, as well as other trends and matching day analyses to confirm the impact of wildfire smoke on ozone concentrations.

1.3 Overview of Lake and Porter Counties

Lake and Porter counties have been part of the Chicago, IL–Indiana–Wisconsin Consolidated Metropolitan Statistical Area (CMSA)/Core Based Statistical Area (CBSA) and Combined Statistical Area (CSA) since the early 1980's. As for ozone, the area has been subject to nonattainment CAA requirements under the 1979 1-hour ozone standard, and 1997, 2008 and 2015 8-hour ozone standards. Currently, the Chiwaukee, WI ozone monitor, in southeast Wisconsin, is the controlling monitor (i.e., the site in the nonattainment area with the highest base year design value) for the Chicago, IL-IN-WI nonattainment area. Along with the Chiwaukee ozone monitor, several Chicago metropolitan area-based ozone monitors have the highest design values in the nonattainment area. Dating back to 1997, no northwest Indiana ozone monitors have had the highest design values in the Lake Michigan region, and none have been designated as a controlling monitor for the Chicago, IL-IN-WI nonattainment area under any of the 8-hour ozone standards.

1.4 Regulatory Significance of Lake and Porter County Ozone

Wildfire impacts on air quality have increased in frequency and scale since U.S. EPA issued the exceptional events rule and guidance for ozone. The current form of the ozone standard is a three-year average of the annual 4th highest concentration. The first three highest values for each annual period are excluded from the design value calculation. However, in recent years it has been common for more than three days of an ozone season to be influenced by wildfire smoke, and the design value does not accommodate the increased frequency and scale of wildfire smoke impacting the U.S. For example, in 2023 there were at least twelve days during the ozone season that were influenced adversely by wildfire smoke in Lake and Porter counties. Instead of the annual fourth high being 73 parts per billion (ppb) for 2023, the annual fourth high for these counties is 77 ppb due to impacts directly associated with wildfire smoke. Lake and Porter counties were reclassified, i.e. bumped-up, from a "moderate" nonattainment classification to a "serious" classification in January 2025, with an attainment deadline of August 3, 2027. This was in part due to the extraordinary wildfire events of 2023. This bump-up resulted in more stringent permitting and costly control requirements for industry in the area.

Since the current attainment deadline of August 3, 2027, falls in the middle of an ozone season, attainment will be determined based on the most recent complete three years of data. In this case, ozone data from 2024-2026 will be used for each county's design value to determine its attainment status. If the area fails to attain by this deadline, it will be reclassified to “severe” nonattainment and even more stringent permitting and costly control requirements may be required. The design value should not include the impacts from naturally occurring or non-manmade precursor emissions; emissions associated with wildfire and firework smoke. These events cannot be controlled. Therefore, Indiana believes an ozone exceptional event demonstration for both Lake and Porter counties will result in a more accurate assessment of air quality in the area and a more obtainable regulatory target as the state strives to attain the current 8-hour ozone standard.

The State of Indiana is responsible for developing an attainment plan that includes emission control requirements necessary for the area to attain the current ozone standard by the deadline. When monitor values are elevated due to naturally occurring events, the state is essentially penalized and becomes responsible for emission reductions that would address the assumed impacts from those events beyond control of the state, unless the events are considered exceptional events and do not factor into design value calculations.

U.S. EPA has traditionally looked at regulatory significance for exceptional events as being applicable solely in instances where the exclusion of the data has NAAQS compliance implications. Impacts from a broader perspective such as reclassifications or artificially high emission reduction targets for attainment planning are not considered regulatorily significant. This narrow view of regulatory significance is extremely short-sighted and puts states in a position to address problems that cannot be solved solely by the states responsible for attainment planning. Therefore, the State of Indiana is respectfully asking U.S. EPA to look at regulatory significance for exceptional events more broadly to allow states where the controlling monitor is not located to demonstrate that their monitors are impacted by exceptional events. This interpretation would ensure that states are only responsible for addressing ozone problems that are within the authority of the affected states to solve.

Regulatory significance should not be a limiting factor as it relates to the Chicago, IL-IN-WI nonattainment area and receiving concurrence on ozone exceptional event demonstrations. Indiana should not be constrained by the controlling monitor located in another state in the designated nonattainment area to seek relief from the naturally occurring impacts from wildfire smoke. Indiana is seeking a more representative design value for each of its monitors, similar to the approach for $PM_{2.5}$ recommended and concurred by U.S. EPA. Removal of days in which wildfire smoke impacted ozone concentrations should be factored into the design value calculations for all monitors throughout the country. This would result in design values that all states can better measure against when developing an ozone attainment demonstration and evaluating local, state and federal control strategies for anthropogenic emissions for attainment planning purposes.

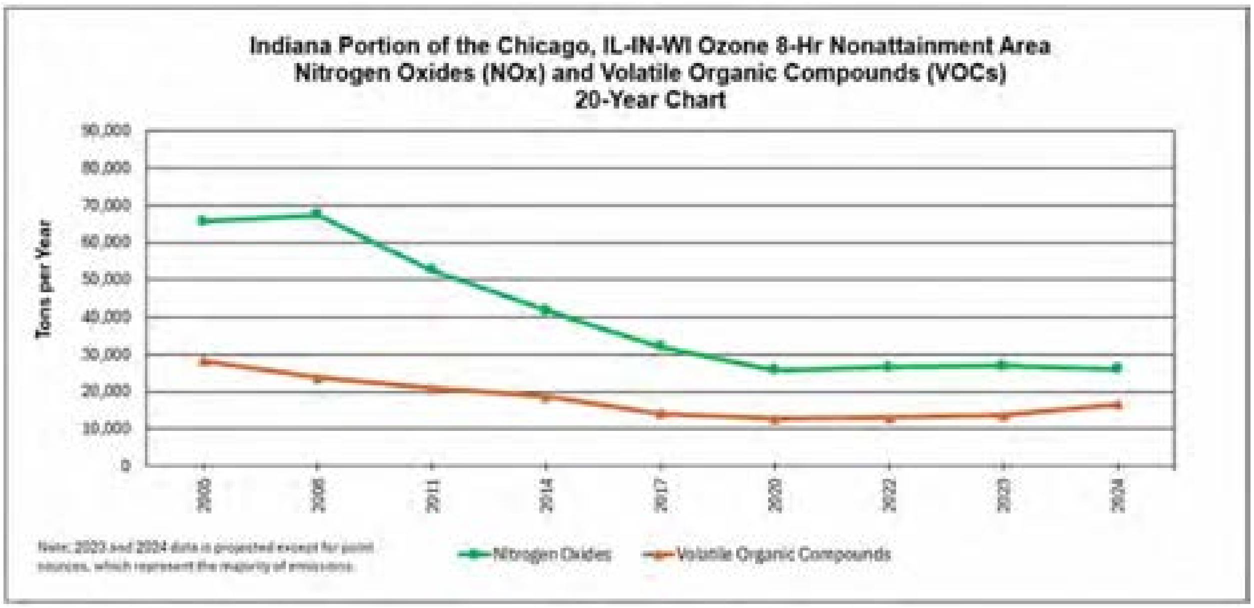
Indiana has identified a total of seventeen days —12 days in 2023 and 5 in 2025 — that were significantly impacted by wildfire smoke that if excluded from ozone design value calculations, would provide design values at the Lake and Porter County ozone monitors that would be at or below the NAAQS.

2.0 Narrative Conceptual Model

2.1 Emissions and Monitoring Review

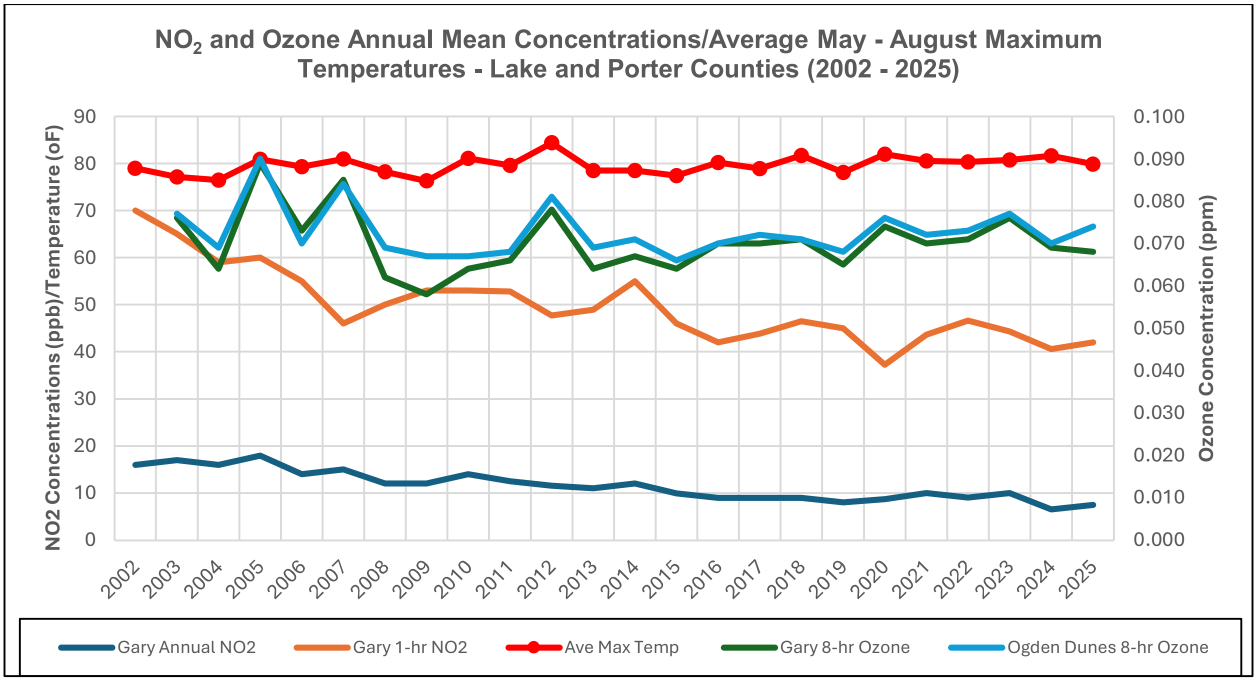
Emissions trends for ozone precursor emissions (NO_x and VOCs) have consistently decreased over the past two decades in Indiana. Figure 2.1 shows NO_x emissions have decreased by approximately 60% and VOC emissions have decreased by approximately 41% from sources located in Indiana's portion of the Chicago, IL-IN-WI nonattainment area over the past 20 years.

Figure 2.1 Northwest Indiana NO_x and VOC Emissions Trends (2005 – 2024)



Despite these emissions reductions, ozone design values, which trended downward from 2005 to 2015, have leveled off and in some cases increased slightly over the past several years. The 1-hour and annual NO_2 concentrations and 4th high maximum daily average 8-hour ozone concentrations are compared with the maximum average temperatures from May through August. NO_2 concentrations have trended down, corresponding with decreasing NO_2 emissions over the past 20 years as shown in the chart below. The spikes in ozone concentrations correspond to higher maximum temperatures as evident in 2005, 2007 and 2012 while ozone impacts from wildfire smoke were elevated in 2023 and 2025. Figure 2.2 shows this disconnect between the emissions reductions realized in northwest Indiana and the leveling off of ozone concentrations and in some cases, increase in ozone trends, would lead to a conclusion that other emissions, man-made or natural, are playing a more significant role on ozone development and transport in the area over the past decade.

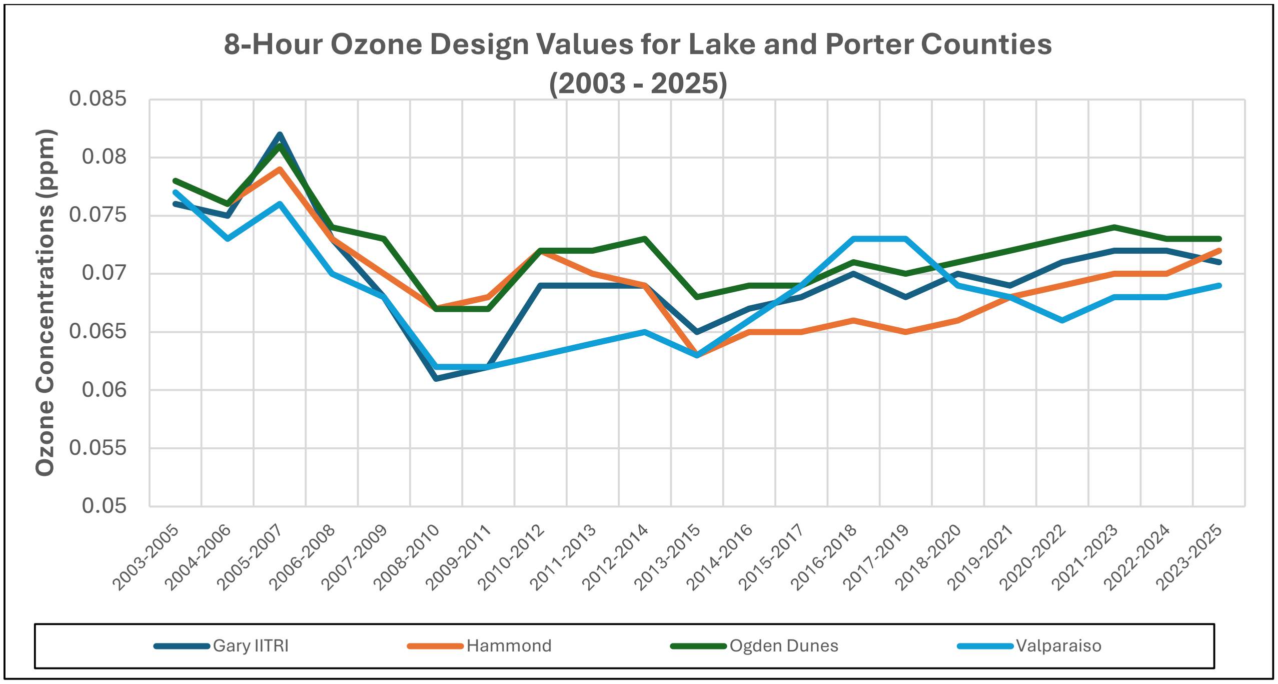
Figure 2.2 Lake and Porter County NOx and Ozone Monitoring Trends



As noted in Figure 2.1, emissions within the Chicago nonattainment area have been reduced dramatically over the past twenty years. However, as noted in Figure 2.3, there is not a direct relationship between the emissions trends and monitoring trends. Monitor values have not trended downward as emissions have been reduced significantly. One reasonable explanation for this is that there are external transport-related influences on air quality measured within the region, namely wildfire and firework smoke.

Eight-hour ozone three-year design values for the four Lake and Porter County ozone monitors are listed below, showing large decreases in design values during the mid and late 2000's. Since 2010, design values have remained steady or have trended upward over the past 15 years as shown in Figure 2.3.

Figure 2.3 Lake and Porter County Ozone Monitors 8-Hour Ozone Design Values



2.2 Wildfire Smoke Impacts

Wildfire smoke has played a major role in higher ozone concentrations observed throughout the Midwest and especially in the southern Lake Michigan area over the past several years. Frequency of wildfires in Canada and the United States have remained fairly consistent over the past several decades, however the acreage burned per year has trended upward with extreme spikes in acreage burned during more recent fire seasons. The resulting wildfire smoke has impacted both ozone and $PM_{2.5}$ concentrations throughout the Midwest. These naturally occurring precursor emissions contribute to the formation of ozone under certain conditions and have elevated ozone concentrations beyond what would be expected.

Figure 2.4 depicts the number of wildfires and acreage burned in the United States by calendar year from 1983 to 2025.

Figure 2.4 U.S. Wildfire and Acreage Burned (1984 – 2025)

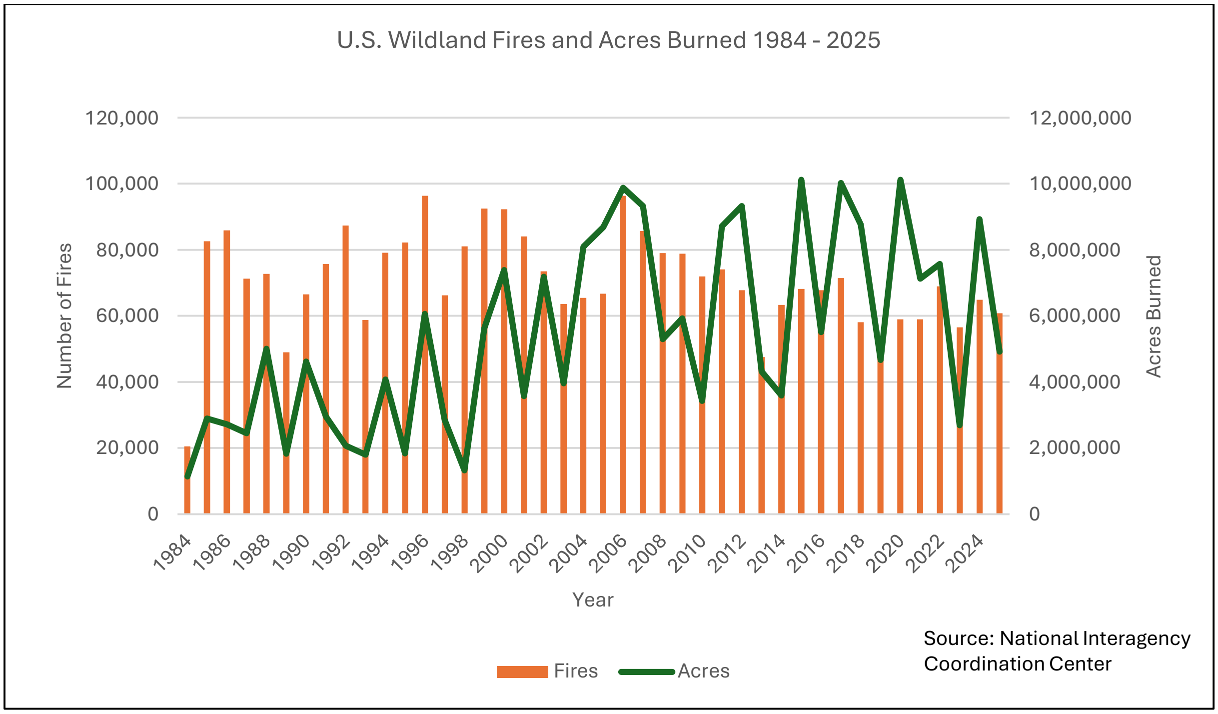
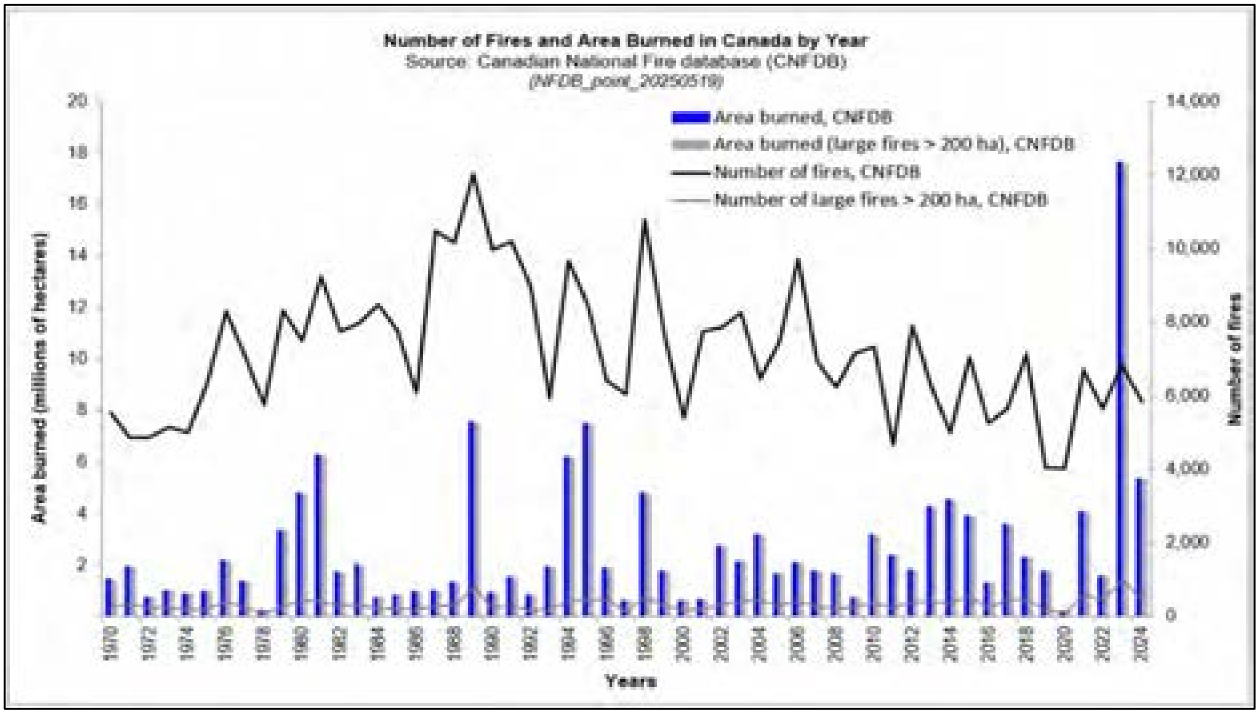


Figure 2.5 depicts the number of wildfires and acreage burned in Canada from 1970 through 2024. As can be noted, 2023 was by far the highest hectares burned in the past 55 years. While this chart has not been updated to include 2025 data, the Canadian National Fire Database (CNFDB) indicates there were nearly 9 million hectares burned in 2025, making it the 2nd most hectares burned in Canada since 1970. Smoke from wildfires from both 2023 and 2025 severely impacted air quality in Indiana and the Midwest.

Figure 2.5 Canadian Wildfire and Areas (Hectares) Burned (1970 – 2024)



The cumulative smoke distribution maps, taken from the NOAA Hazard Mapping[2] system fire point analysis, shows northwest Indiana, in 2023, had between 160 and 180 smoke frequency days and between 105 and 120 smoke frequency days in 2025. Figures 2.6 and 2.7 represent the smoke day distribution for the entire country for 2023 and 2025, with the majority of smoke days concentrated over the eastern half of the country in 2023 as a result of the severe wildfire season Canada experienced while the Central Plains and Mississippi Valley experienced a higher frequency of wildfire smoke days during 2025.

[2] https://www.ospo.noaa.gov/products/land/hms.html#stats-smoke

Figure 2.6 Cumulative Smoke Frequency Days for 2023

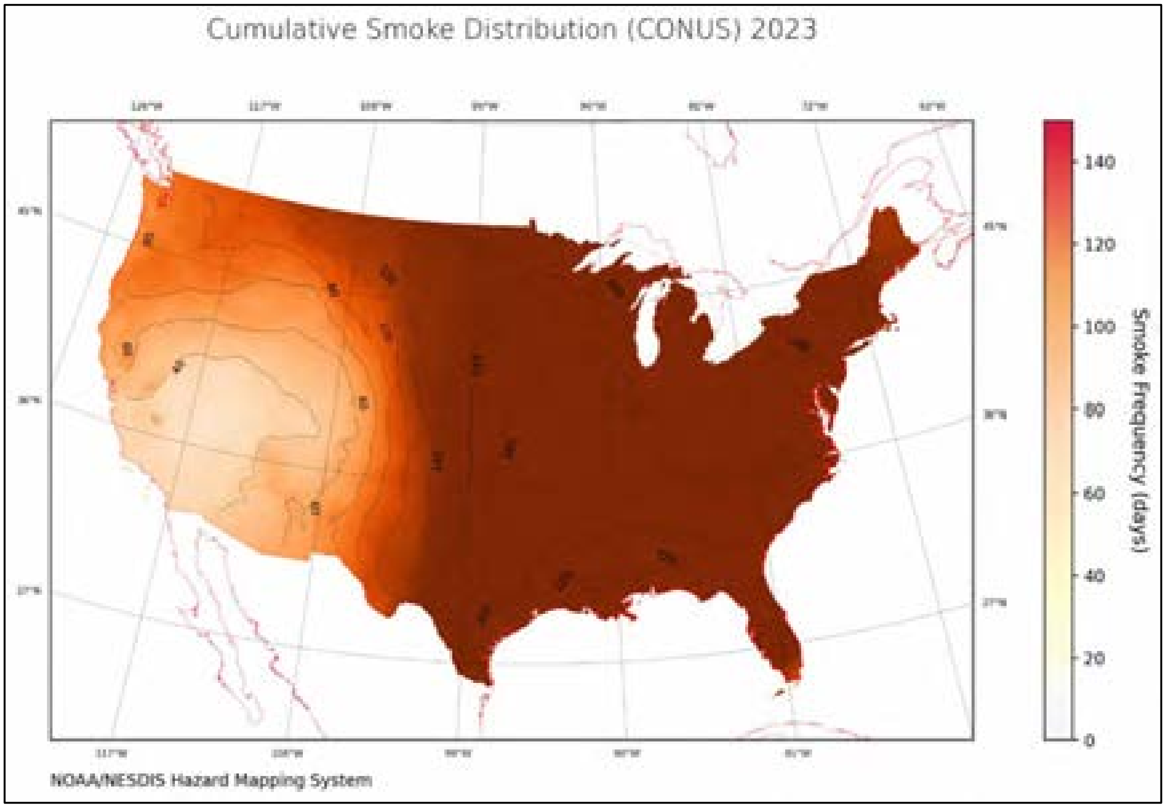
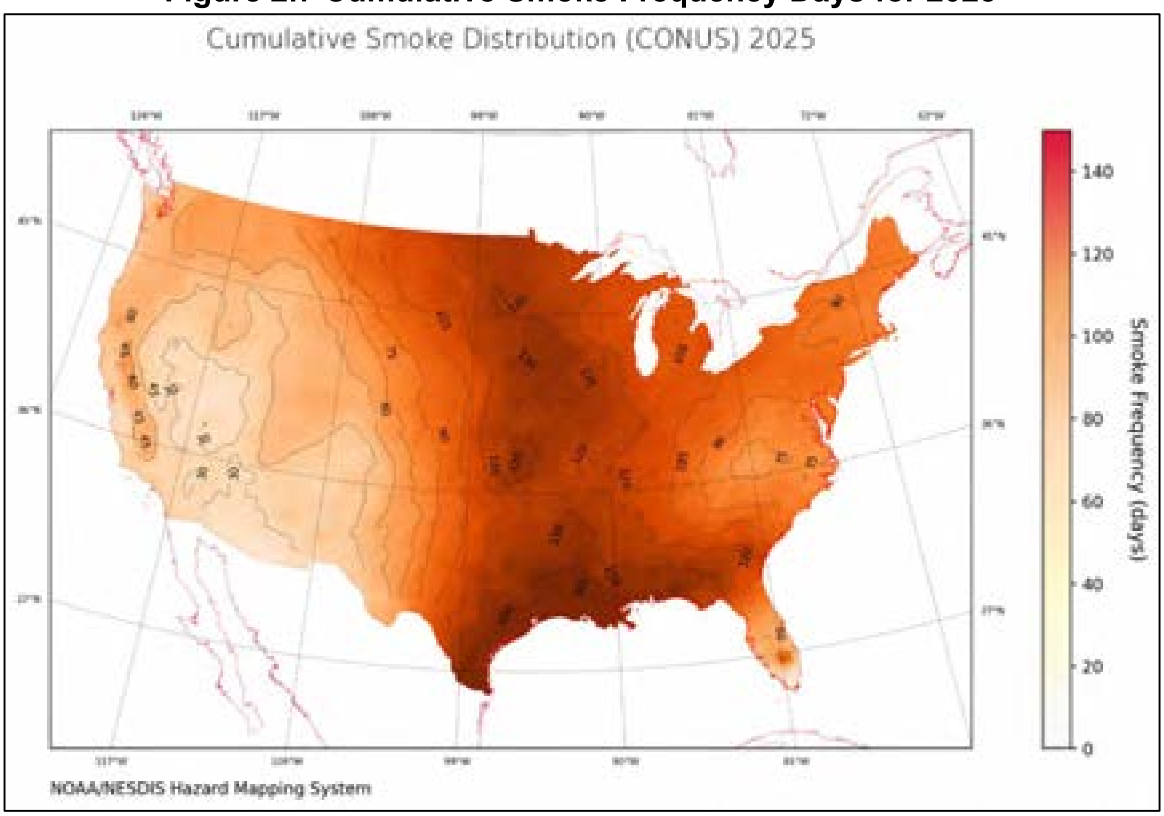


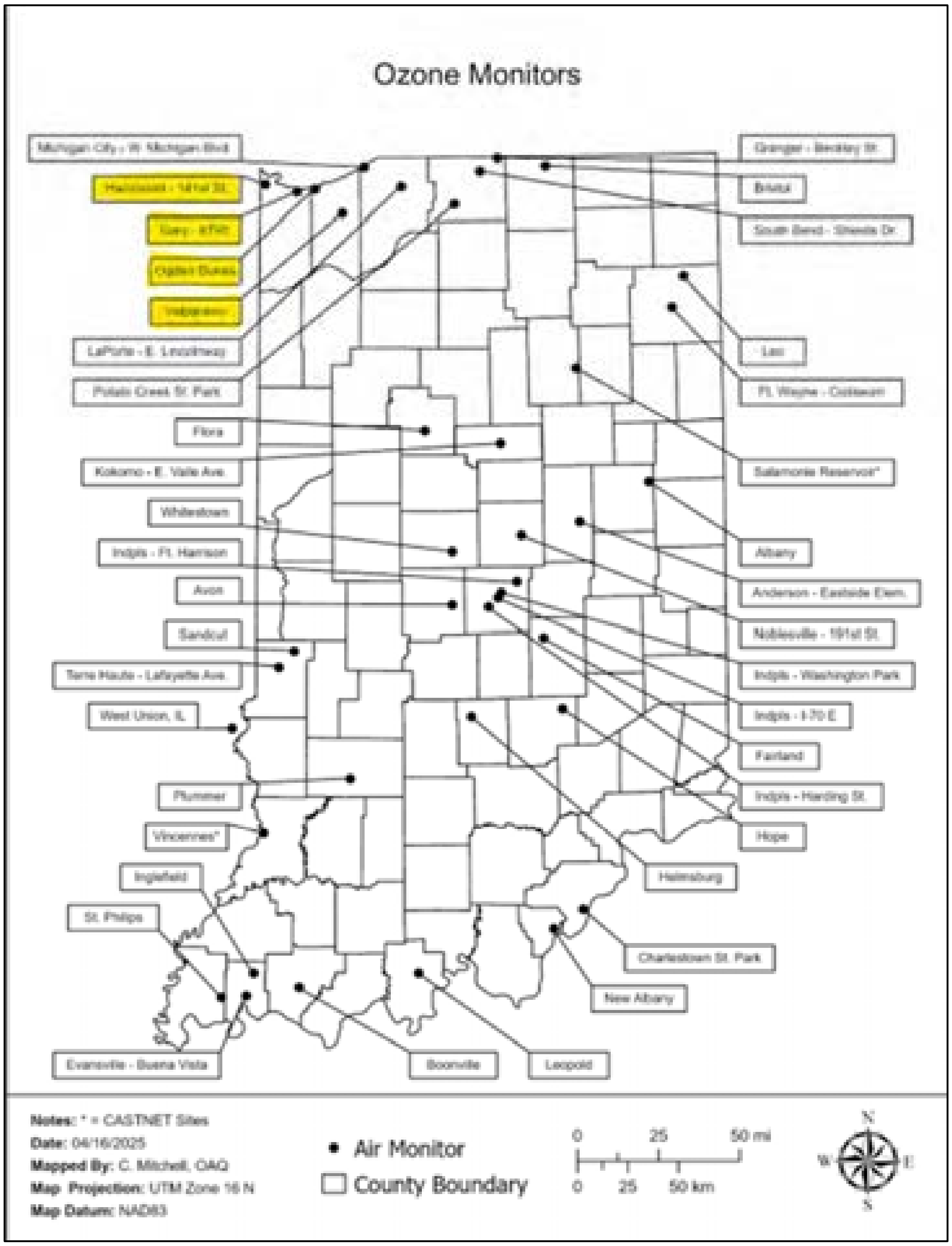
Figure 2.7 Cumulative Smoke Frequency Days for 2025



2.3 Location and Description of Lake/Porter Counties Ozone Monitors

Indiana has a total of thirty-eight ozone monitoring sites within the state, collecting hourly data primarily from March 1 through October 31. Figure 2.8 shows the monitor locations throughout the state of Indiana with the four Lake and Porter County monitors highlighted. Each monitor is a State or Local Air Monitoring Station (SLAMS) monitor with a scale set for neighborhood or urban to determine population exposure or the highest concentrations.

Figure 2.8 – Indiana's Ozone Air Monitoring Network



Figures 2.9 and 2.10 provide satellite maps showing the Ogden Dunes monitor (ID# 18-127-0024). The monitor is located at Water Treatment Plant, 84 Diana Rd, Ogden Dunes, along the Lake Michigan lakeshore. The monitor was established November 11, 1983, and is designated as a SLAMs monitor at an urban scale to determine highest concentrations. The monitor location is indicated by the red marker.

Figure 2.9 – Overview of Ogden Dunes Ozone Monitor Location

Figure 2.10 – Map of Ogden Dunes Ozone Monitor

Figures 2.11 and 2.12 provide satellite maps showing the Gary-IITRI ozone monitor (ID# 18-089-0022) which is located at IITRI Bunker, 201 Mississippi St, Gary, south of the U.S Gary Steel facility along the Lake Michigan lakeshore. The monitor was established July 1, 1995, and is designated as a SLAMs monitor at a neighborhood scale to determine population exposure. The monitor location is indicated by the red marker.

Figure 2.11 – Overview of Gary-IITRI Ozone Monitor Location

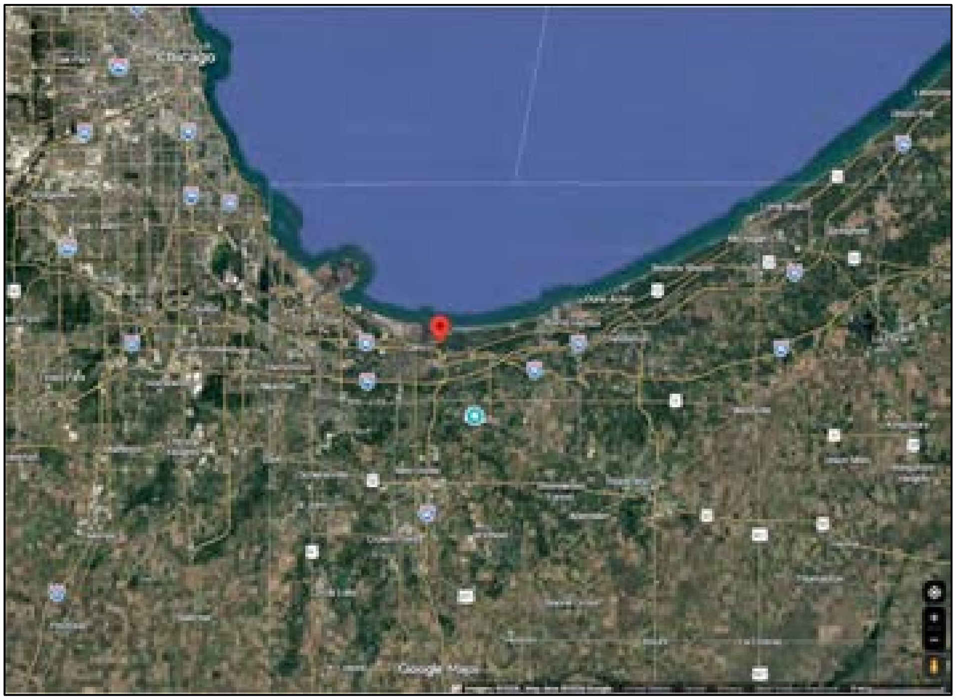


Figure 2.12 – Map of Gary-IITRI Ozone Monitor

Figures 2.13 and 2.14 provide satellite maps showing the Hammond – 141st St ozone monitor (ID# 18-089-2008). This monitor is located at 1200 East 141st St in Hammond. The monitor was established January 1, 1976, and is designated as a SLAMs monitor at a neighborhood scale to determine population exposure. The monitor location is indicated by the red marker.

Figure 2.13 – Overview of Hammond 141st St. Ozone Monitor Location

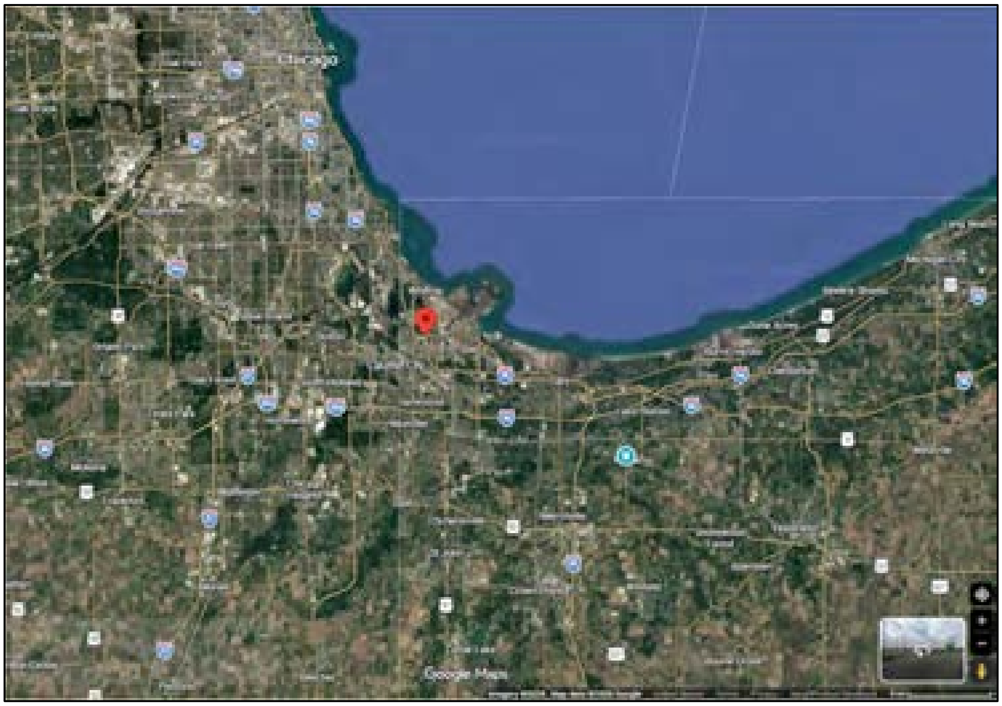


Figure 2.14 – Map of Hammond 141st St. Ozone Monitor

Three of the four monitors in Lake and Porter counties in northwest Indiana exceeded the 8-hour ozone design value three-year average 4th high concentration for 2023-2025. The majority of the 8-hour daily exceedances occurred in 2023 and 2025, due to smoke impacts. Table 2.1 shows the four Lake and Porter County monitors, the annual 4th high values for 2023, 2024 and 2025 and the current 2023-2025 8-hour design values.

Table 2.1 - 2023-2025 8-hour Ozone Design Values

Monitor	2023 Fourth Highest MDA8 Ozone Value (ppb)	2024 Fourth Highest MDA8 Ozone Value (ppb)	2025 Fourth Highest MDA8 Ozone Value (ppb)	2023-2025 8-Hour Ozone Design Value (ppb)
Gary-IITRI	76	69	68	71
Hammond	75	67	76	72
Ogden Dunes	77	70	74	73
Valparaiso	72	65	70	69

Tables 2.2 through 2.4 show the highest ranked 8-hour ozone concentrations for each of the three violating monitors for 2023 and 2025. Days are denoted that were requested by Indiana as exceptional event days in 2023 as well as the days the U.S. EPA concurred with for the requested $PM_{2.5}$ EE day. It should be noted that the controlling monitor for 2022-2024 annual $PM_{2.5}$ designations in Lake County was the Madison Street $PM_{2.5}$ monitor, which has a 1 – 3 day sampling frequency. Therefore, only the monitored days within any smoke event were evaluated and concurred by U.S. EPA. Indiana submitted all days within smoke events during 2023 for U.S. EPA review. As U.S. EPA's final concurrence with selected days was based on regulatory significance, it is assumed that any requested smoke days associated with smoke events, with one or more concurred days within that event, would be concurred as well. Indiana acknowledges the fact that U.S. EPA's deferring concurrence determinations was based on the lack of regulatory significance on annual $PM_{2.5}$ concentrations at the time of their review.

Table 2.2 - Gary-IITRI Ranked 8-hour Ozone Concentrations for 2023 and 2025

Annual Rank	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)
1st	4/14/2023	80	7/14/2025	80
2nd	7/25/2023**	78	6/16/2025	73
3rd	6/18/2023**	77	7/2/2025	73
4th	6/10/2023**	76	6/11/2025	68
5th	6/21/2023**	76	6/12/2025	67
6th	5/30/2023**	75	9/18/2025	67
7th	8/3/2023**	75	9/19/2025	67
8th	6/2/2023**	74	8/5/2025	66
9th	6/19/2023**	74		
10th	7/4/2023*	73		
11th	5/11/2023*	72		
12th	5/23/2023	72		
13th	7/23/2023**	71		
14th	6/3/2023**	70		

* Denotes Requested $PM_{2.5}$ Exceptional Events Day or Smoke Event

** Denotes U.S. EPA concurrence on $PM_{2.5}$ Exceptional Events Day

Table 2.3 - Hammond Ranked 8-hour Ozone Concentrations for 2023 and 2025

Annual Rank	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)
1st	8/3/2023**	81	7/14/2025	87
2nd	7/25/2023**	78	6/11/2025	77
3rd	6/18/2023**	77	6/16/2025	76
4th	6/28/2023**	75	8/6/2025	76
5th	7/4/2023*	73	9/19/2025	73
6th	5/23/2023*	72	7/29/2025	72
7th	7/23/2023**	71	7/2/2025	70
8th	6/24/2023**	70	8/5/2025	70

* Denotes Requested $PM_{2.5}$ Exceptional Events Day or Smoke Event

** Denotes U.S. EPA concurrence on $PM_{2.5}$ Exceptional Events Day

Table 2.4 - Ogden Dunes Ranked 8-hour Ozone Concentrations for 2023 and 2025

Annual Rank	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)
1st	7/4/2023*	81	7/14/2025	81
2nd	8/3/2023**	81	6/12/2025	76
3rd	6/21/2023**	78	7/2/2025	75
4th	6/2/2023**	77	8/6/2025	74
5th	6/10/2023**	77	6/16/2025	73
6th	6/19/2023**	76	8/5/2025	70
7th	7/25/2023**	76	6/11/2025	69
8th	4/14/2023	75	6/16/2025	67
9th	6/18/2023**	75		
10th	7/23/2023**	75		
11th	5/30/2023**	74		
12th	5/23/2023	73		
13th	8/20/2023*	73		
14th	6/3/2023*	71		
15th	6/23/2023**	71		

* Denotes Requested $PM_{2.5}$ Exceptional Events Day or Smoke Event
** Denotes U.S. EPA concurrence on $PM_{2.5}$ Exceptional Events Day

To determine the regulatory significance of making the exceptional events request, the requested days were removed from the 2023 through 2025 daily ozone monitoring data, using U.S. EPA's Exceptional Events Analysis and Visualization Tools[3] to determine the revised design value at each of the three monitors. Table 2.5 shows the updated 2023 4th high values for 2023 and 2025 and the 2023-2025 design values at each monitor with the requested smoke-impacted days excluded.

[3] https://www.epa.gov/air-quality-analysis/exceptional-events-analysis-and-visualization-tools

Table 2.5 - 8-hour Ozone Design Values Removing the Minimum Wildfire Smoke Influenced Days

Monitor	2023 Fourth Highest MDA8 Ozone Value (ppb)	2024 Fourth Highest MDA8 Ozone Value (ppb)	2025 Fourth Highest MDA8 Ozone Value (ppb)	2023-2025 8-Hour Ozone Design Value (ppb)
Gary-IITRI	73	69	67	70
Hammond	71	67	72	70
Ogden Dunes	73	70	67	70

Section 2.4 Additional Information

Please see Appendix A for meteorological analyses of the ozone events, Appendix B for descriptions of the Canadian wildfires, and Appendix C for matching day analyses.

3.0 Clear Causal Relationship between Event and Monitored Data

3.1 Summary of Spatial/Temporal Ozone Patterns

A summary of maximum daily 8-hour ozone values from 2021-2025 are compared for each of the Lake and Porter County ozone monitors. Ozone is most prevalent during the spring, summer and early fall. The values are compared to the NAAQS of 70 ppb and the 99th percentile for all five years of data. As is evident in Figures 3.1 through 3.3 for the Ogden Dunes, Hammond and Gary IITRI monitors, the requested ozone values to be excluded due to wildfire smoke are above the NAAQS and in most cases are near or exceed the 99th percentile of highest ozone values during the 5-year period. Research on the ozone data for the years 2021, 2022, and 2024 indicates the vast majority of the highest ozone values correspond to wildfire smoke as well.

Figure 3.1 – Timeseries of the Daily Maximum 8-hour Average Ozone Concentrations – Ogden Dunes

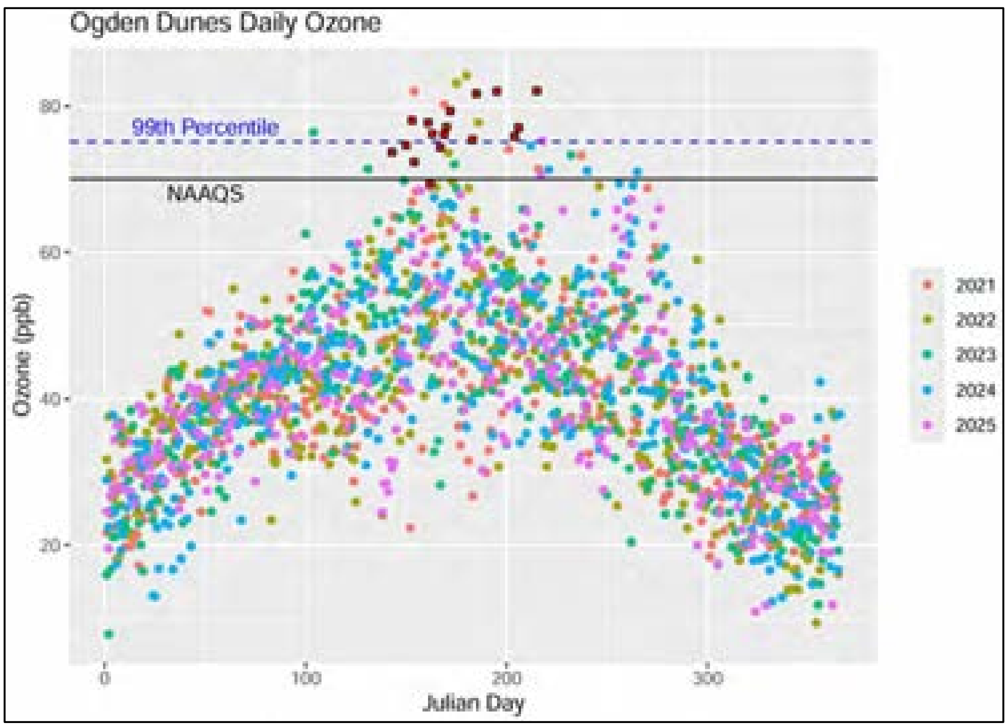


Figure 3.2 – Timeseries of the Daily Maximum 8-hour Average Ozone Concentrations - Gary IITRI

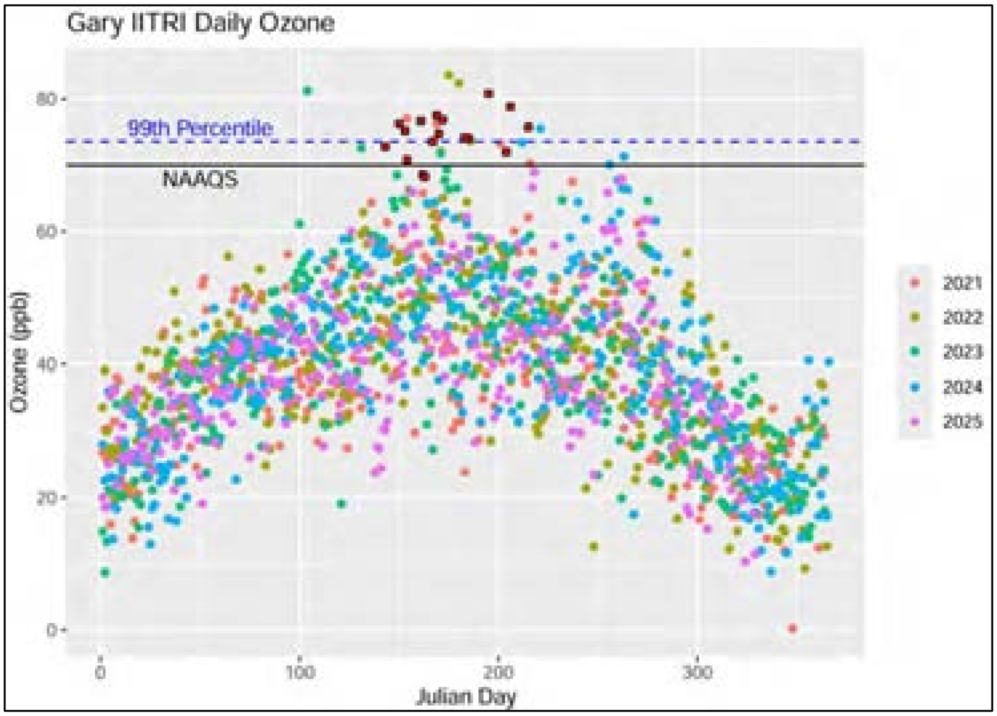


Figure 3.3 – Timeseries of the Daily Maximum 8-hour Average Ozone Concentrations - Hammond

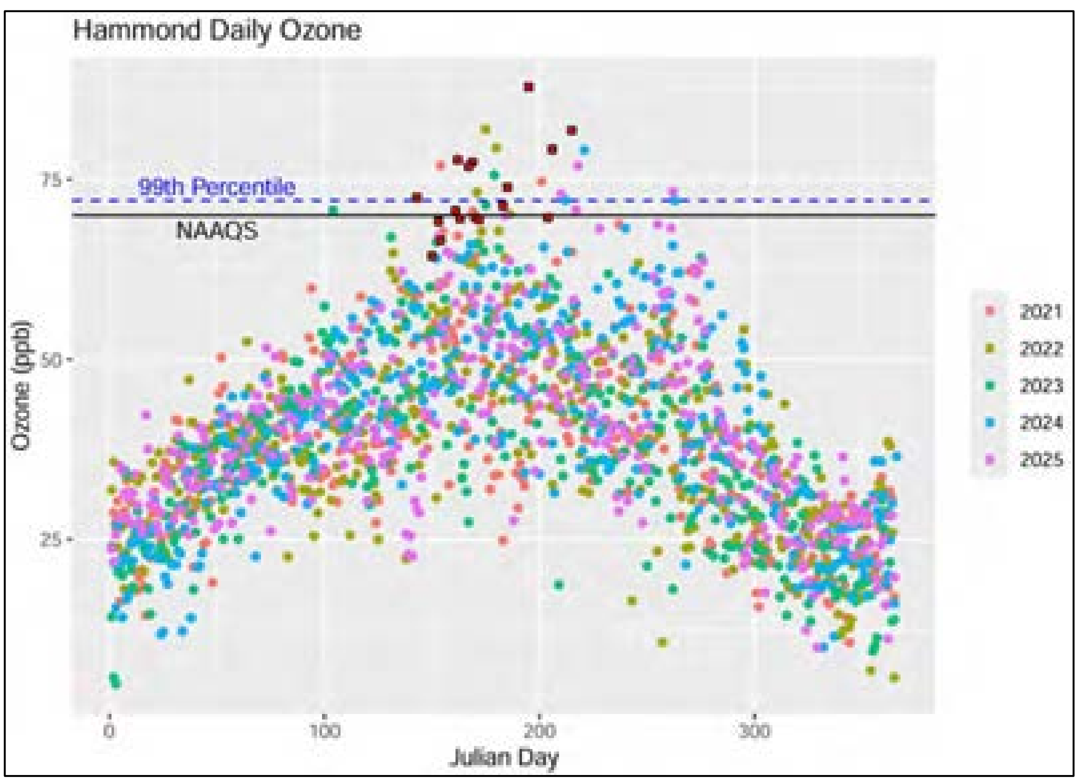
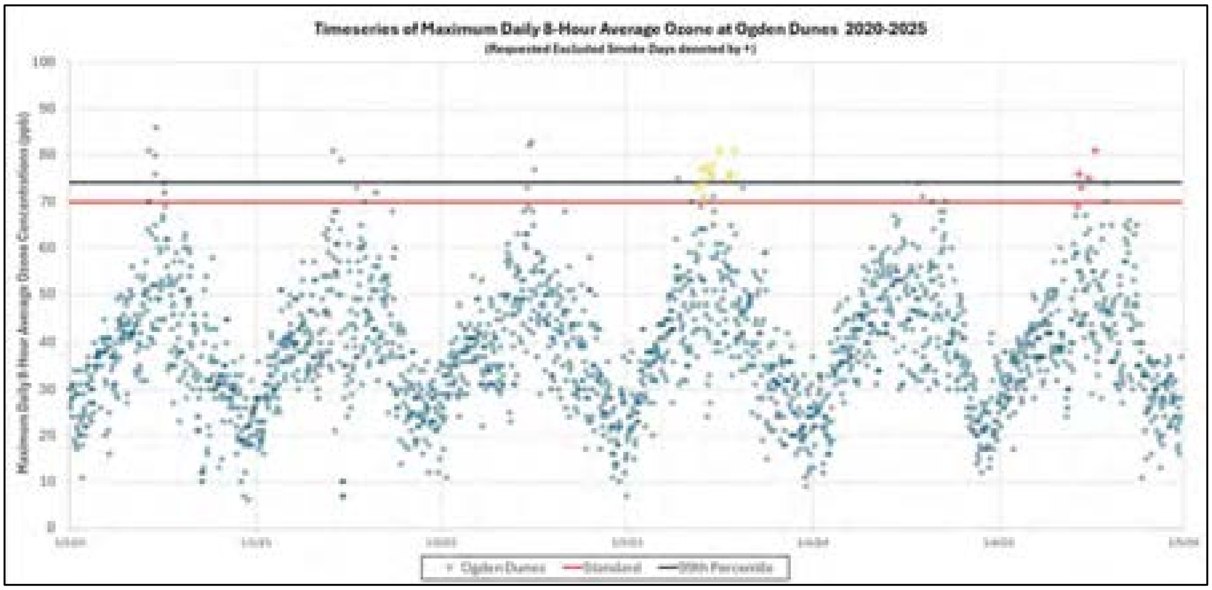


Figure 3.4 is a time series plot of the maximum daily 8-hour average ozone concentrations from 2020 – 2025 at the Ogden Dunes monitor. The plot shows high ozone values in 2023 and 2025 impacted by smoke and are requested as exceptional events. Hammond and Gary IITRI monitors show similar trends with the highest maximum daily 8-hour averages occurring on days when wildfire smoke impacts are present.

Figure 3.4 Timeseries of Maximum Daily 8-Hour Ozone – Ogden Dunes



3.2 Analysis Description for Clear Causal Evidence

IDEM used the following items to prove clear causal relation between wildfire smoke and increased ozone concentrations on the requested days for exclusion:

- **Meteorological Overview**
  - This data includes IDEM's summary for the days on and around the days requested for exclusion, surface, 500mb and 850 mb maps, wind rose and pollution rose graphs and hourly wind direction.
- **Ozone Diurnal Patterns**
  - Requested excluded days hourly ozone concentrations are graphically compared to the mean 2021-2025 ozone season concentration and to the 95th percentile concentration.
- **Comparison with other pollutants**
  - IDEM compared the ozone concentration with the nearest monitors for $PM_{2.5}$. Nitrogen Dioxide (NO_2), Black Carbon (BC) and Carbon monoxide (CO) were compared to the five-year average daily concentration. These pollutants are all primary pollutants released during biomass combustion. CO was approximately 118% to 126% higher than average when affected

by wildfire smoke.[4] NO_2 readings were increased but not as noticeable or consistent[5]. Black carbon was approximately double normal concentrations.[6]

- **MODIS AOD Satellite Imagery**
  - Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions.
- **NOAA GOES Satellite Imagery**
  - Including NOAA text narrative of satellite imagery.
- **TEMPO NO_2 Analysis for 2025**
  - The Tropospheric Emissions: Monitoring of Pollutants (TEMPO) mission is part of a constellation of instruments measuring air quality over the Northern Hemisphere. Its measurements from geostationary orbit of ozone, aerosols, and clouds will create a revolutionary dataset that provides understanding and improves prediction of air quality and physical effects on climate. TEMPO sensors use NO_2 as one indicator to identify and track wildfire plumes.
- **TROPOMI Daily Satellite Monitoring of Formaldehyde**
  - TROPOspheric Monitoring Instrument (TROPOMI) Daily Satellite Monitoring aboard the Sentinel-5P satellite involves five main steps:

    1. Global daylight coverage
       Sentinel-5P is in a Sun-synchronous orbit that crosses every point on Earth at roughly the same local time each day (about 13:30 LT). As the spacecraft orbits, TROPOMI scans a wide swath (~2600 km), capturing nearly global coverage daily.
    2. Measurement of reflected sunlight
       It measures sunlight reflected from Earth and its atmosphere across specific ultraviolet, visible, near-infrared, and shortwave-infrared wavelengths.
       Different trace gases absorb different parts of this spectrum.

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[4] New Study Analyzes Air Quality Impacts of Wildfire Smoke - DRI

[5] Impact of Wildfire Smoke on PM2.5, CO, NO2, and SO2 Levels | Published in Scholarly Review Journal

[6] PowerPoint Presentation: Observations of Anomalously High Black Carbon Mass Absorption Coefficients in Fresh Smoke Plumes from Wildfires

3. Gas retrieval algorithms (Level-2)
   Software converts the raw radiances into gas concentrations (columns) for species like formaldehyde and NO_2.

4. Daily gridding and filtering (Level-3)
   Daily L3 products like TROPOMI-HCHO-L3 are created by taking all Level-2 measurements for that day, applying quality filters (e.g., removing clouds, low-quality retrievals), averaging them onto a regular grid (0.1° × 0.1° or similar) and producing a globally consistent map for the day. L3 files are easier to analyze because they are uniform and less noisy. Here are the typical HCHO thresholds to identify wildfire activity in TROPOMI HCHO Level-3 products. Background tropospheric HCHO columns over rural/clean regions are usually around:1–4 × 10^{15} molecules/cm² (low, mostly biogenic).Typical wildfire-associated enhancements: Moderate fire influence is 5–8 × 10^{15} molecules/cm², Strong wildfire signal is> 8 × 10^{15} molecules/cm² and Extreme fire influence is 1.2 × 10^{16} molecules/cm².[7]
5. Detection of changes and anomalies
   Scientists and analysts can use the daily record to monitor wildfires and biomass burning.

- **AIRNOW Ozone and $PM_{2.5}$ daily concentrations**
  - U.S. EPA's AirNow Air Quality and Fire and Smoke maps provide a variety of fire- and smoke-related information including air quality data from permanent and temporary monitors operated by air quality agencies as well as fire locations, smoke plume locations and smoke forecast outlooks.
- **GAM Modeling Analysis**
  - General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships[8]. In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable, modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories[9]. This study demonstrated the importance

[7] ACP - Source and variability of formaldehyde (HCHO) at northern high latitudes: an integrated satellite, aircraft, and model study

[8] Generalized Additive Models | An Introduction with R, Second Edition |

[9] Wildfire Impacts on O3 in the Continental United States Using PM2.5 and a Generalized Additive Model (2018–2023) | Environmental Science & Technology

of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and Ozone.

- **EMBER Modeling Analysis**
  - The Expedited Modeling of Burn Events Results (EMBER)[10] provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes. EMBER has not been updated for 2025.
- **Matching Day Analysis**
  - IDEM performed a matching day analysis, identifying days with similar meteorology and compares non-smoke event days/events on a day-by-day basis. Four meteorological parameters were chosen for the matching days analysis. A higher coefficient of determination (R^2) value indicates greater correlation between the meteorological parameter and the maximum daily 8-hour average (MDA8) ozone measurement.

    The parameters used to determine which days in the data set had similar conditions to the Exceptional Event day are:

    - Average Solar Radiation ($R^2 = 0.11$),
    - Minimum Relative Humidity ($R^2 = 0.17$)
    - Temperature Change ($R^2 = 0.21$)
    - Maximum Temperature ($R^2 = 0.23$).

    Using these parameters, matching days were calculated based on the following thresholds:

    - Solar Radiation (± 35 W/m^2)
    - Relative Humidity (± 10%)
    - Temperature Change (difference between daily minimum and maximum): (± 2^{O} F)
    - Temperature Maximum (± 2^{O} F)

    Once the days were identified with similar meteorological parameters within the thresholds above, the observed maximum daily 8-hour average ozone value on those days was compared with the observed ozone on the requested EE day.
- **Back Trajectory Analysis**
  - The impact of smoke on this $PM_{2.5}$ event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The back

[10] Expedited Modeling of Burn Events Results (EMBER) | US EPA

trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The 168-hour long-term trajectories use the Reanalysis data set.

- **HRRR Model**
  - To support the veracity and reliability of the smoke attribution in this Exceptional Events Analysis, NOAA's High-Resolution Rapid Refresh (HRRR) and Rapid Refresh (RAP) modeling systems were evaluated. The HRRR is a 3 km, hourly updated, cloud-resolving model that incorporates 3 km radar assimilation every 15 minutes. This provides higher-resolution detail relative to the 13 km RAP system, which supplies the continental-scale, hourly updated analysis and model fields used to initialize HRRR.
  - Archived HRRR and RAP vertically integrated and near-surface smoke forecast maps for early 2023 were reviewed. While the earliest maps are not fully conclusive, the majority indicate smoke influencing the analysis area during the relevant period. These maps will be included within the demonstration to provide additional weight-of-evidence for the event characterization.

3.3 Daily Ozone Events

Each piece of evidence demonstrates a clear causal link between transported wildfire smoke and elevated ozone levels in Lake and Porter counties. The following section applies the same evidence-based framework to each specific exceedance event. Each ozone event examines how these analytical methods, meteorological analysis, pollutant comparisons, satellite observations, statistical modeling, and trajectory assessments, collectively support the identification of each ozone exceedance as an exceptional event influenced by Canadian wildfire smoke.

3.3.1 May 23, 2023 Ozone Event Executive Summary

On May 23, 2023, Northwest Indiana experienced ozone exceedances across all Lake and Porter County monitors, with values ranging from 72–73 ppb, surpassing the 70 ppb NAAQS, as shown in Table 3.3.1. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian Wildfire regions are visible.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 5–10 ppb of ozone attributable to wildfire smoke.

- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to the Shaw Fire, the Paskwa Fire and Long Lake Fire.

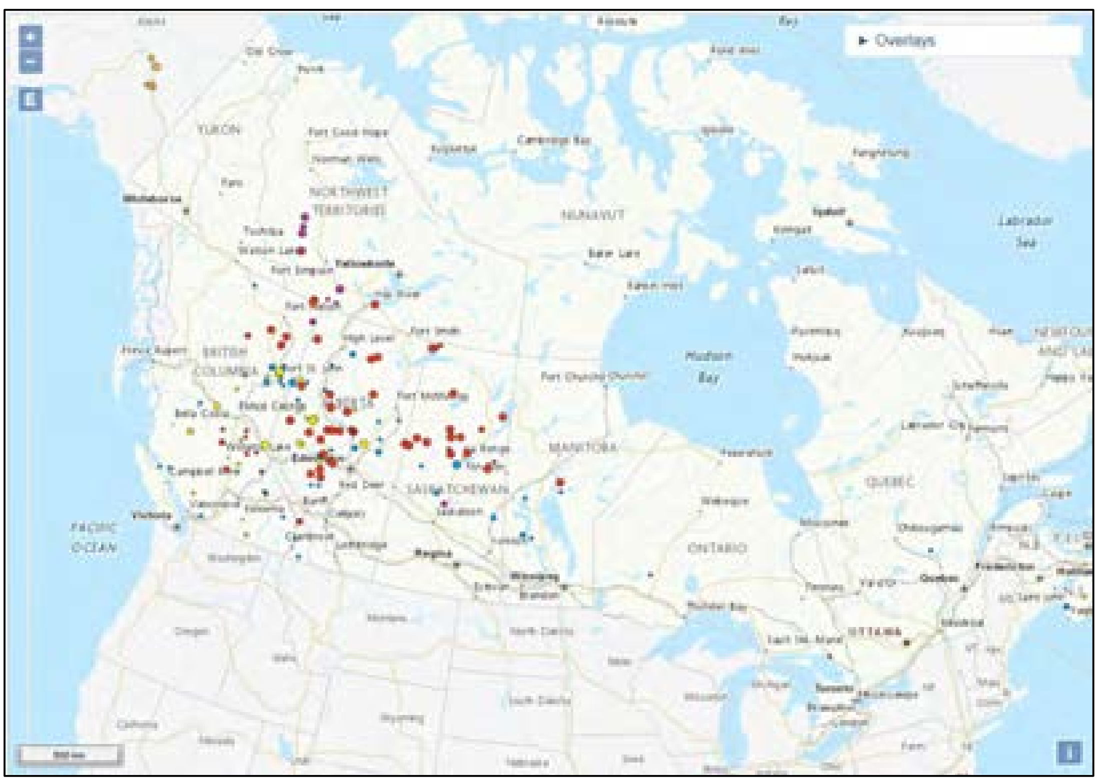
This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of May 23, 2023, as an exceptional event under U.S. EPA guidelines.

Table 3.3.1 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

Date	Gary-IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
5/23/2023	72	72	73	72

On May 23, 2023, multiple Canadian wildfires, as shown in Figure 3.3.1, contributed ground level smoke that caused all four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS.

Figure 3.3.1 – Canadian Wildfires May 23, 2023



Source: https://cwfis.cfs.nrcan.gc.ca/interactive-map?zoom=0.8&center=400000%2C1000000&month=5&day=23&year=2023#iMap

Major contributors to the smoke plumes that reached Lake and Porter counties in late May 2023 included the:

- Long Lake Fire, the largest fire in Alberta at the time, burning over 260,000 acres;
- Paskwa Fire, burning over 87,000 acres near Fox Lake generating massive smoke columns;
- Shaw Fire, the largest fire in Saskatchewan in 2023; the wildfire peaked at over 186,000 hectares. It forced the partial evacuation of Buffalo Narrows and threatened communities including Île-à-la-Crosse and Patuanak.

3.3.2 Meteorological Episode Overview

For the May 22-23, 2023 period, there was upper-level ridging over the northern Plains while a general trough pattern was setting up over southeast Canada. This set-up ushered in wildfire smoke from western Canada that rode over the upper air ridge and was pulled southward as a gradient set up between the two upper air features. There was a surface high-pressure over southeast Canada that moved south bringing smoke down from the western Canadian wildfires on May 22 and 23. A cold front moved out of Canada southward out ahead of the high-pressure system. The resulting northerly and easterly winds enhanced the wildfire smoke impacts on the area from the smoke-filled Canadian air. On May 23, anti-cyclonic flow around a surface high pressure continued to bring the wildfire smoke from the north as the high remained entrenched over the Midwest. Figure 3.3.2 (May 22) and Figure 3.3.3 (May 23) show surface, 850 mb and 500 mb weather maps, depicting surface and upper air features that enhanced smoke transport into the northwest Indiana area.

Figure 3.3.2 - Surface (top), 850 (bottom left) and 500 mb (bottom right) Plots from 12Z on May 22, 2023

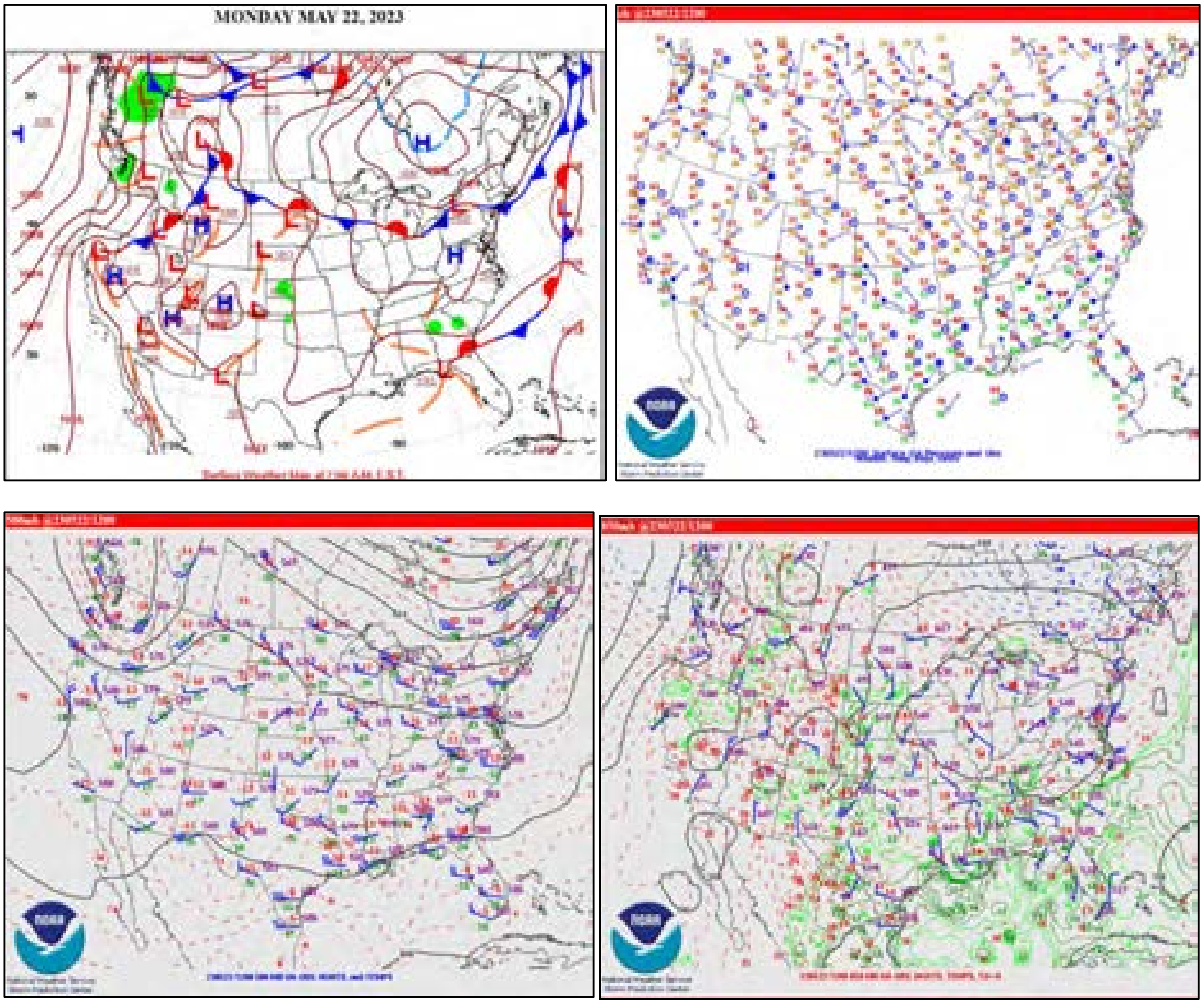
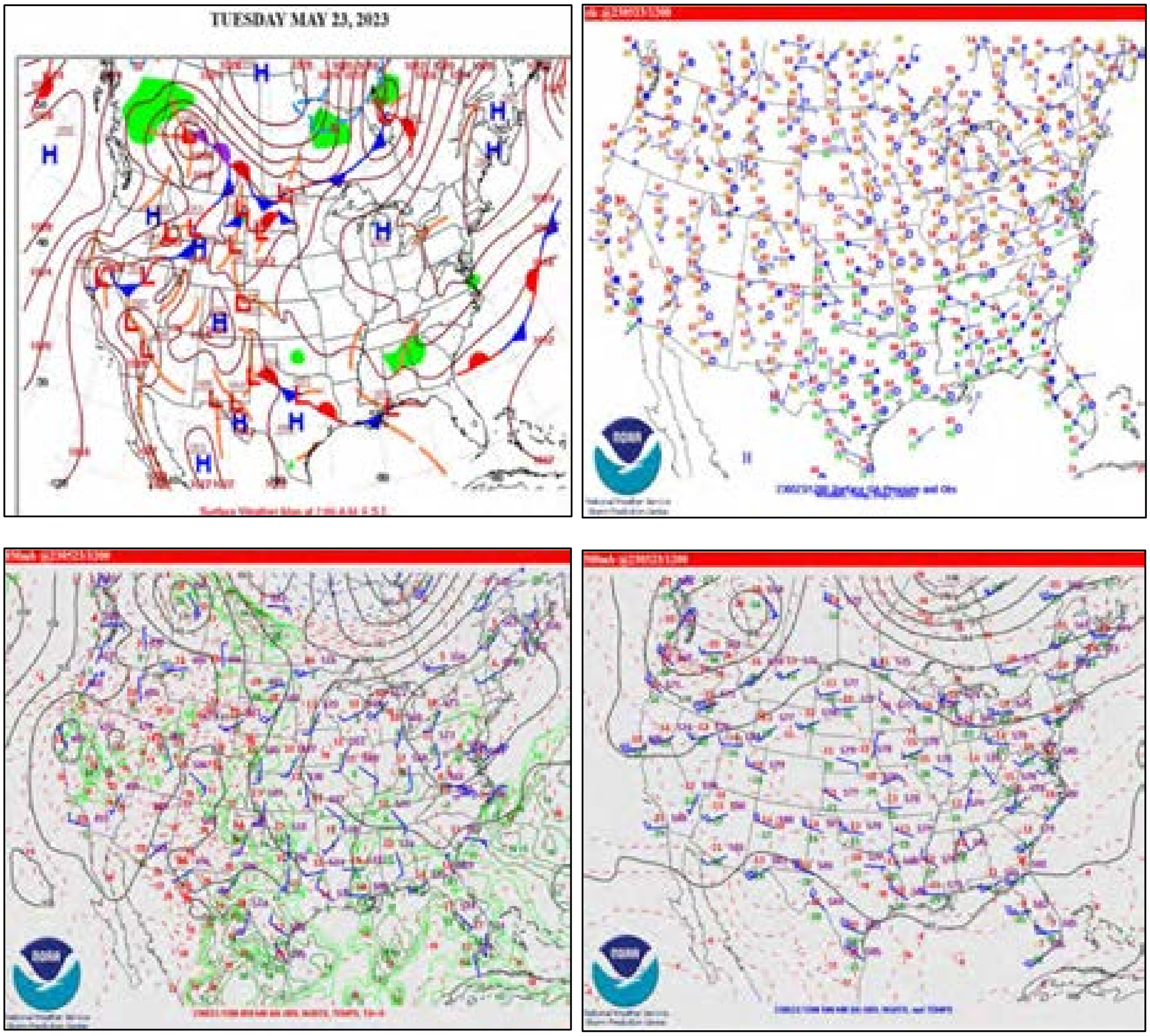


Figure 3.3.3 – Surface (top), 850 (bottom left) and 500 mb (bottom right) Plots from 12Z on May 23, 2023



Wind rose (Figure 3.3.4) and pollution rose (Figure 3.3.5) analyses were taken from the Gary IITRI meteorological station. Wind directions for May 23 were predominantly from the north and northeast. The pollution rose for Ogden Dunes showed the higher ozone values from the north and northeast, indicating transport from western Canadian wildfires in the provinces of Alberta, Saskatchewan and Manitoba. While these areas are located north and west of Lake County, long range transport of the wildfire smoke occurred with impacts in the Midwest as anti-cyclonic flow around the surface high pressure pulled the wildfire smoke in northwest Indiana. The resulting north and northeast winds circulated the wildfire smoke impacts into Lake County, as shown in the backward trajectory analysis of this document.

Figure 3.3.4 – Gary IITRI Windrose

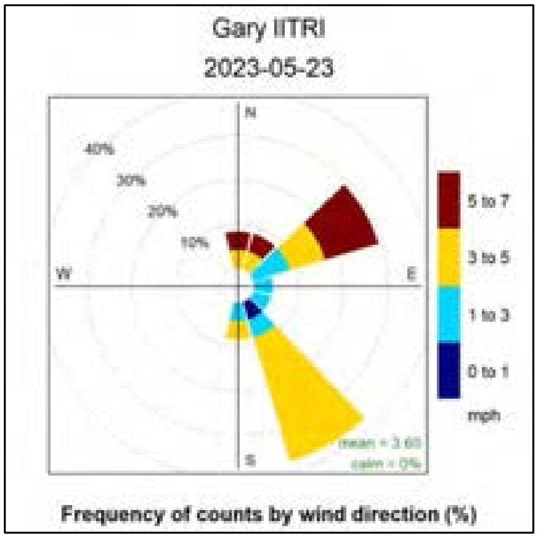


Figure 3.3.5 –Ogden Dunes Ozone Pollution Rose

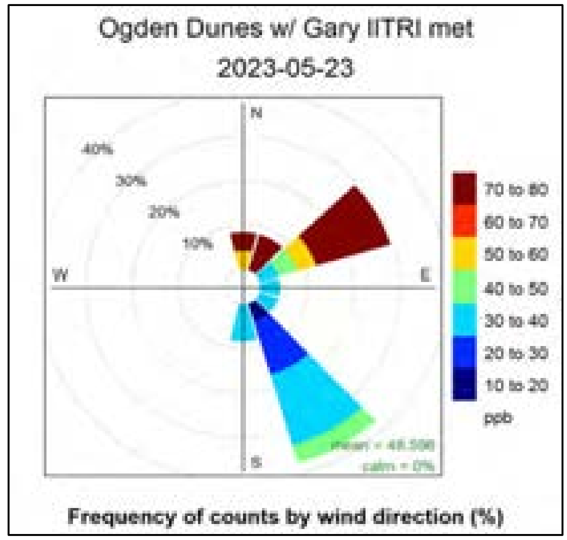


Figure 3.3.6 shows the timeseries of wind directions that indicate a turning of the winds to the northeast throughout May 23, that brought in additional Canadian wildfire smoke during the day.

Figure 3.3.6 - Hourly Wind Directions at Gary IITRI for May 23, 2023

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RWD	144	151	152	157	155	153	161	169	168	69	3	26	1	37	51	54	56	64	63	73	101	127	147	140

3.3.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for May 23, 2023 for Gary-IITRI (Figure 3.3.7), Hammond (Figure 3.3.8) and Ogden Dunes (Figure 3.3.9) were compared to the five–year ozone season mean (black line) and the 5^{th} - 95^{th} percentile of those readings. For most of the day, the hourly readings at all three ozone monitors exceeded the 95^{th} percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.3.7 - Ozone Diurnal Pattern for Gary IITRI – May 23, 2023

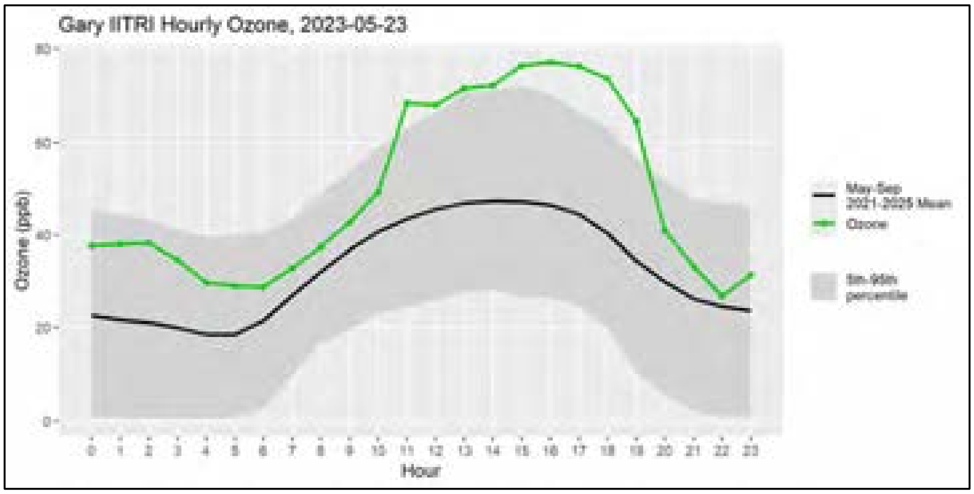


Figure 3.3.8 - Ozone Diurnal Pattern for Hammond – May 23, 2023

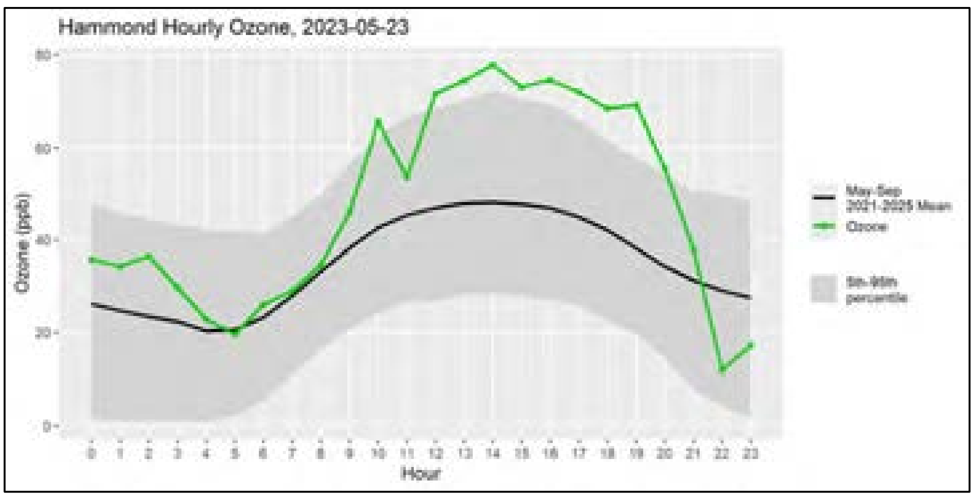
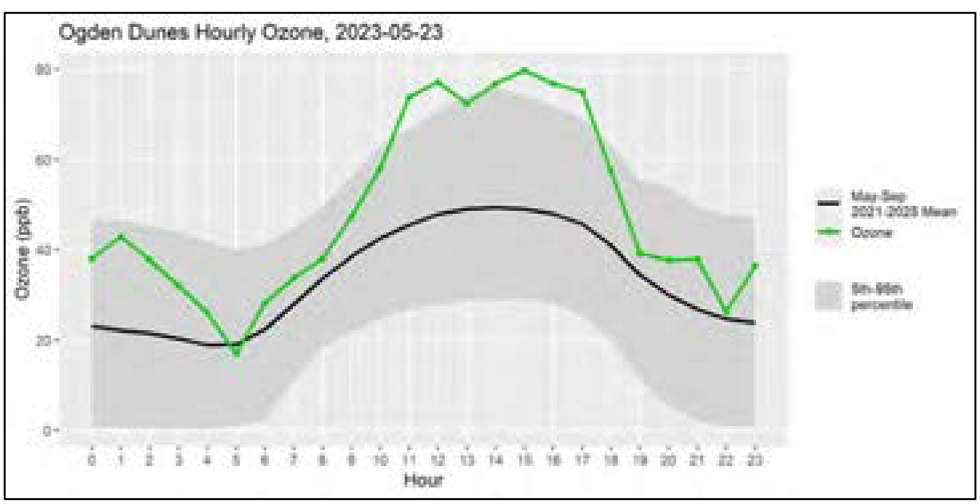
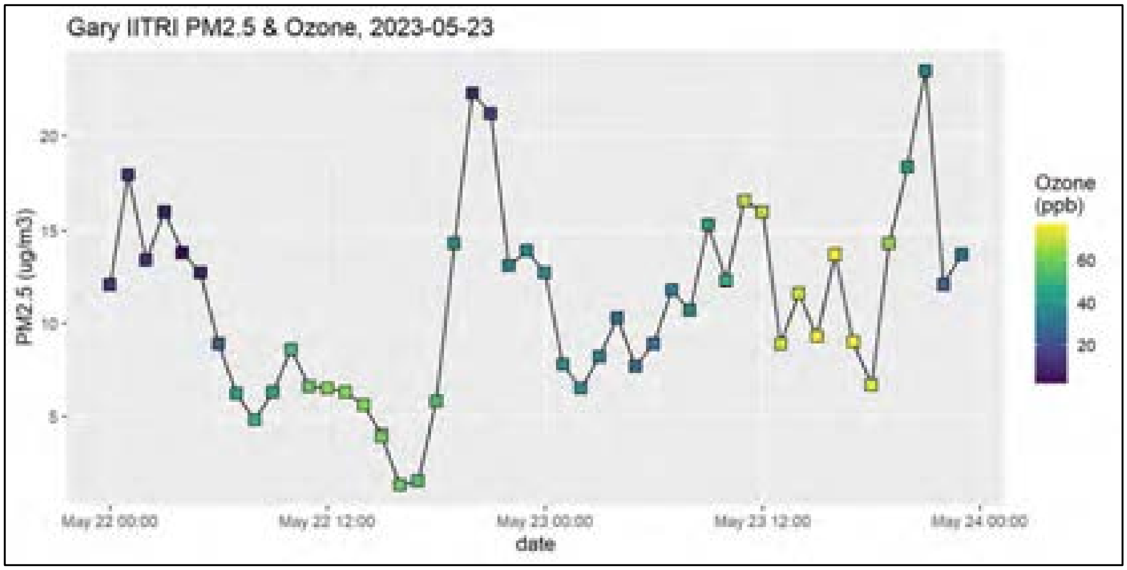


Figure 3.3.9 - Ozone Diurnal Pattern for Ogden Dunes – May 23, 2023



Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for May 22-23 as shown in Figure 3.3.10. $PM_{2.5}$ concentrations ranged from 7-25 ug/m^3 on May 23.

Figure 3.3.10 - Gary IITRI $PM_{2.5}$ and Ozone Hourly Data Comparison May 22-23, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon, indicating the presence of wildfire smoke.

Table 3.3.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-year Average	Percentage Black Carbon Above 5-Year Average
5/23/2023	165%	109%	142%

3.3.4 AOD and Satellite Analyses

Figure 3.3.11 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The plot to the left is an overview of the Midwest while the plot to the right is a closeup of northwest Indiana. The dark red color in northwest Indiana indicates the presence of moderate to heavy smoke. The northwest Indiana area is indicated by the white circle in each figure.

Figure 3.3.11- Aerosol Optical Depth (AOD) - May 23, 2023

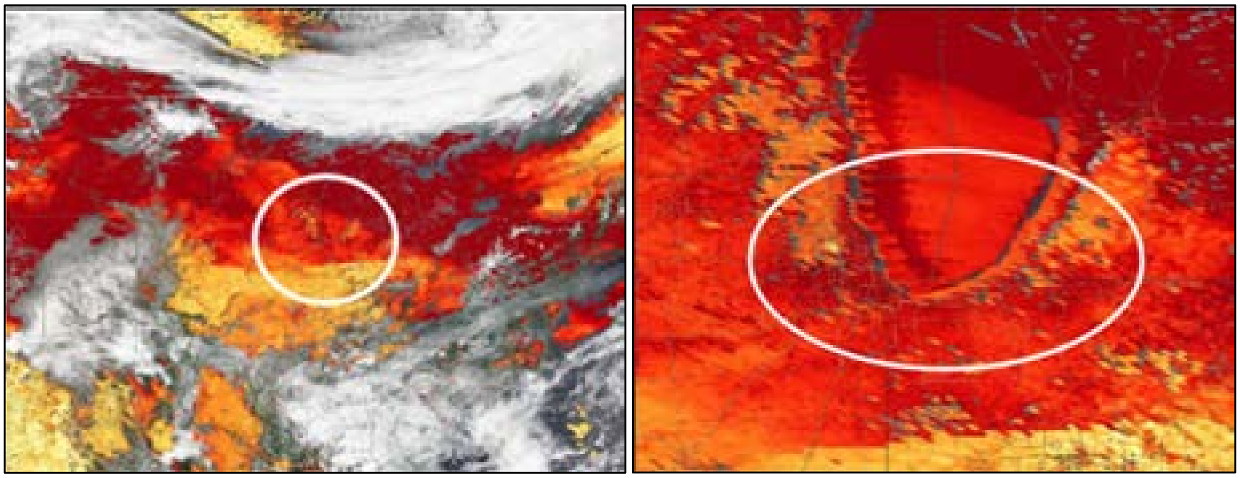


Figure 3.3.12 displays satellite images indicating Canadian wildfire smoke coming from Manitoba, Saskatchewan and Alberta on May 15, 2023. This shows the extent of the wildfires at that time which continued into the following week and impacted northwest Indiana on May 23.

Figure 3.3.12 - Satellite Imagery for Western Canadian Wildfire Smoke - May 15, 2023

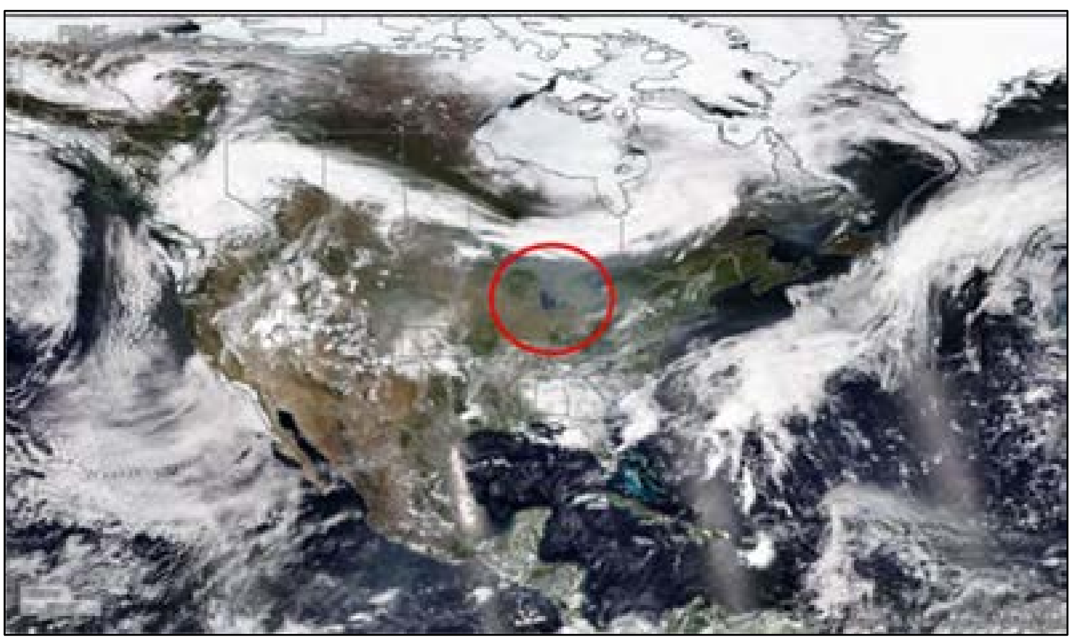
Figure 3.3.13 captured by NOAA's GOES 18 satellite image of North America taken May 21, 2023 shows clouds and a plume of gray smoke extending from western Canada to

the upper Midwest states, including Indiana. The northwest Indiana area is indicated by the red circle on the satellite image[11].

Figure 3.3.13 - Satellite Imagery of Northern Hemisphere Smoke - May 21, 2023

Figure 3.3.14 shows smoke working its way into northern Indiana on May 23. The northwest Indiana area is indicated by the red circle on the satellite image.

Figure 3.3.14 - Satellite Imagery of Upper Midwest on May 23, 2023



[11] NOAA NESDIS

3.3.5 NOAA Smoke Narrative

The National Oceanic and Atmospheric Administration (NOAA) Office of Satellite and Product Operation publishes a narrative of smoke observed in satellite imagery for the NOAA Satellite Smoke Narrative. Below is the narrative for May 23, 2023 and the observed smoke in North America. Detailed discussion concerning smoke in Indiana, the Great Lakes or Midwest regions are bolded and underlined.

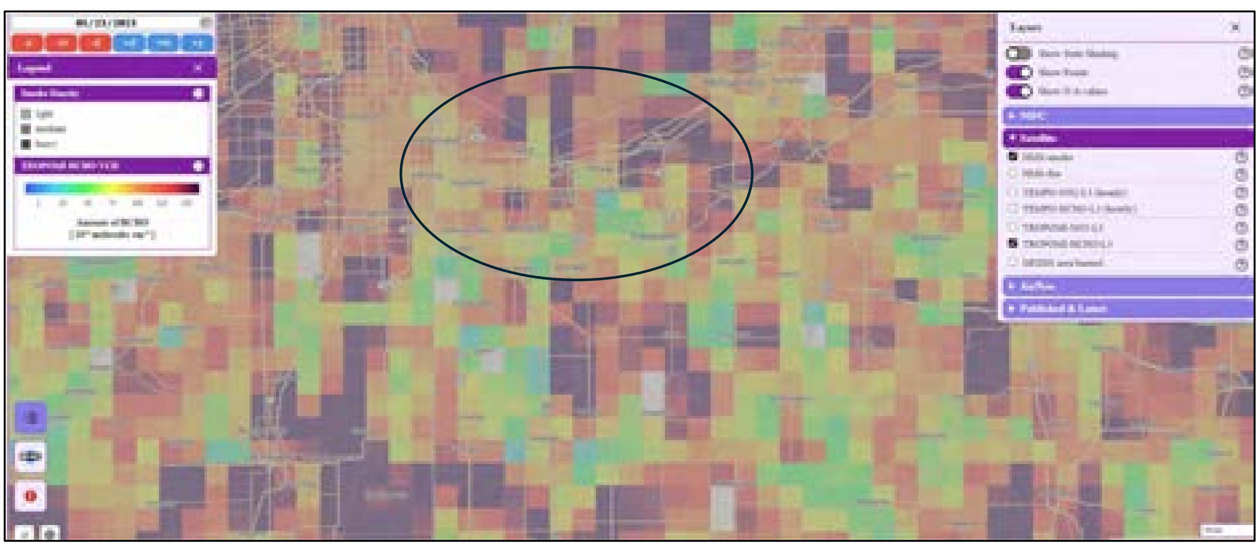
DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1720Z May 23,2023

SMOKE:
Canada/U.S./Atlantic...
A very large area of thin density smoke sourced from ongoing wildfires in western Canada was detected parts of British Columbia, Nunavut, and the Northwest Territories, and a large part of Alberta, Saskatchewan, Manitoba, Ontario, and Quebec. Within this area, moderate density smoke was detected over northern Alberta, central Saskatchewan, southern Manitoba, and parts of Ontario and Quebec. Thick density smoke may exist over parts of Alberta and Saskatchewan, but cloud cover prevented further analysis. **<u>In the U.S., a thin density plume covered just about all of the central and eastern part of the country and extended out over the western Atlantic to just south of Newfoundland. Within this thin density area, moderate density smoke was detected over the Northern Plains to the Great Lakes/Ohio Valley,</u>** across the Mid-Atlantic and parts of New England, and offshore into the western Atlantic to south of Newfoundland.

3.3.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.3.15 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 8-16 × 10^{15} molecules/cm^2 indicate strong to extreme wildfire smoke influence.

Figure 3.3.15- TROPOMI Satellite Daily Formaldehyde Monitoring



3.3.7 Smoke Maps and Ozone/$PM_{2.5}$ Map Analyses

In Figures 3.3.16 through 3.3.19, AirNow shows the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated both pollutant concentrations for both pollutants. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.3.16 - AirNow Ozone Isopleth Map - May 23. 2023

Figure 3.3.17 - AirNow Ozone Maps - May 23. 2023

Figure 3.3.18 – AirNow $PM_{2.5}$ Maps - May 23. 2023

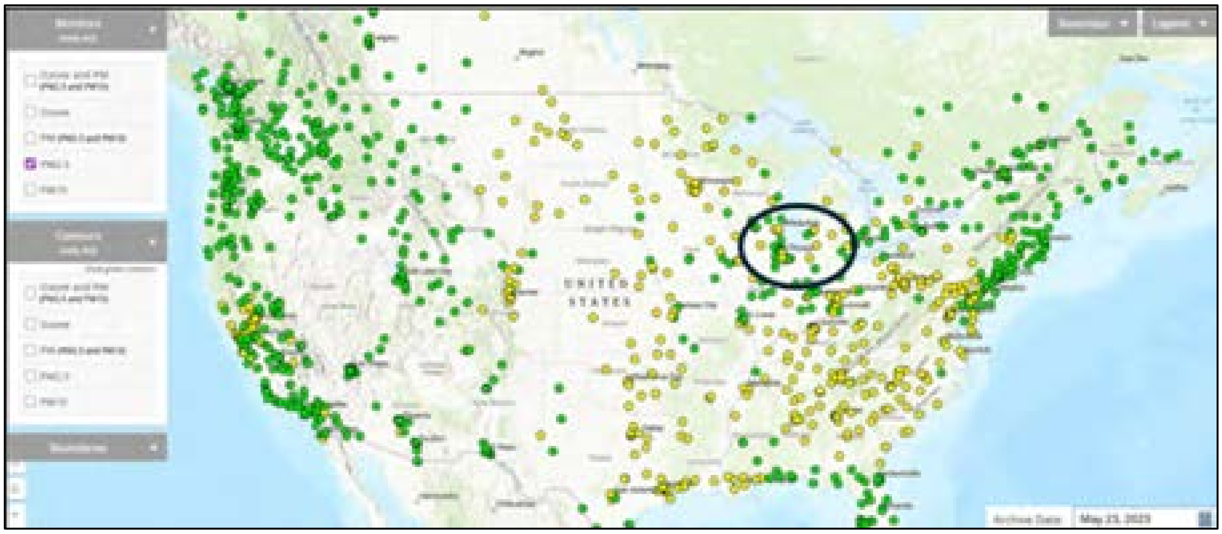
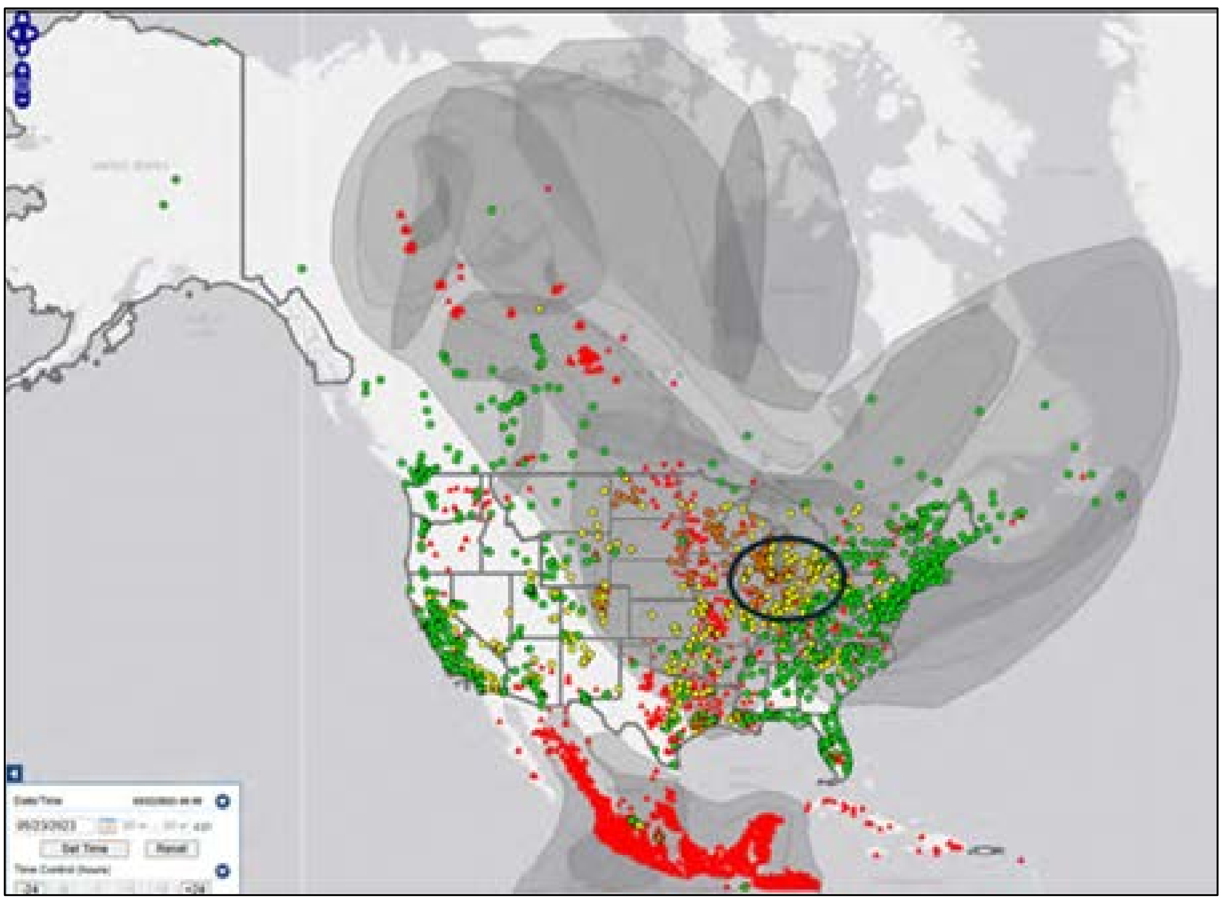


Figure 3.3.19 - AirNow Smoke and Ozone Maps - May 23. 2023



3.3.8 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable, modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes.

Figures 3.3.20 through 3.3.23 show indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the white circles in each of the maps.

Figure 3.3.20 - GAM Smoke Maps Indicating Smoke Days May 23, 2023

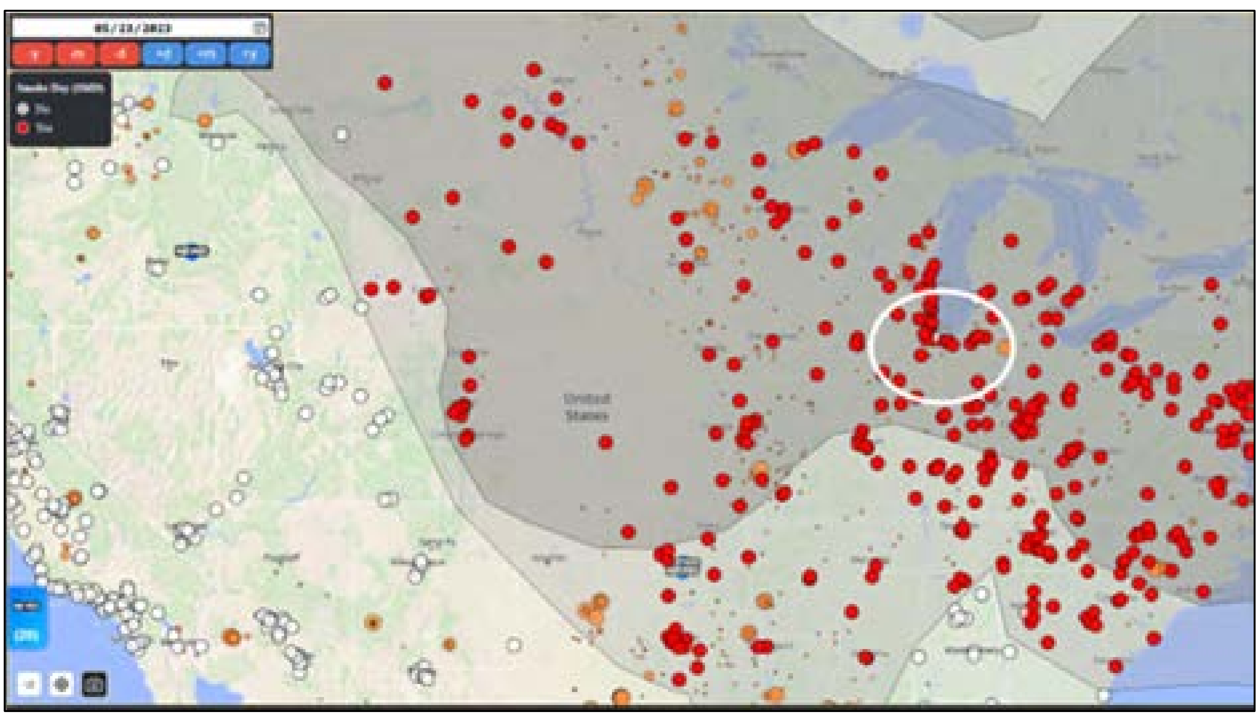


Figure 3.3.21 - GAM Observed ozone with Smoke days May 23, 2023

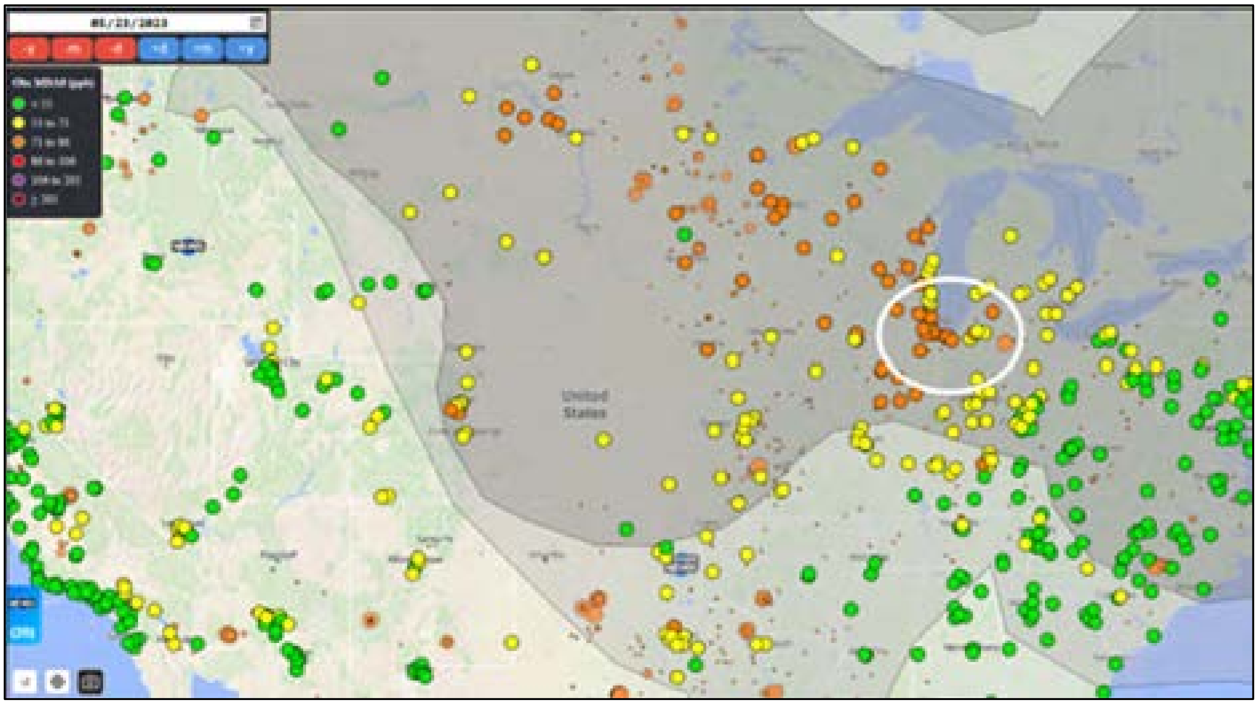


Figure 3.3.22 - GAM Smoke estimates May 23, 2023

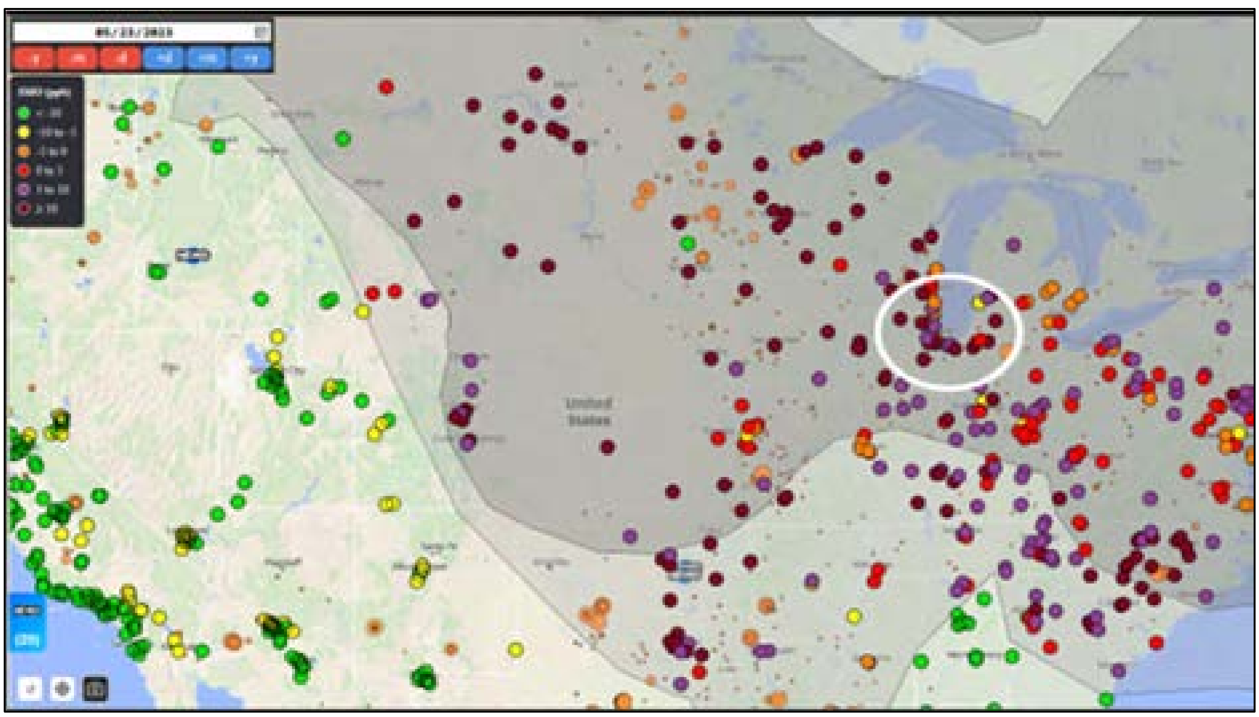


Figure 3.3.23 - EMBER Smoke estimates May 23, 2023

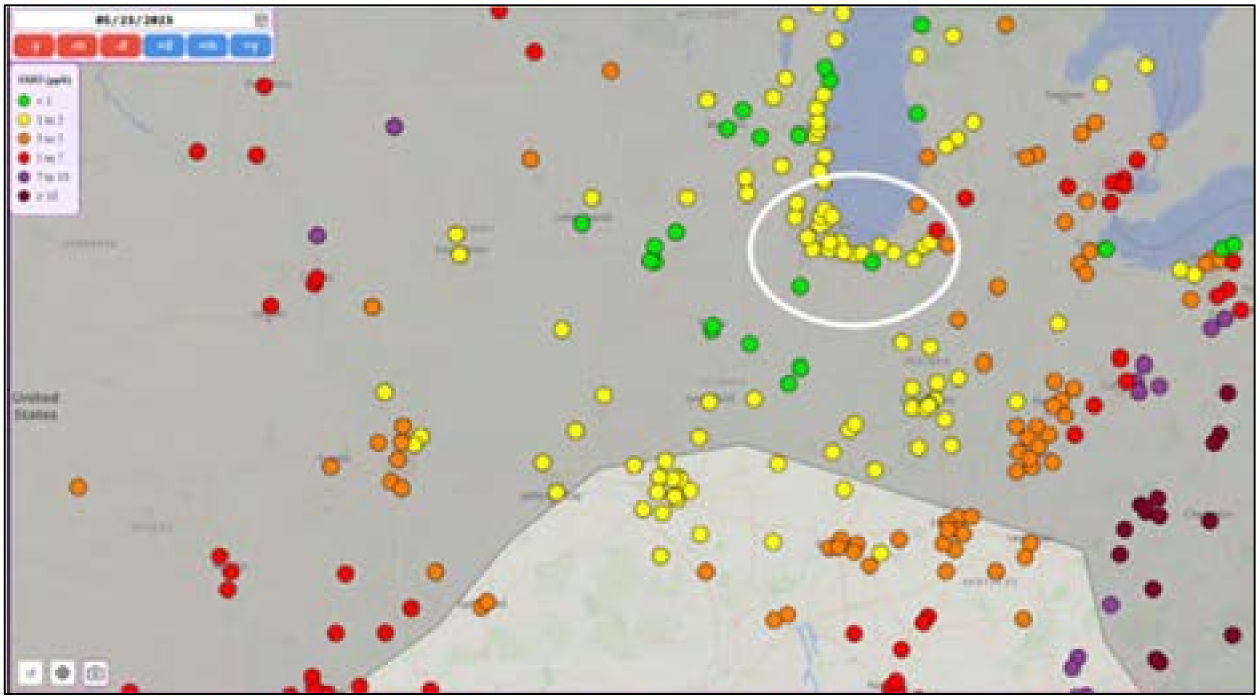


Table 3.3.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence. In general, both predictive models show smoke impacted ozone concentrations, from 0 to 6 ppb to as much as 10 ppb at the Lake and Porter County ozone monitors.

Table 3.3.3 - Observed versus GAM/EMBER predicted MDA 8-hour Ozone Values May 23, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	72	62.3	9.7	67	5
180892008	Hammond	72	NA	NA	68	4
181270024	Ogden Dunes	73	64.8	8.2	73	0
181270026	Valparaiso	72	61.4	10.6	66	6

3.3.9 Matching Day Analysis

IDEM performed a matching day analysis, identifying days with similar meteorology and compares non-smoke event days/events on a day-by-day basis. This analysis will determine what impact wildfire smoke had ozone concentrations on May 23, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.3.4 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 22 ppb lower than the MDA8 ozone concentrations was observed on May 23 with the maximum matching day MDA8 ozone concentration of 55 ppb.

Table 3.3.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values May 23, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	73	55	51.5

3.3.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT back trajectories and Hazard Mapping System (HMS) smoke layers. In Figure 3.3.24, the back trajectories have three starting heights, 50 meters (m) (green), 100 m (blue), and 500 m (red). Figure 3.3.25 has higher level trajectories at 1000 m (green), 2000 m (blue) and 3000 m (red) heights for May 22, 2023. In Figure 3.3.26, the back trajectories have three starting heights, 50 meters (m) (green), 100 m (blue), and 500 m (red). Figure 3.3.27 has higher level trajectories at 1000 m (green), 2000 m (blue) and 3000 m (red) heights for May 23, 2023. The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. The May 22 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure 3.3.27 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over the wildfires in Manitoba and Saskatchewan. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.3.24 – Back Trajectories - May 22 (50, 100 and 500 meters - 72 hours)

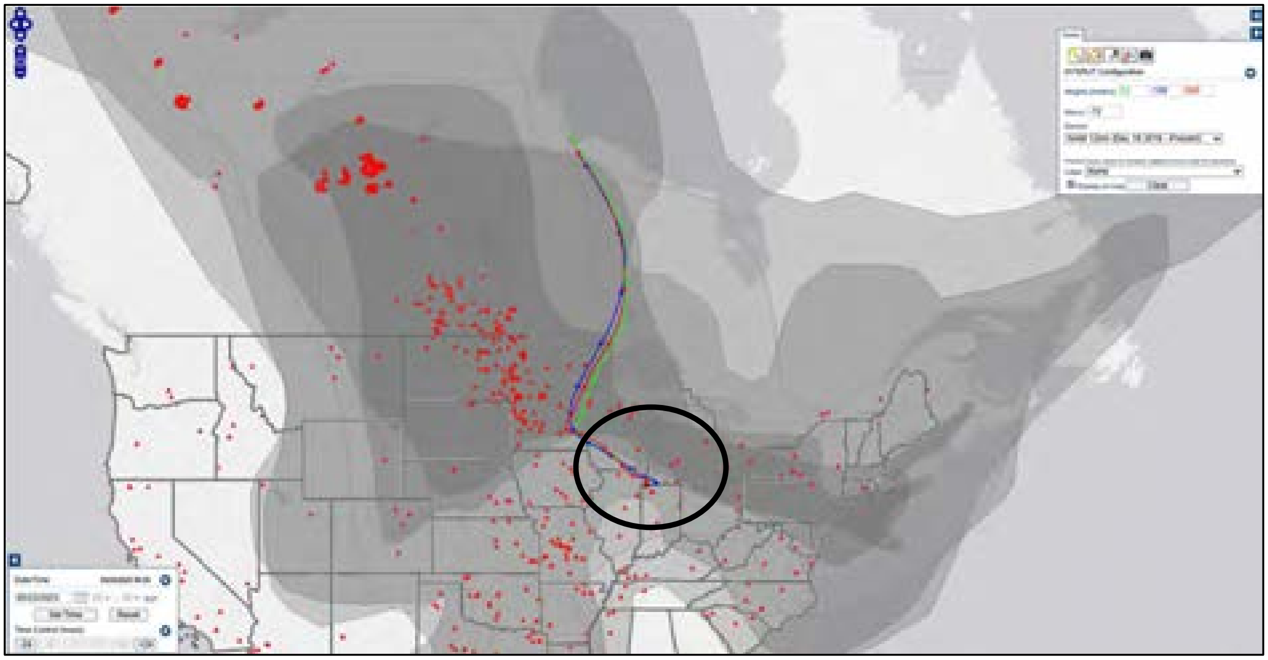


Figure 3.3.25 - Back Trajectories - May 22 (1000, 2000 and 3000 meters - 72 hours)

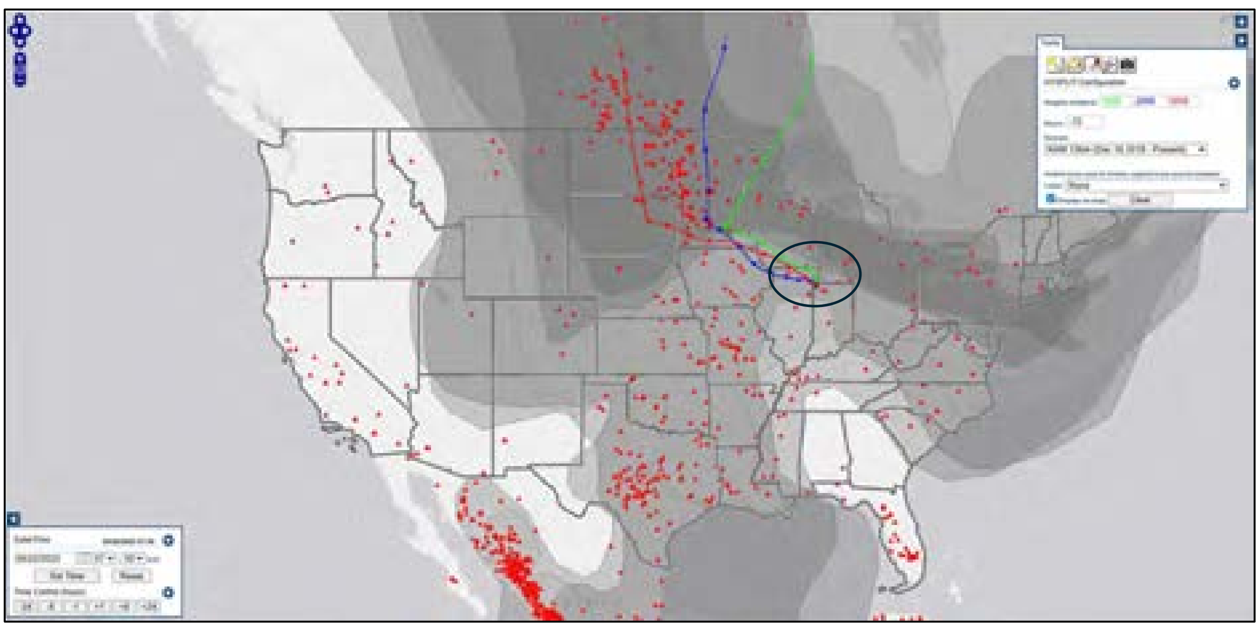


Figure 3.3.26 - Back Trajectories - May 23 (50, 100 and 500 meters - 72 hours)

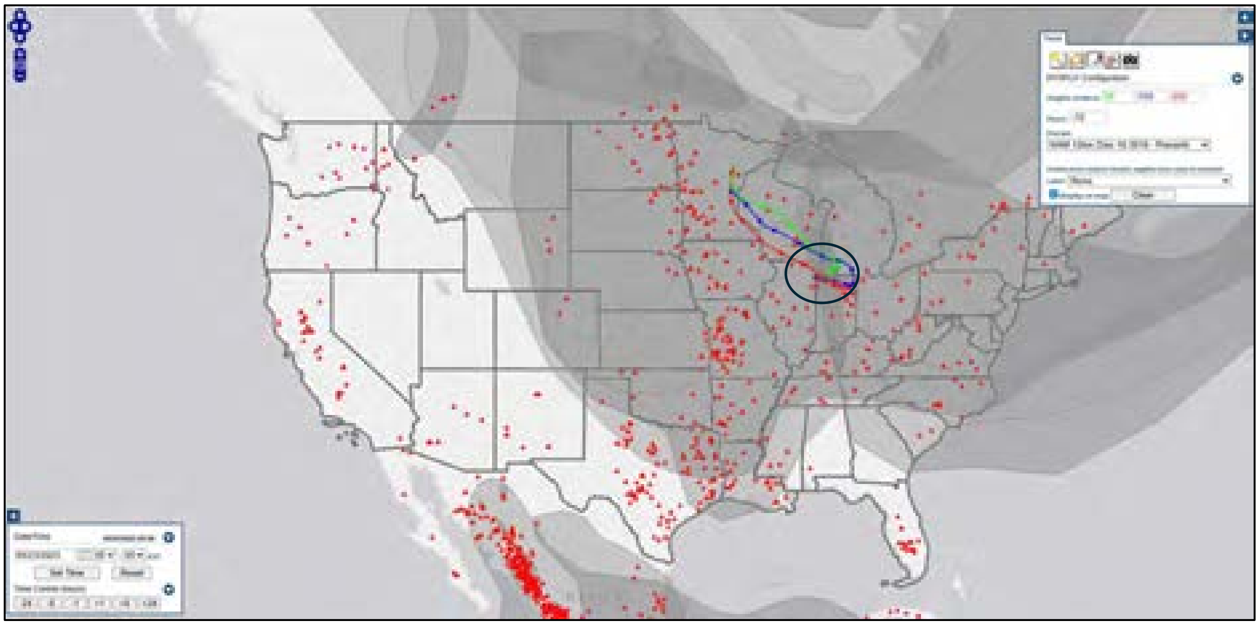


Figure 3.3.27- Back Trajectories - May 23 (1000, 2000 and 3000 meters - 72 hours)

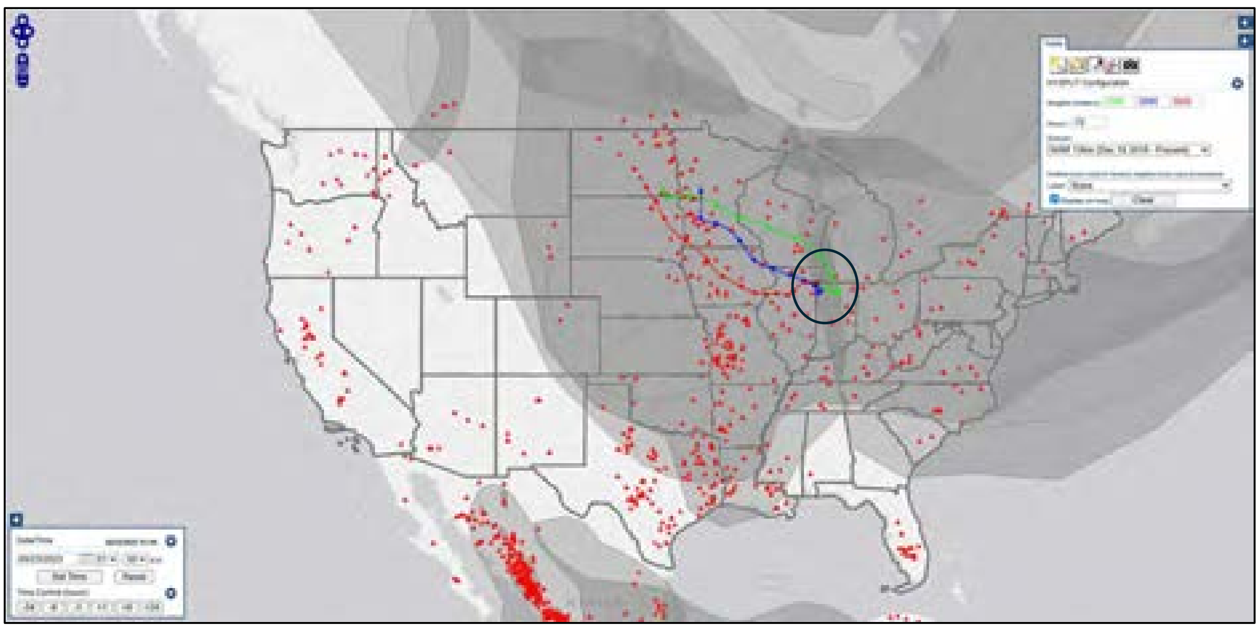
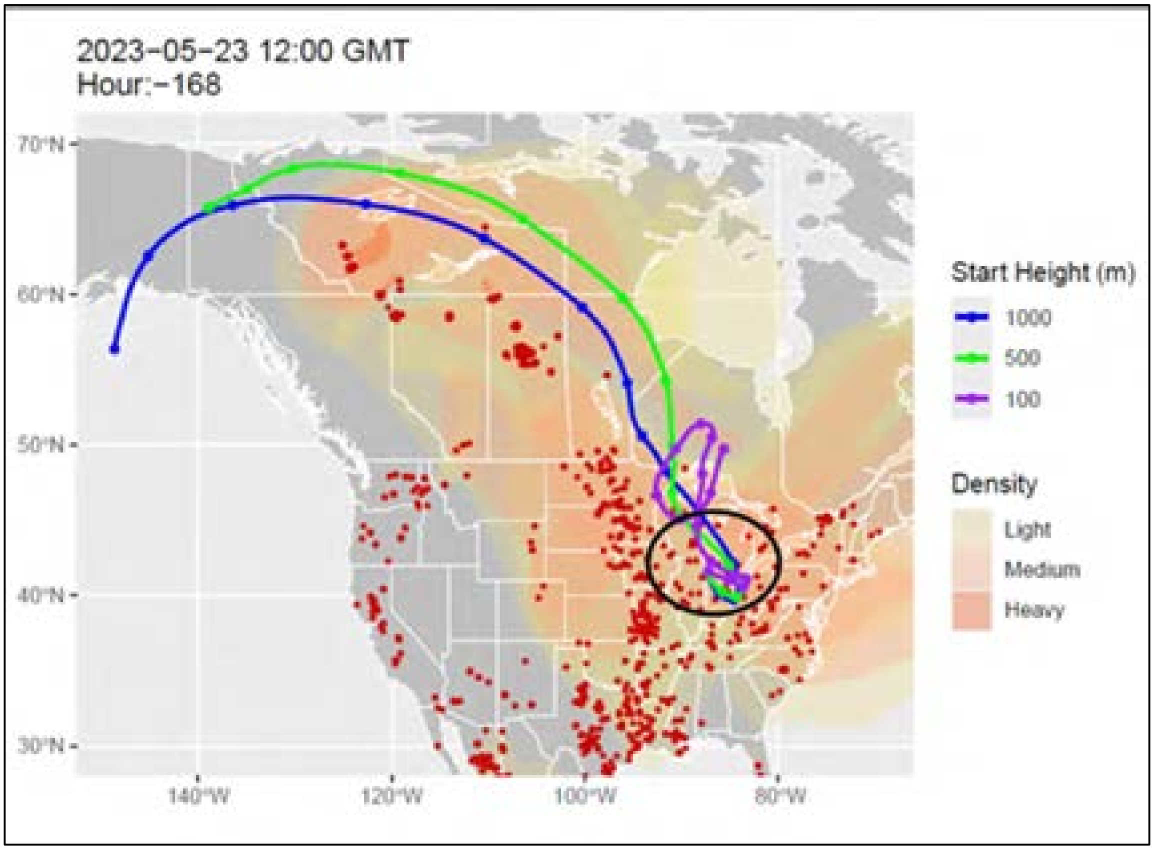


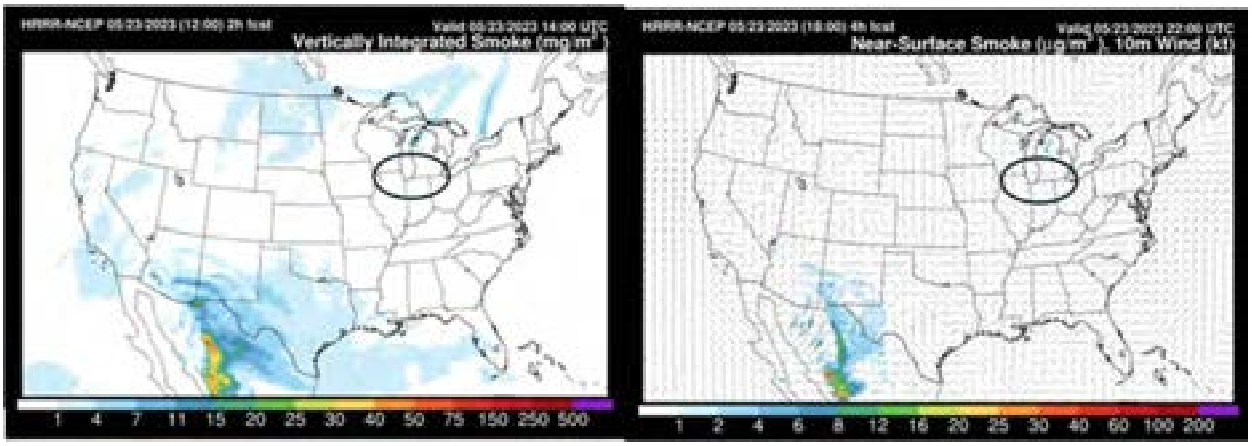
Figure 3.3.28- Long-Range Back Trajectories - May 23 (100, 500 and 1000 meters - 168 hours)



3.3.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.3.29 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.3.29 HRRR Smoke Model



3.3.12 Media Mentions

Below are links to media articles, detailing the Canadian wildfires that impacted the Midwest, including northwest Indiana in late May. States of emergency were called in several Canadian provinces in early May as numerous wildfires burned out of control as a result of the warmest and driest fire season in over 40 years. The resulting smoke was transported into the U.S. and a result; elevated ozone was noted throughout the Midwest. Media mentions of smoke shifting further south into Chicago and Indianapolis emphasize the transport of the wildfire smoke into northwest Indiana. National Weather Service reports from various NWS stations throughout the Midwest noted the heavy smoke throughout this period.

Wildfire season ends for Alberta, but some fires still burning

Early-season 2023 wildfires generated record-breaking surface ozone in the Upper Midwest

Smoke from Canadian fires is pouring into the US and could linger for days

‘Why didn’t they stop this fire?’ Métis community reeling after planned protected area goes up in flames

Smoke From Canada’s Wildfires Creating Hazy, Red Skies in Chicago

3.3.13 Summary of Requested Exclusion of May 23, 2023

Table 3.3.5 - Summary Table - Gary IITRI

Event Date	May 23, 2023
MDA8 Ozone Concentration (PPB)	72
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone	62.3 PPB
EMBER smoke impact (Observed MDA8 minus EMBER Impact)	5 PPB
Matching day MDA8 ozone (max., avg.) (ppb)	55, 51.5
HYSPLIT indicated wildfire regions	Shaw Fire, Paskwa Fire and Long Lake Fire
Do HRRR Models indicate smoke?	No
Media Mentions	Yes
Clear causal relationship established?	Yes

3.4 May 30, 2023 Ozone Event

3.4.1 Executive Summary

On May 30, 2023, Northwest Indiana experienced ozone exceedances across most of the Lake and Porter County monitors, with values ranging from 72–73 ppb, surpassing the 70 ppb NAAQS, as shown below in Table 3.4.1. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 5–18 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to the Barrington Lake, Long Lake and Shaw fires.
- May 30, 2023 has been concurred by U.S. EPA as an Exceptional Event for $PM_{2.5}$

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of May 30, 2023, as an exceptional event under U.S. EPA guidelines.

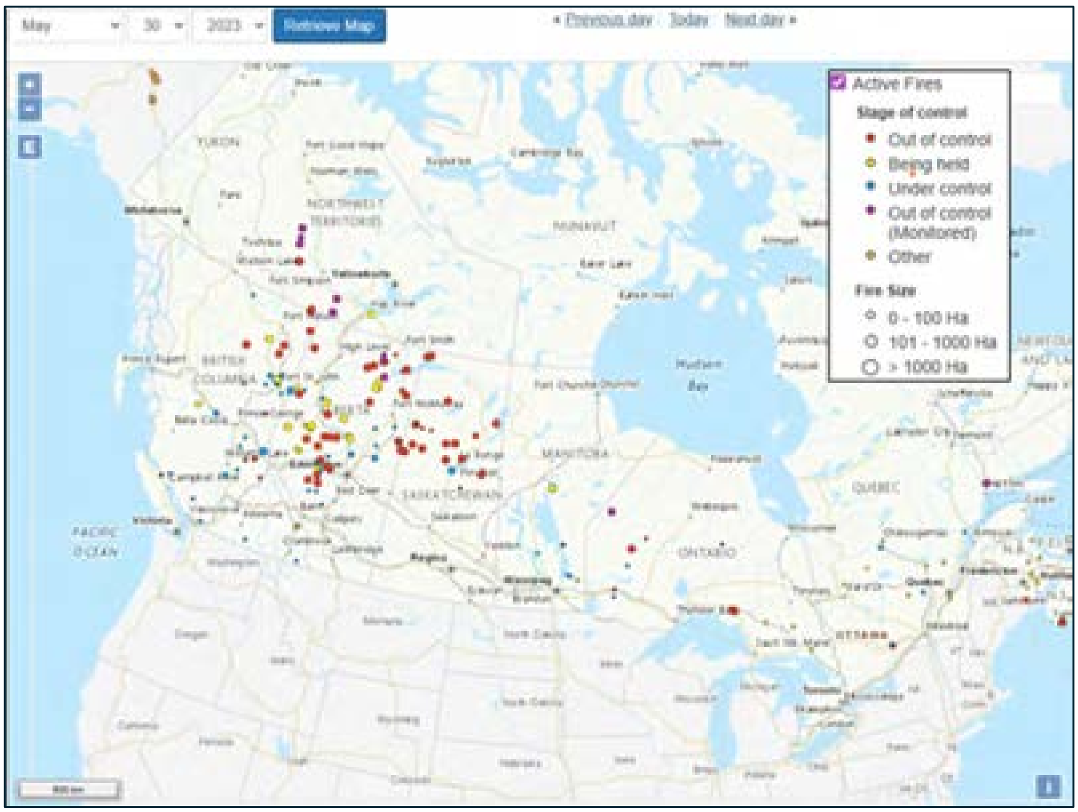
Table 3.4.1 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

Date	Gary-IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
5/30/2023	75	64	74	70

On May 30, 2023, multiple Canadian wildfires, as shown in Figure 3.4.1, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in late May 2023 included the:

- Long Lake Fire, the largest fire in Alberta at the time, burning over 260,000 acres.
- Paskwa Fire, which burned over 87,000 acres near Fox Lake generating massive smoke columns.
- Shaw Fire, the largest fire in Saskatchewan in 2023, the wildfire peaked at over 186,000 hectares. It forced the partial evacuation of Buffalo Narrows and threatened communities including Île-à-la-Crosse and Patuanak.
- Barrington Lake Fire, in Shelburne County, was the largest wildfire in Nova Scotia's recorded history. Ignited on May 26, 2023, it burned through the end of July, devastating the southwestern part of the province

Figure 3.4.1 – Canadian Wildfires May 30, 2023

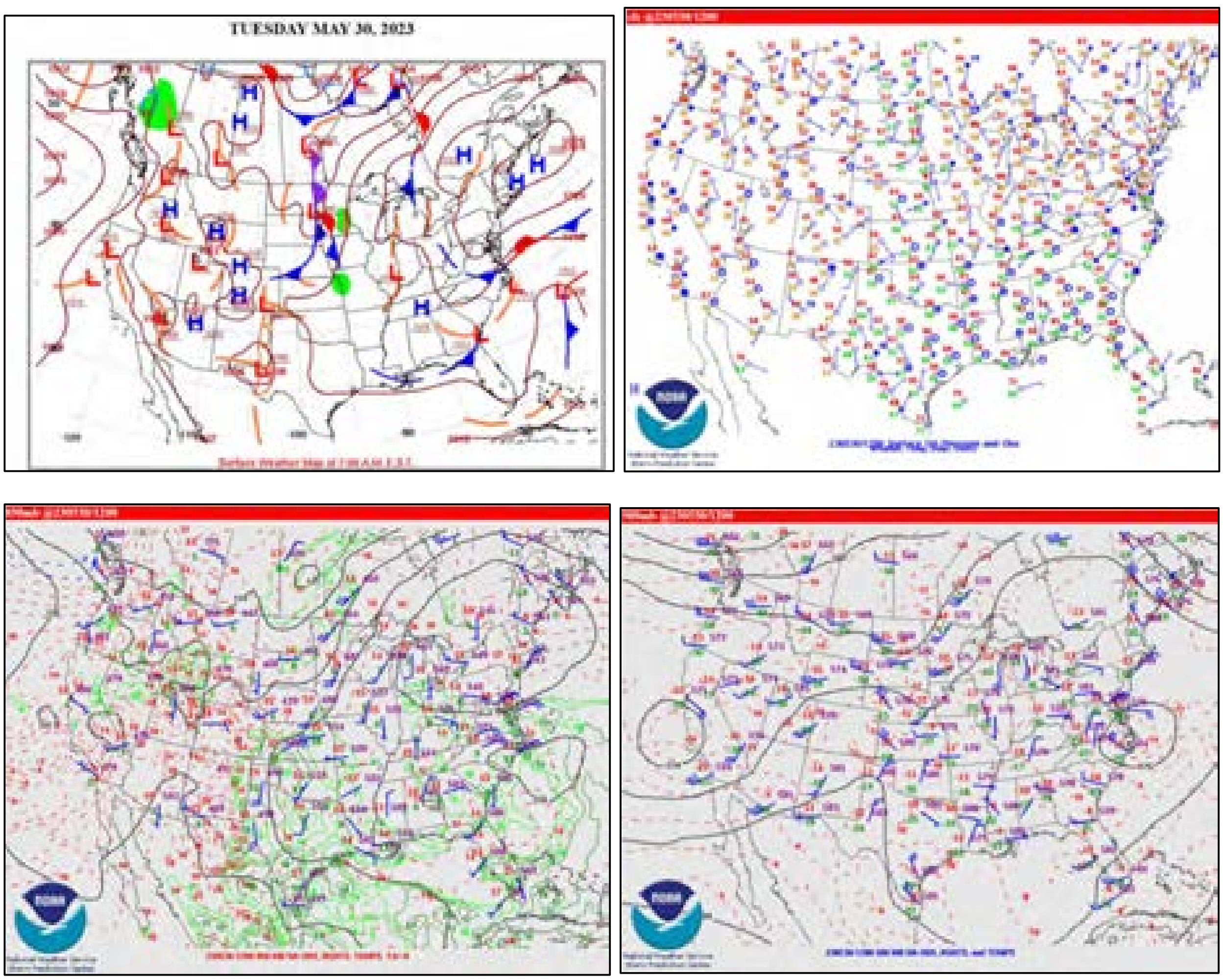


Source: https://cwfis.cfs.nrcan.gc.ca/interactive-map?zoom=0.8&center=400000%2C1000000&month=5&day=23&year=2023#iMap

3.4.2 Meteorological Episode Overview for May 30, 2023

Surface high pressure set up over the southeast portion of Canada as upper air ridging was evident for May 30 over northeastern U.S. and southeastern Canada. This surface and upper air alignment helped to circulate wildfire smoke from northeastern British Columbia, northern Alberta and central/northern Saskatchewan up and over the ridge and back around the southern extent of the surface high pressure system. This ushered in light smoke resulting from the Canadian wildfires, mixed with smoke from seasonal fires in the Mississippi Valley into the Midwest and northwest Indiana. With warmer temperatures in the mid to upper 80’s °F and sunny skies to enhance the solar radiative effects, already conducive ozone conditions were enhanced even more with the wildfire smoke to produce elevated levels of ozone throughout the area. This pattern remained in place for several days, promoting additional smoke transport, resulting in higher ozone concentrations for an extended period of time. Figure 3.4.2 shows the surface, 850 mb and 500 mb maps of the conditions on May 30.

Figure 3.4.2 - Surface, 850 and 500 mb Plots from 12Z on May 30, 2023



Wind rose and pollution rose analyses were taken from the Gary IITRI meteorological station. Wind directions for May 30 were predominantly from the north and northeast as shown in Figure 3.4.3. The pollution rose for Ogden Dunes showed the higher ozone values from the north and northeast, indicating transport from the Nova Scotia and southeast Canadian wildfires, located northeast of Lake County. Figure 3.4.4 points out the directional impacts of the wildfire smoke on ozone concentrations. The timing of the turning of the winds on May 30 (Figure 3.4.5) shows the more northernly and northeasterly flow corresponding with the wildfire smoke intrusion into the area as ozone concentrations increased.

Figure 3.4.3 – Gary IITRI Windrose

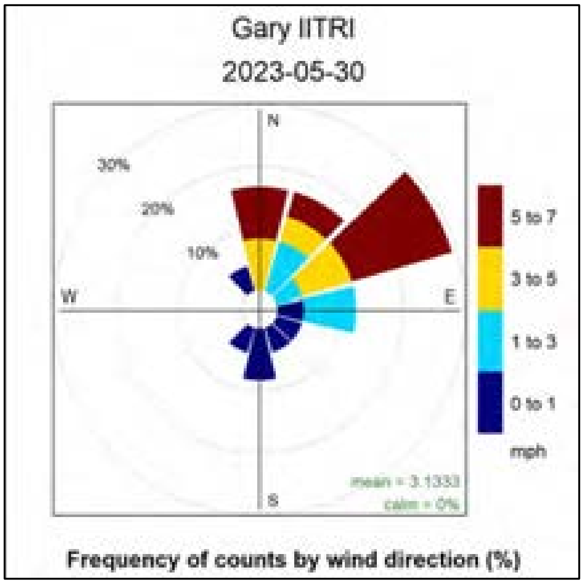


Figure 3.4.4 –Ogden Dunes Pollution Rose

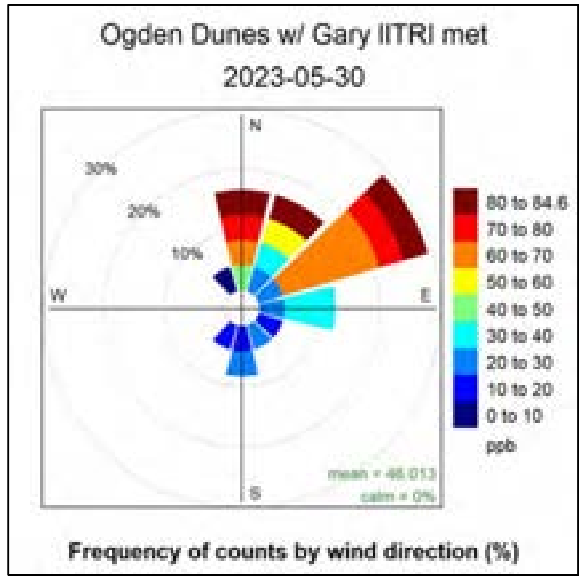
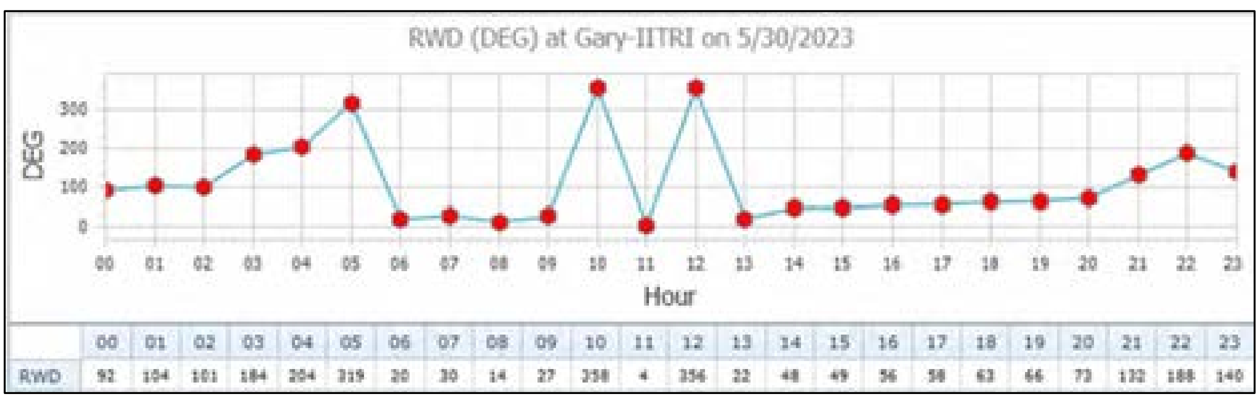


Figure 3.4.5 shows the timeseries of wind directions that reinforce the winds from the northeast throughout the day on May 30, that brought in additional Canadian wildfire smoke during the day.

Figure 3.4.5 - Hourly Wind Directions at Gary IITRI for May 30, 2023



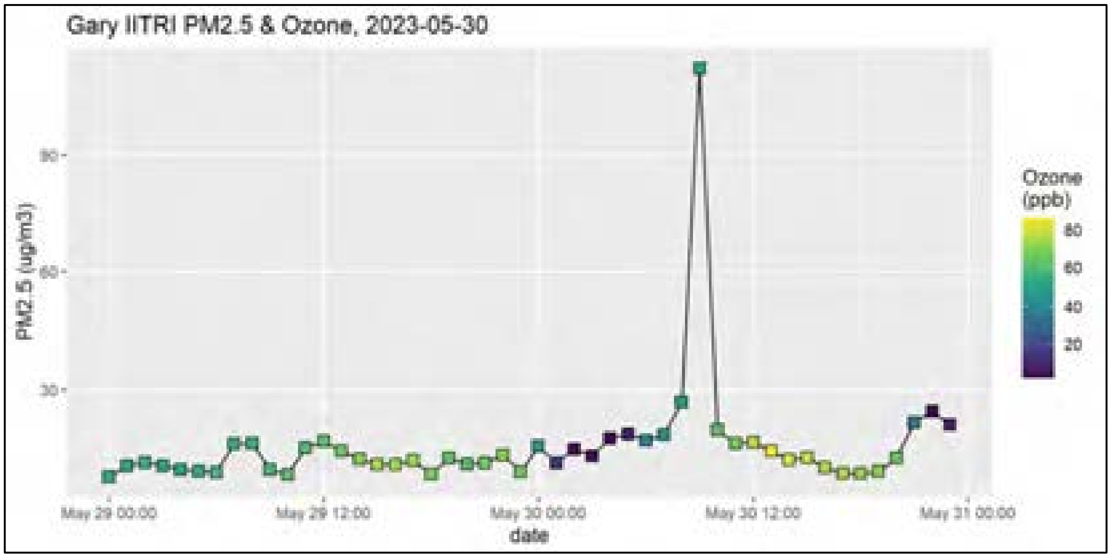
3.4.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for May 30, 2023 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.4.6. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.4.6 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes

Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for May 29 - 30 as shown in Figure 3.4.7. $PM_{2.5}$ concentrations were around 25 ug/m^3 on May 30.

Figure 3.4.7 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data May 30, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.4.2 shows the percentage above the five-year average. All three pollutants were well above the average, indicating the presence of wildfire smoke in the area during this time.

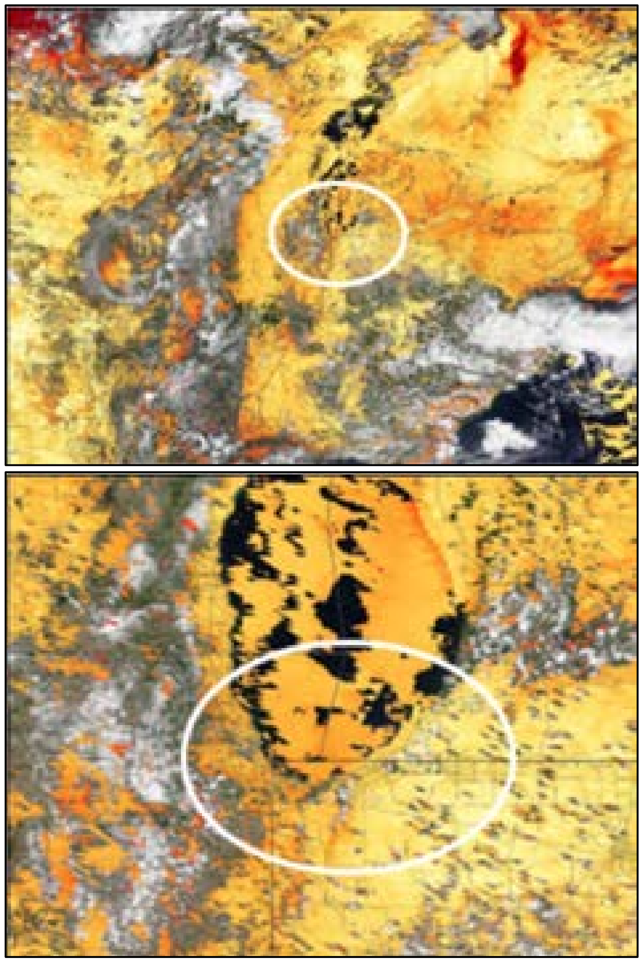
Table 3.4.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
5/30/2023	198%	221%	166%

3.4.4 AOD and Satellite Analyses

Figure 3.4.8 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The moderate orange color in northwest Indiana indicates the presence of light to moderate smoke. The northwest Indiana area is indicated by the white circle in each figure.

Figure 3.4.8- Aerosol Optical Depth (AOD) - May 30, 2023



The image captured by NOAA's GOES 18 satellite for North America taken May 30, 2023 shows clouds and a plume of gray smoke extending from western Canada to the upper Midwest states, including Indiana. Figure 3.4.9 shows the North American continent with wildfire smoke over the northwest Indiana area indicated by the red circle on the satellite image Credit: NOAA NESDIS

Figure 3.4.9 - Satellite Imagery of Upper Midwest May 30, 2023

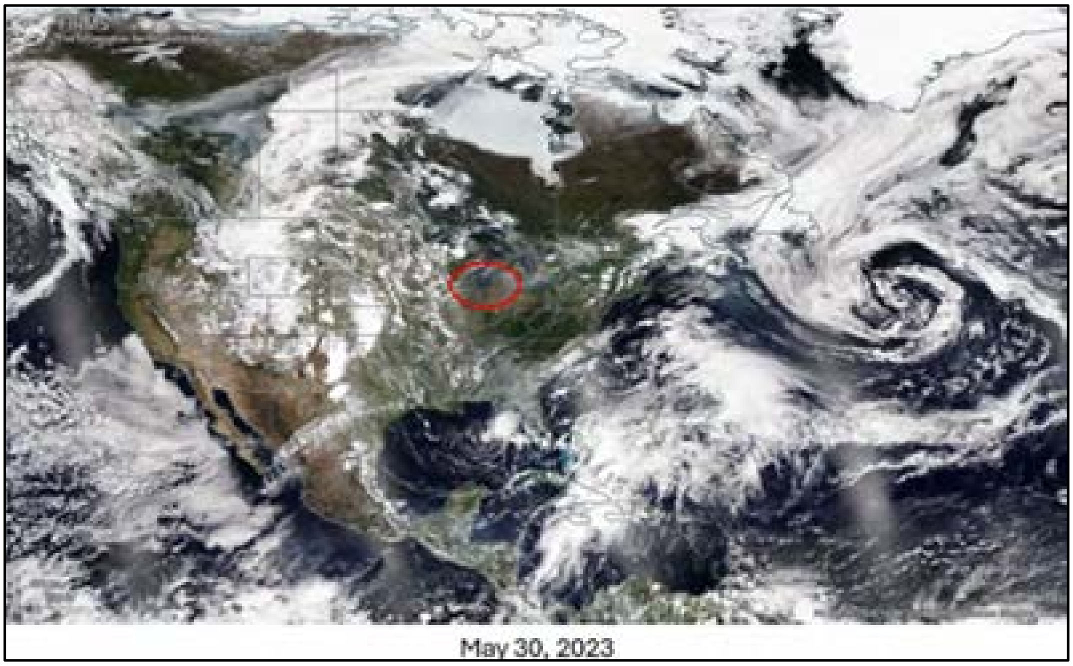


Figure 3.4.10 shows smoke working into northern Indiana from the northeast on May 30. High clouds partially obscure the smoke transport but the smoke is evident further to the east and north. The northwest Indiana area is indicated by the red circle on the satellite images.

Figure 3.4.10 - Satellite Imagery of Upper Midwest on May 30, 2023

3.4.5 NOAA Smoke Narrative

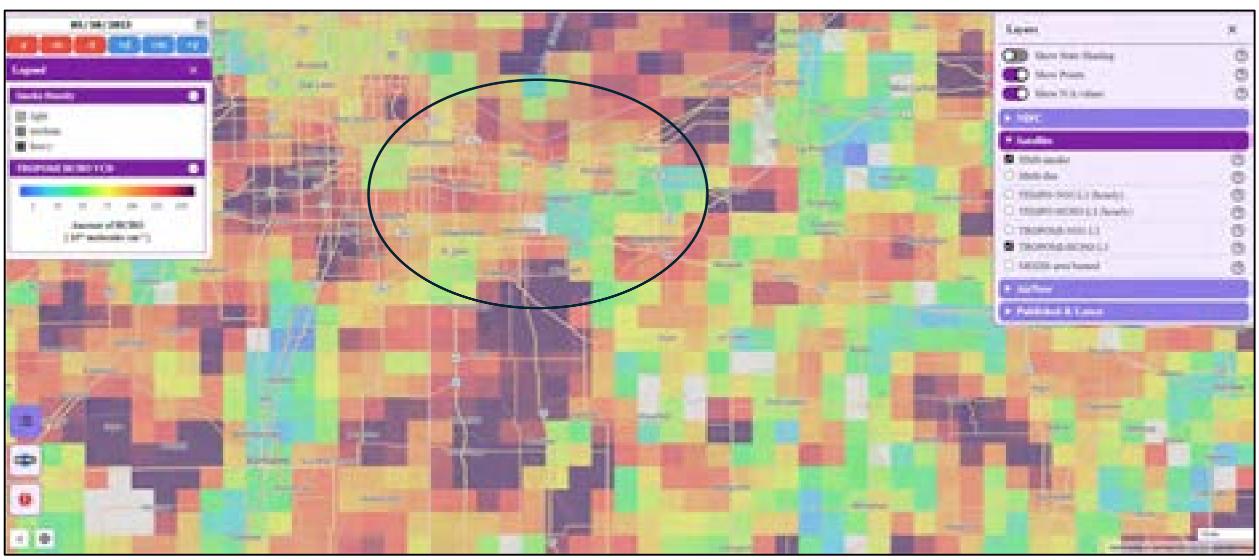
DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 1610Z May 30, 2023

SMOKE:
Canada/Atlantic...
A large area of smoke primarily linked to **major wildfire activity in northeastern British Columbia, northern Alberta. and central/northern Saskatchewan** continues to blanket a large part of Canada. Areas of high smoke concentration were found along northern Alberta, central/northern Saskatchewan, southeastern Northwestern Territories, and northwestern Manitoba. Moderate density smoke was detected over northern Hudson's Bay and across central Quebec, extending over the northwestern Atlantic Ocean. Overall, the bulk of the large area smoke was dispersing eastward in the general direction of the northern Atlantic.
Central U.S...
Light smoke resulting from Canadian wildfires extended south into the Great Plains where it mixed with smoke from seasonal fires in the Mississippi Valley reaching the coastal areas along the Gulf of Mexico.

3.4.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.4.11 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 7-13 × 10^{15} molecules/cm^2 indicating moderate to extreme wildfire smoke influence.

Figure 3.4.11- TROPOMI Satellite Daily Formaldehyde Monitoring



3.4.7 Smoke Maps and Forward/Backward Trajectories Analyses

In Figures 3.4.12 through 3.4.15, AirNow shows the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding areas, indicating smoke impacts aided in these elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.4.12 - AirNow Smoke Ozone on May 30, 2023

Figure 3.4.13 - AirNow Ozone on May 30, 2023

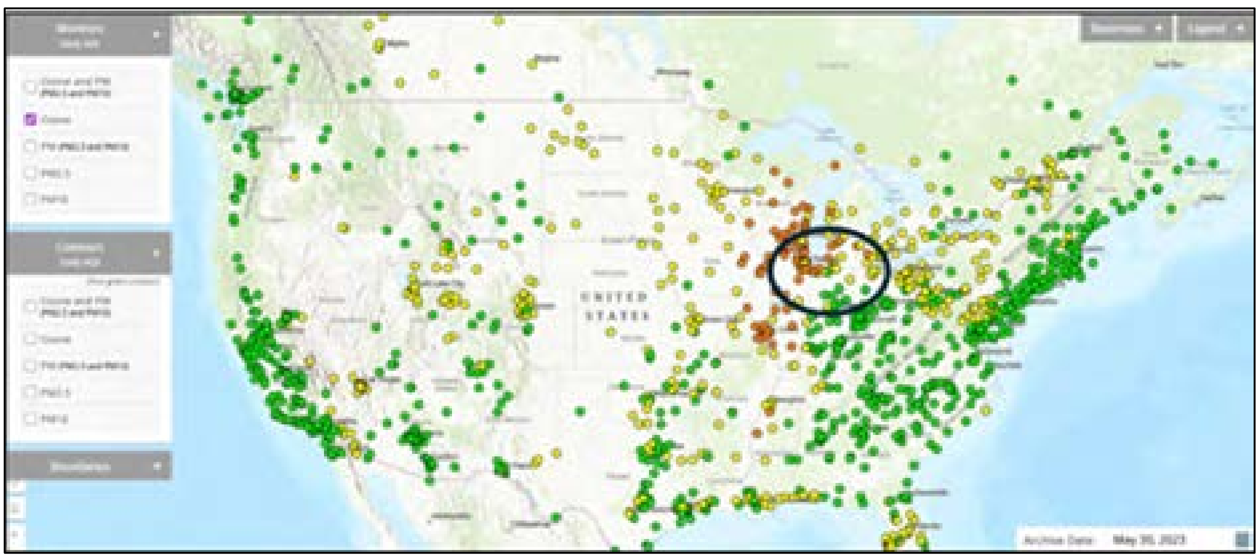


Figure 3.4.14 - AirNow $PM_{2.5}$ on May 30, 2023

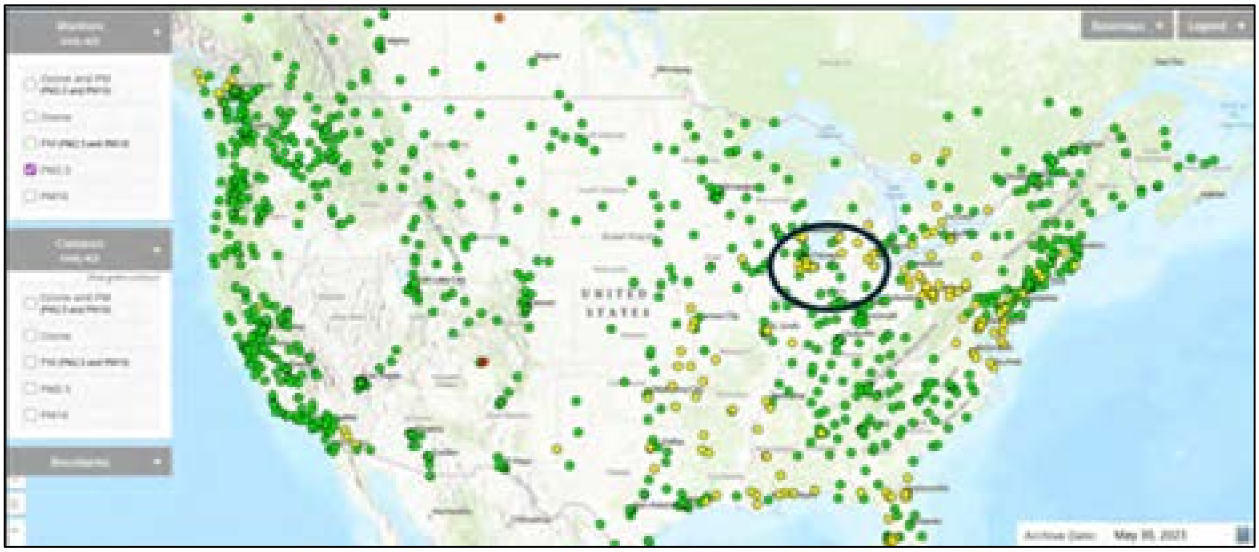
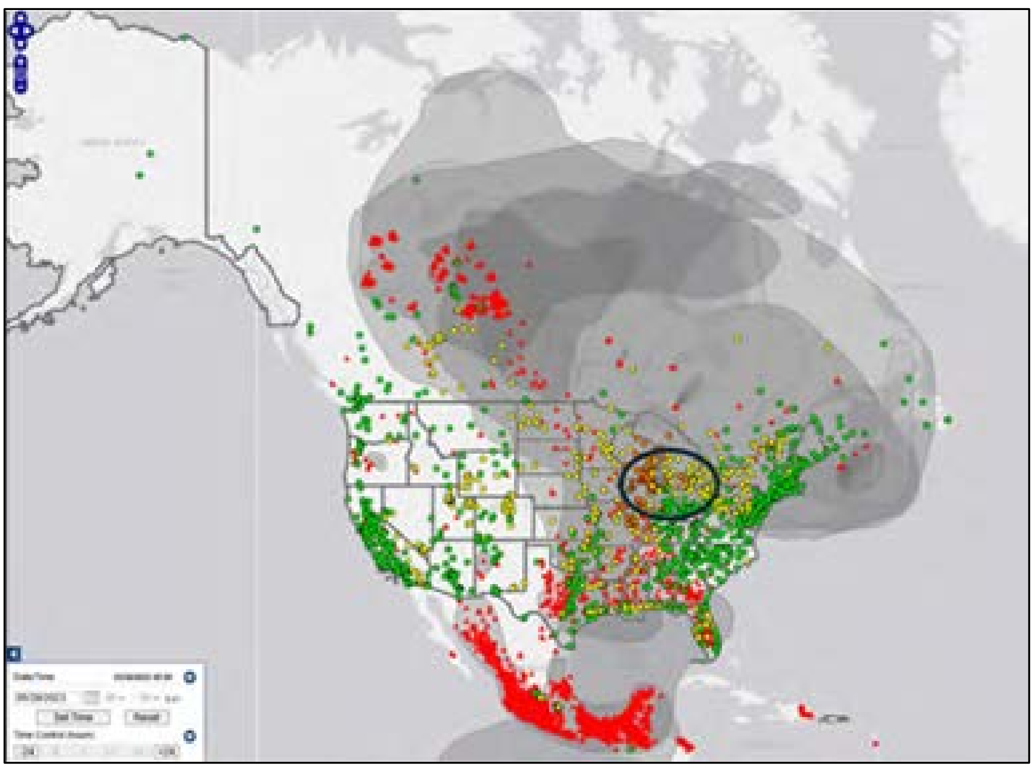


Figure 3.4.15 - AirNow Smoke and Fire Map with Ozone Values on May 30, 2023



3.4.8 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes.

Figures 3.4.16 through 3.4.19 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the black circles on each of the maps.

Figure 3.4.16 - GAM Smoke Maps Indicating Smoke Days May 30, 2023

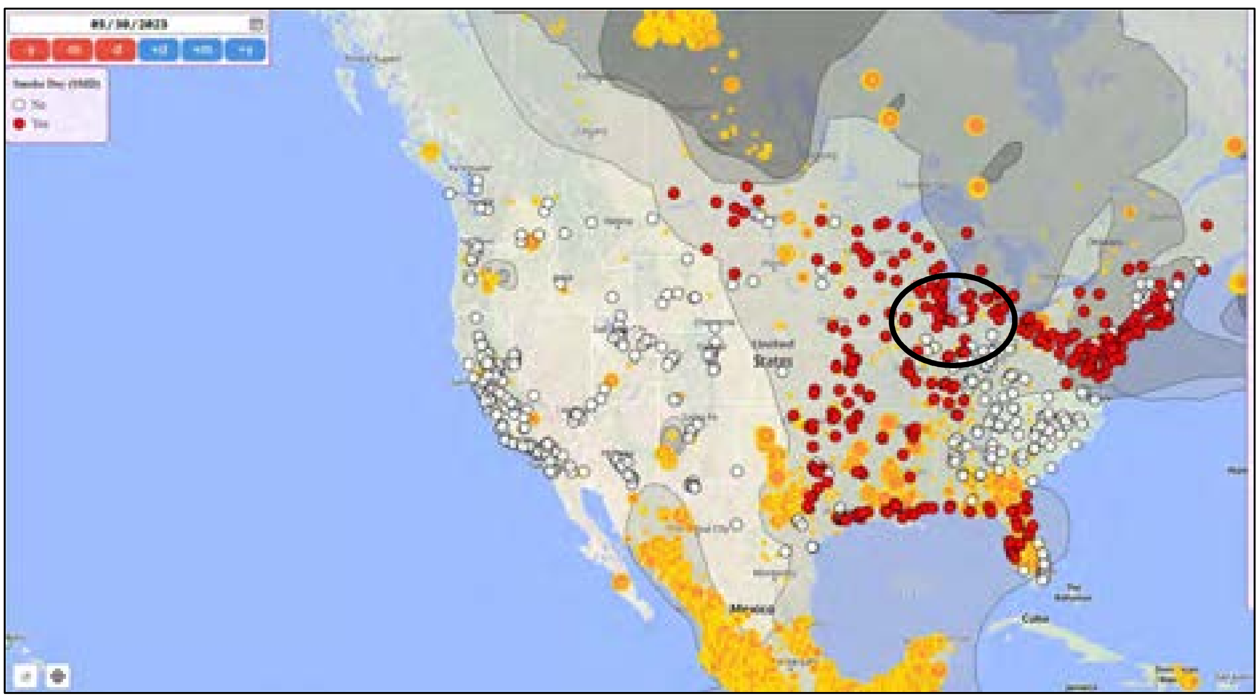


Figure 3.4.17 - GAM Observed ozone with Smoke days May 30, 2023

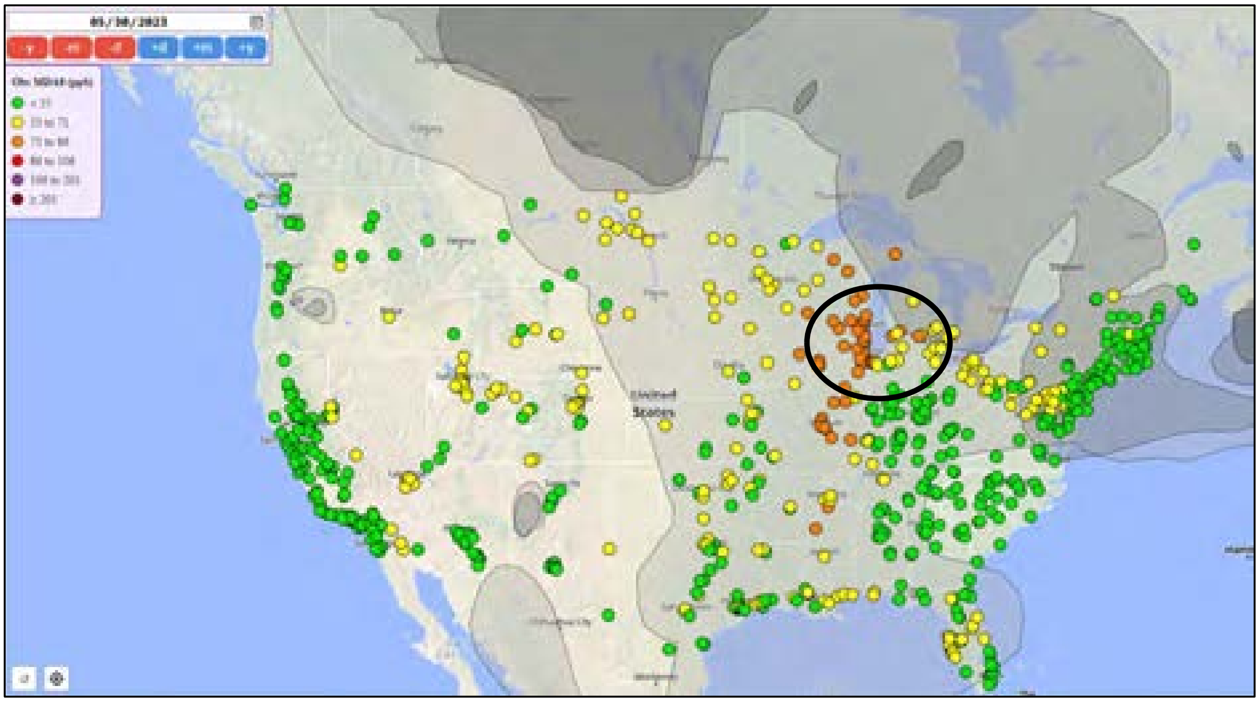


Figure 3.4.18 - GAM Smoke estimates May 30, 2023

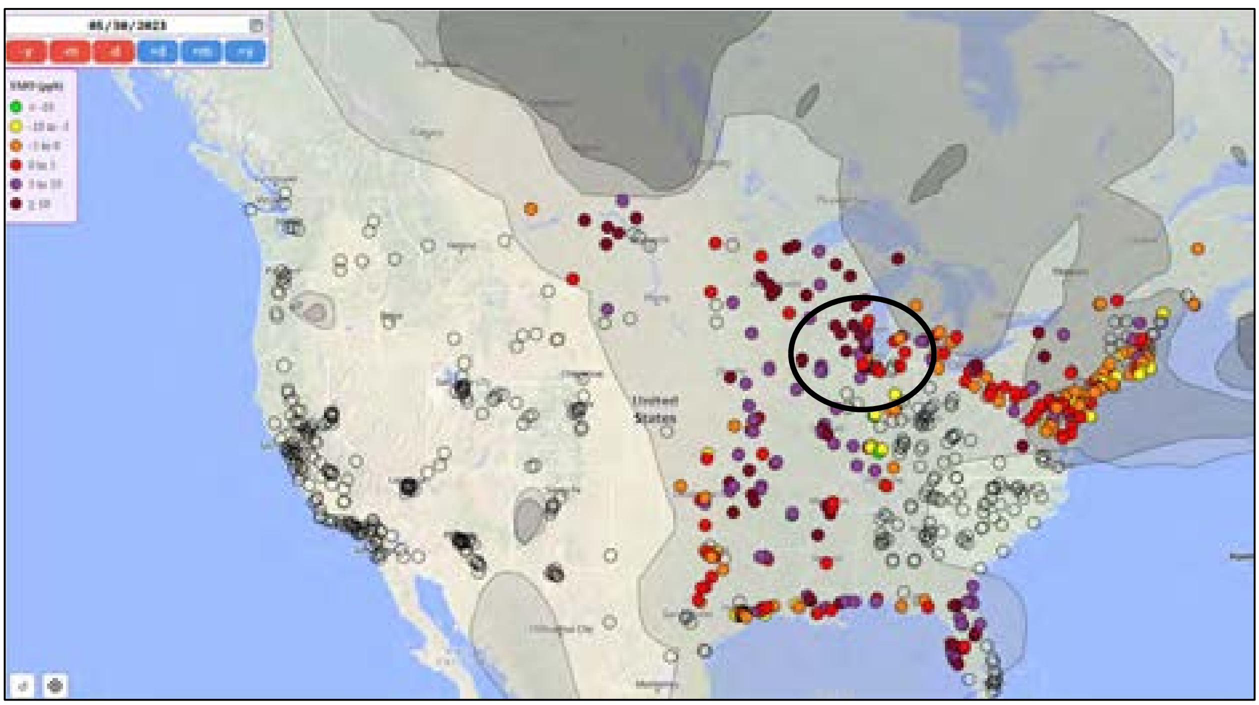


Figure 3.4.19 - EMBER Smoke estimates May 30, 2023

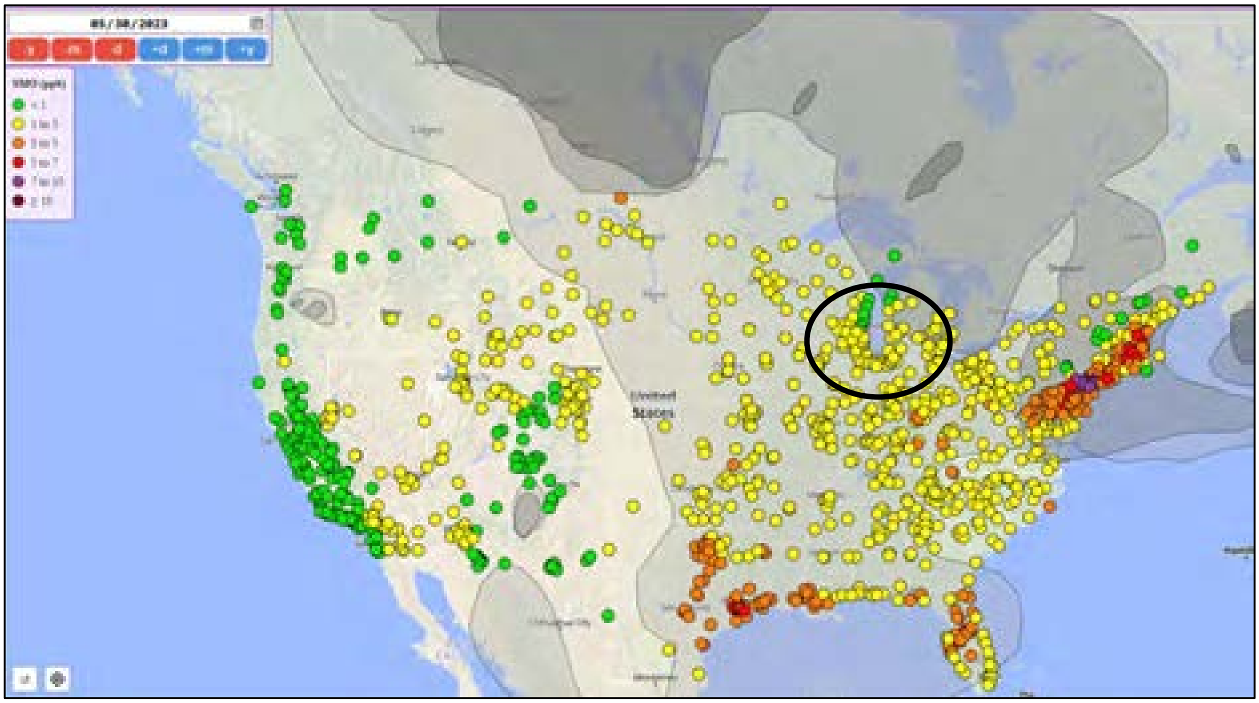


Table 3.4.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence. In general, both predictive models show smoke impacted ozone concentrations, from 4 to 5 ppb to as much as 17 ppb at the Lake and Porter County ozone monitors.

Table 3.4.3 - Observed versus GAM/EMBER predicted MDA 8-hour Ozone Values May 30, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	75	69.9	5.1	58	17
180892008	Hammond	64	NA	NA	62	2
181270024	Ogden Dunes	74	70	3.9	58	16
181270026	Valparaiso	70	66	3.8	56	14

3.4.9 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on May 30, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.4.4 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 22 ppb lower than the MDA8 ozone concentrations observed on May 30 with the maximum matching day MDA8 ozone concentration of 65.8 ppb.

Table 3.4.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values May 30, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	74	65.8	52.1

3.4.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories in Figure 3.4.20 have three starting heights, 50 m (green), 100 m (blue), and 500 m (red). Figure 3.4.21 shows higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. May 30 three-day back trajectories indicate smoke from eastern Canada being drawn down to northwest Indiana. The trajectories in Figure 3.4.22 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air starting east and drawing from wildfires in Nova Scotia before pulling smoke from Manitoba, Saskatchewan and Alberta. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps

Figure 3.4.20 - Back Trajectories from May 30 (50, 100 and 500 meters - 72 hours)

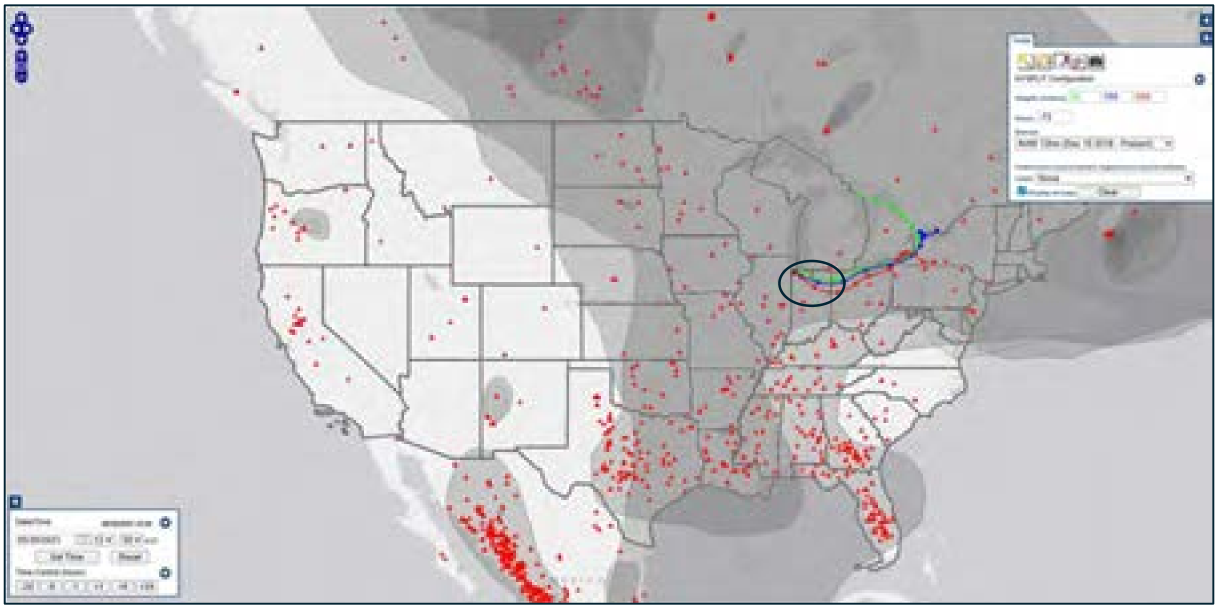


Figure 3.4.21- Back Trajectories from May 30 (1000, 2000 and 3000 meters - 72 hours)

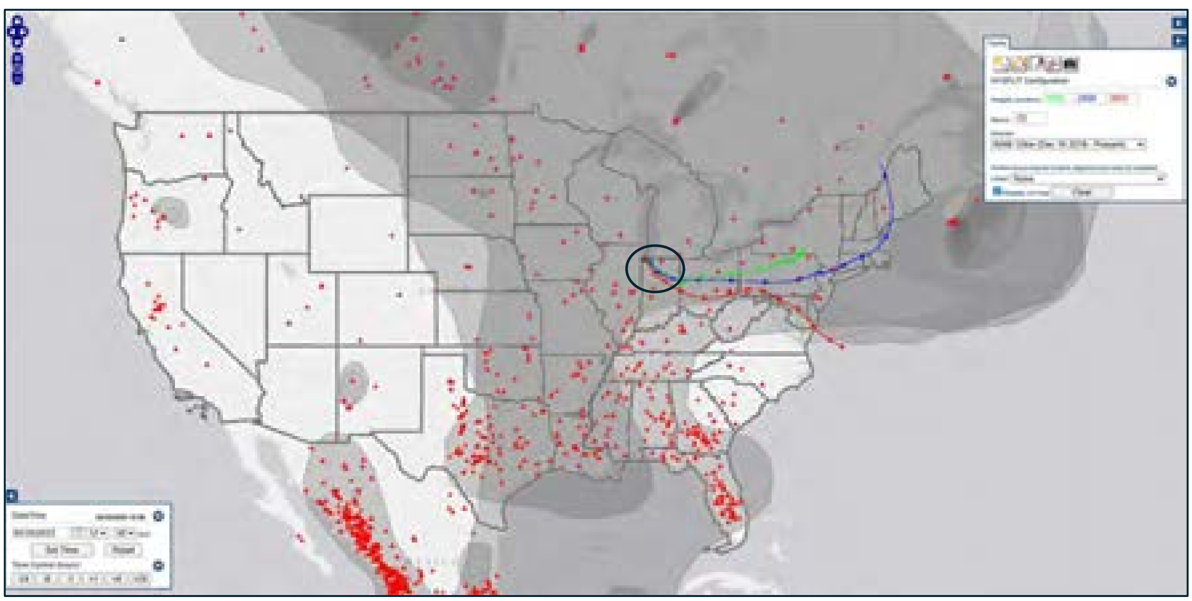
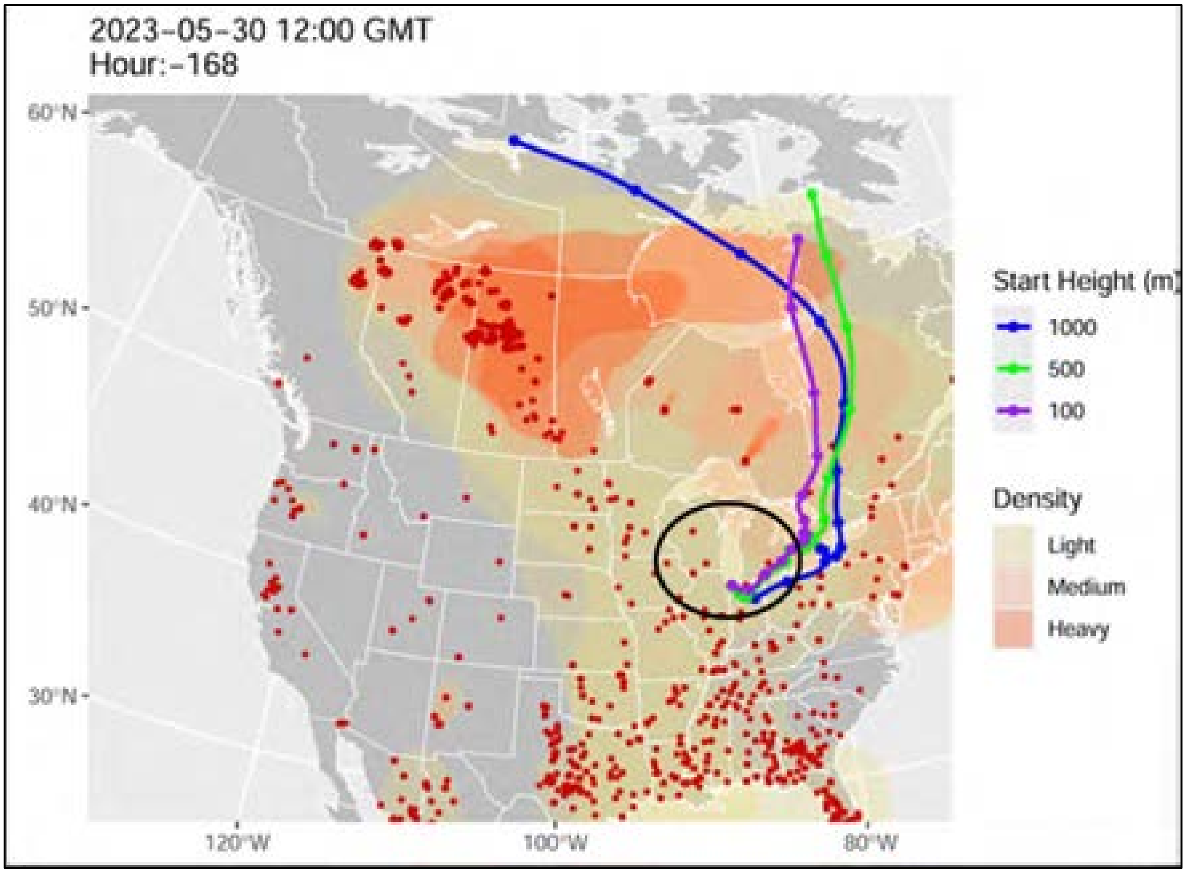


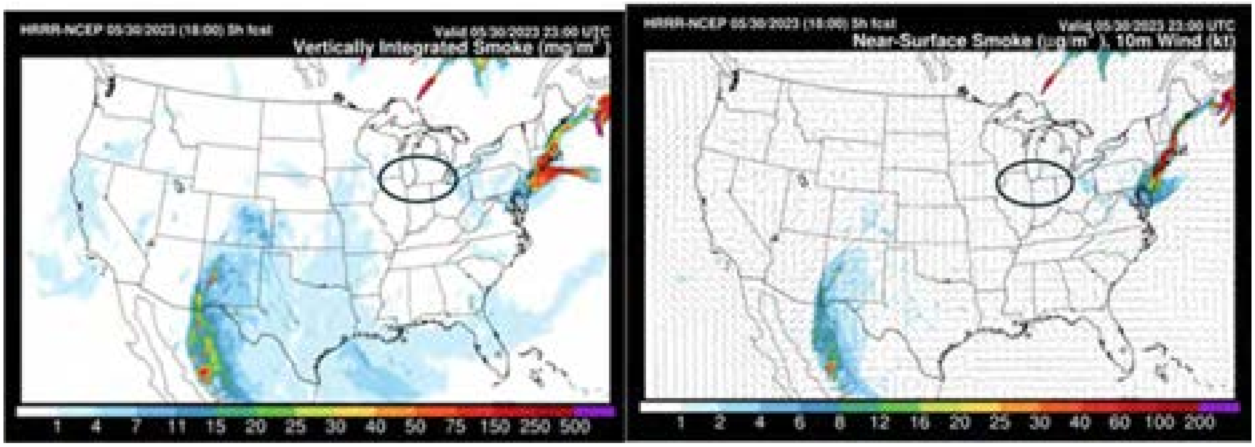
Figure 3.4.22 - Long-Range Back Trajectories from May 30 (100, 500 and 1000 meters - 168 hours)



3.4.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.4.23 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.4.23 HRRR Smoke Model



3.4.12 Media Mentions

[Smoke from Nova Scotia's largest wildfire in history chokes the Northeast]

[Wildland Urban Interface Fire: May 2023]

[Early-season 2023 wildfires generated record-breaking surface ozone in the Upper Midwest]

[Smoke from Canadian fires is pouring into the US and could linger for days]

[Smoke From Canada’s Wildfires Creating Hazy, Red Skies in Chicago]

3.4.13 Summary of Requested Exclusion of May 30, 2023

Table 3.4.5 - Summary Table - Gary IITRI

Event Date	May 30, 2023
MDA8 Ozone Concentration (PPB)	75
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone	69.9 PPB
EMBER smoke impact (Observed MDA8 minus EMBER Impact)	17 PPB
Matching day MDA8 ozone (max., avg.)	65.8, 52.1
HYSPLIT indicated wildfire regions	Shaw Fire, Saskatchewan; Long Lake and Paskwa
Do HRRR Models indicate smoke?	No
Media Mentions	Yes
Clear causal relationship established?	Yes

3.5 June 2-3, 2023 Ozone Event

3.5.1 Executive Summary

On June 2, 2023 and June 3, 2023, Northwest Indiana experienced ozone exceedances across all Lake and Porter County monitors, with values ranging from 66 to 79 ppb, surpassing the 70 ppb NAAQS at multiple locations. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate up to 12 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to the area of Barrington Lake Fire, Nova Scotia; Sept-Iles Fire, Quebec; Lebel-sur-Quévillon (LSQ) fire, and Raddison 2 Fire, Quebec.

- June 2, 2023 has been concurred by U.S. EPA as an Exceptional Event for $PM_{2.5}$

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of June 2, 2023, and June 3, 2023, as an exceptional event under U.S. EPA guidelines.

Table 3.5.1 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

Date	Gary-IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
6-2-2023	74	68	77	79
6-3-2023	70	66	71	71

On June 2 and 3, 2023, multiple Canadian wildfires, as shown in Figures 3.5.1 and 3.5.2, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in early June included the:

- Barrington Lake wildfire, the largest in Nova Scotia's recorded history. It began in Shelburne County on May 26, 2023, and was driven by the driest conditions in the province since WWII.
- Sept-Îles wildfire, a critical event during the early June 2023 Quebec wildfire season, marked by a rapid escalation that forced nearly 10,000 residents to flee their homes.
- Lebel-sur-Quévillon (LSQ) fire complex, which was one of the most significant and persistent threats during the 2023 Quebec wildfire season. The town of roughly 2,000 residents was forced to evacuate twice in less than three weeks as massive, out-of-control blazes approached the municipality.

Figure 3.5.1 – Canadian Wildfires June 2, 2023

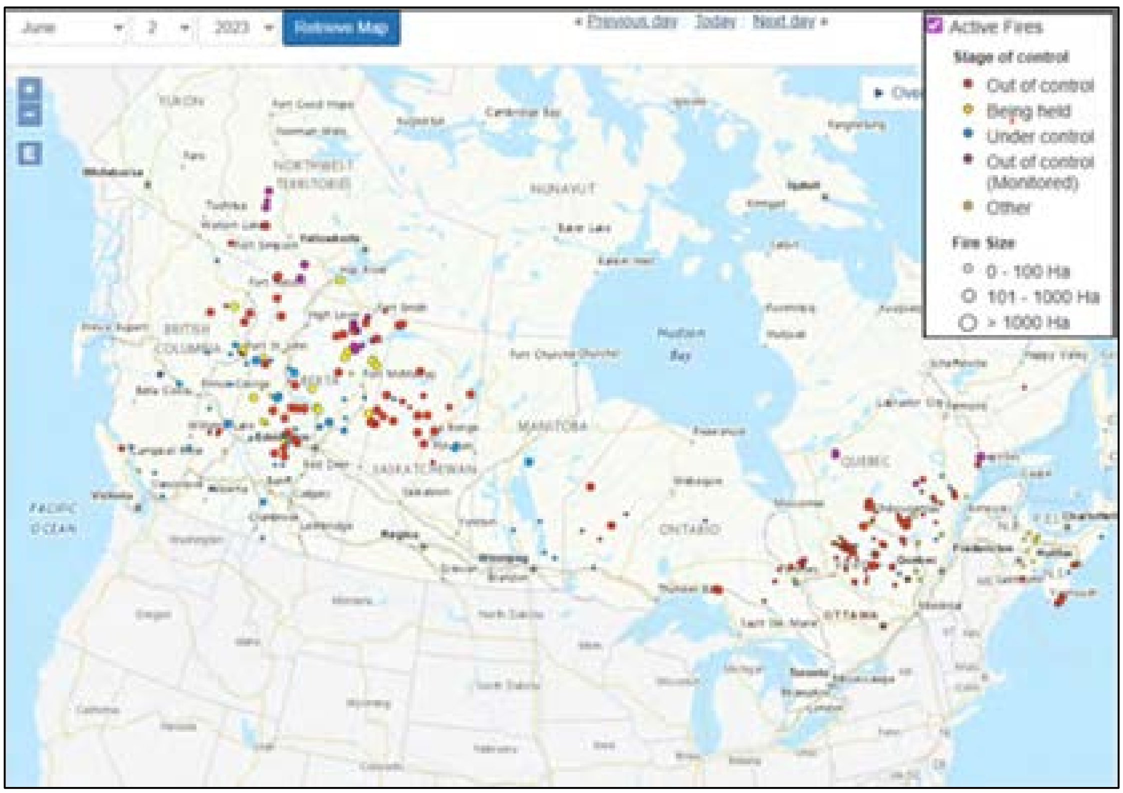
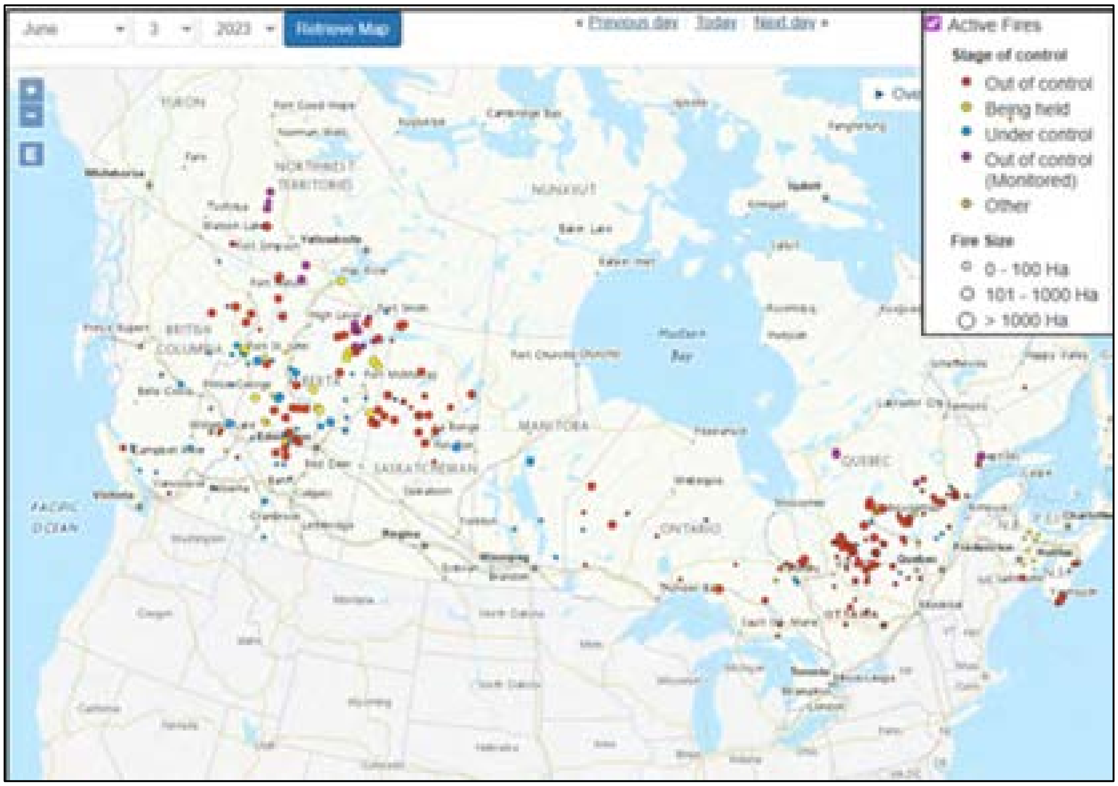


Figure 3.5.2 – Canadian Wildfires June 3, 2023



Source: https://cwfis.cfs.nrcan.gc.ca/interactive-map?zoom=0.8&center=400000%2C1000000&month=5&day=23&year=2023#iMap

3.5.2 Meteorological Episode Overview

Surface high pressure set up over West Virginia as a broad upper air trough was developing over southeastern Canada for June 2. This surface high pressure was moving south as the trough is strengthening and a cold front developed along the U.S./Canadian border by June 3. Behind the cold front, wildfire smoke from Nova Scotia and growing wildfires in Quebec and Ontario was being transported into the area. Warmer temperatures in the upper 80's °F and lower humidity levels helped to create even more conducive ozone conditions which produced elevated levels of ozone throughout the area. This pattern remained in place for several days as the cold front moved south and west, bringing more smoke into northwest Indiana. This resulted in higher ozone concentrations for the next week. Figure 3.5.3 shows the surface, 850 mb and 500 mb maps of the weather conditions on June 2 and Figure 3.5.4 shows these weather conditions on June 3.

Figure 3.5.3 - Surface, 850 and 500 mb Plots from 12Z on June 2, 2023

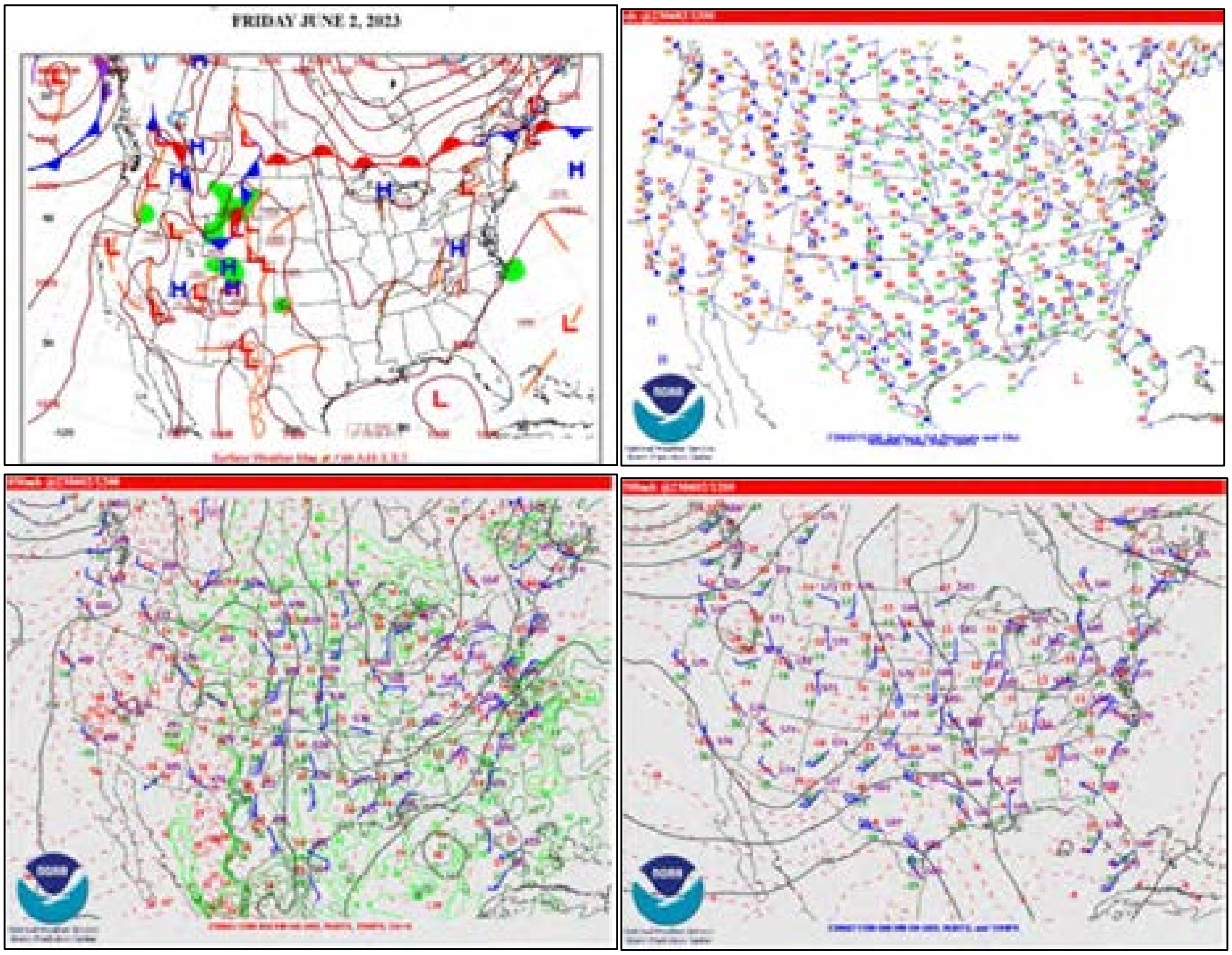
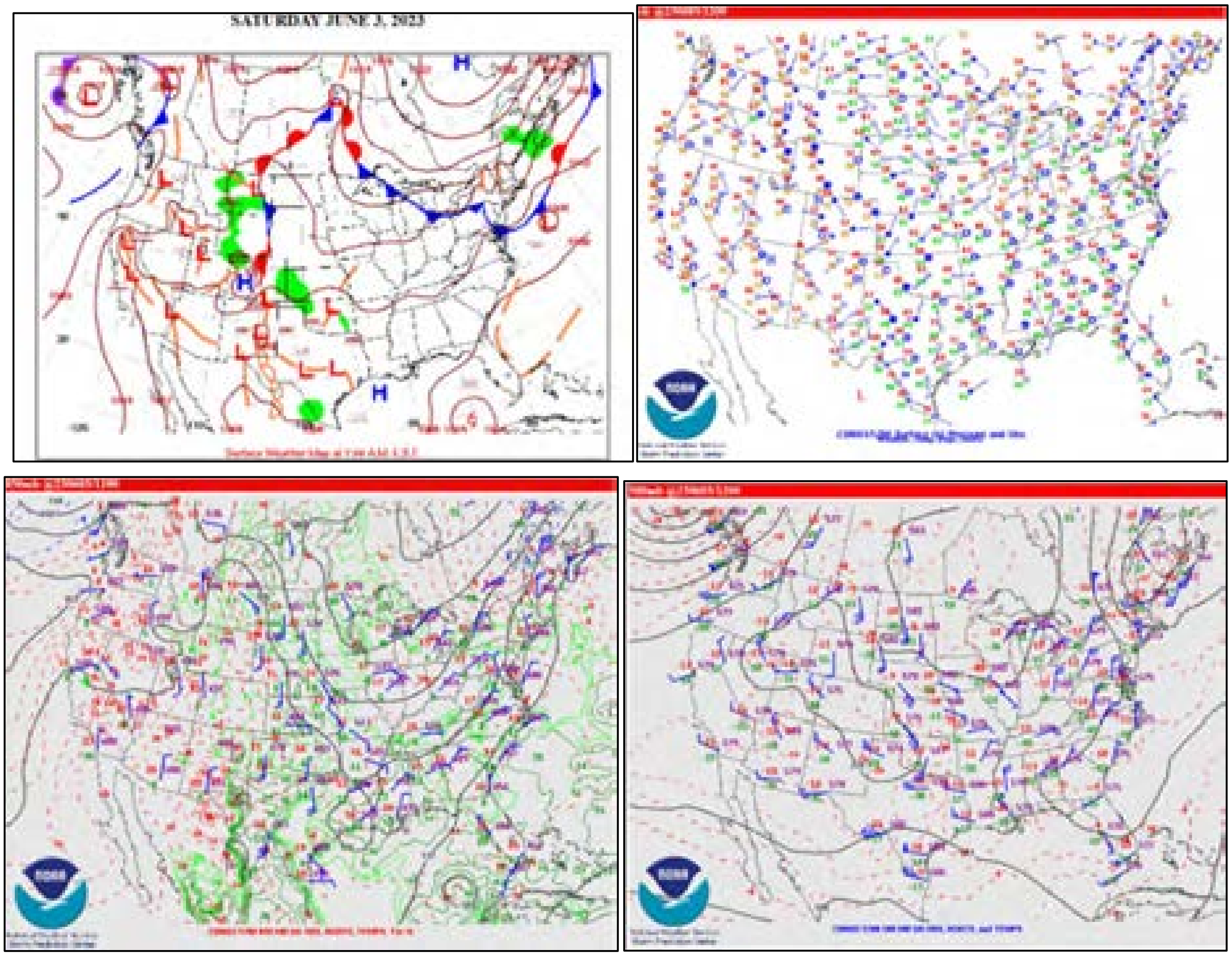


Figure 3.5.4 - Surface, 850 and 500 mb Plots from 12Z on June 3, 2023



Wind rose and pollution rose analyses were taken from the Gary IITRI meteorological station. Wind directions on June 2 (Figure 3.5.5) were primarily from the northeast, while wind directions on June 3 Figure 3.5.7) were primarily from the north. The pollution rose for Ogden Dunes showed the higher ozone values from the north on June 2 (Figure 3.5.6) and northeast on June 3 (Figure 3.5.8), indicating transport from southeastern Canadian wildfires. There were dry conditions and high surface pressure in the area during this time as well, resulting in stagnant conditions and a buildup of pollutants leading up to this event. Skies were sunny and temperatures were warm, also contributing to increased ozone production. Long range back trajectories indicate transport from wildfires in eastern Canada.

Figure 3.5.5 – Gary IITRI Windrose

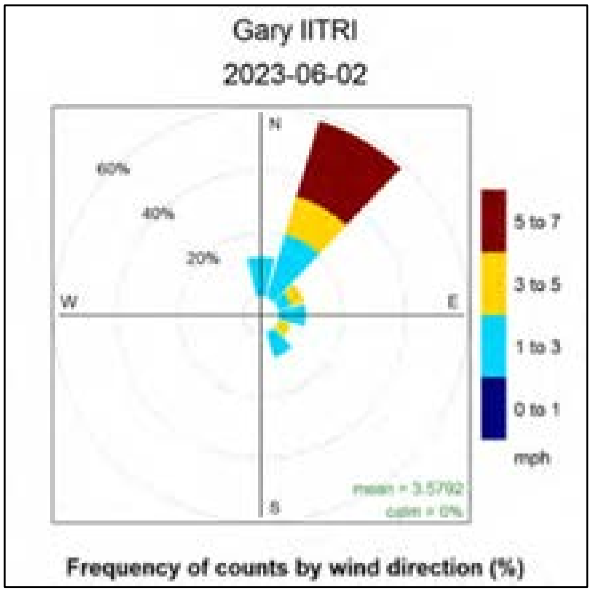


Figure 3.5.6 –Ogden Dunes Pollution Rose

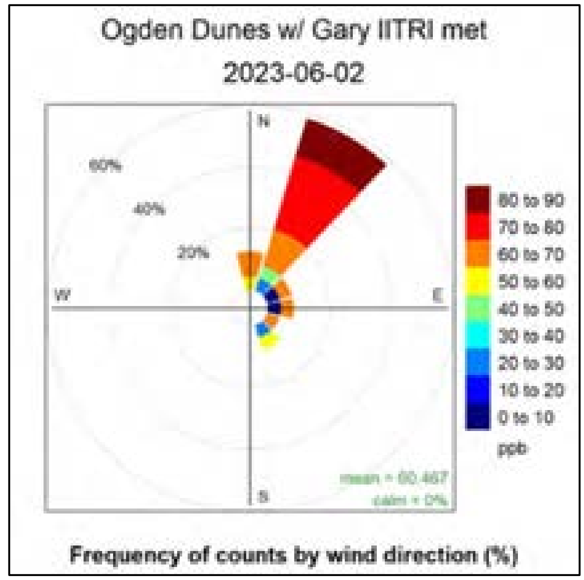


Figure 3.5.7 – Gary IITRI Windrose

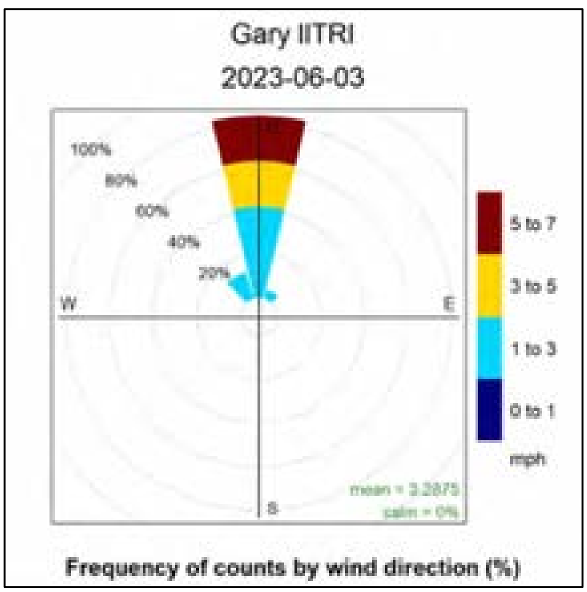


Figure 3.5.8 –Ogden Dunes Pollution Rose

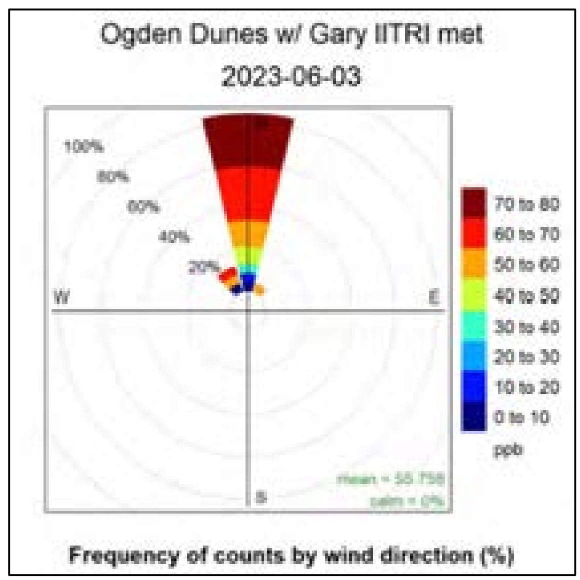
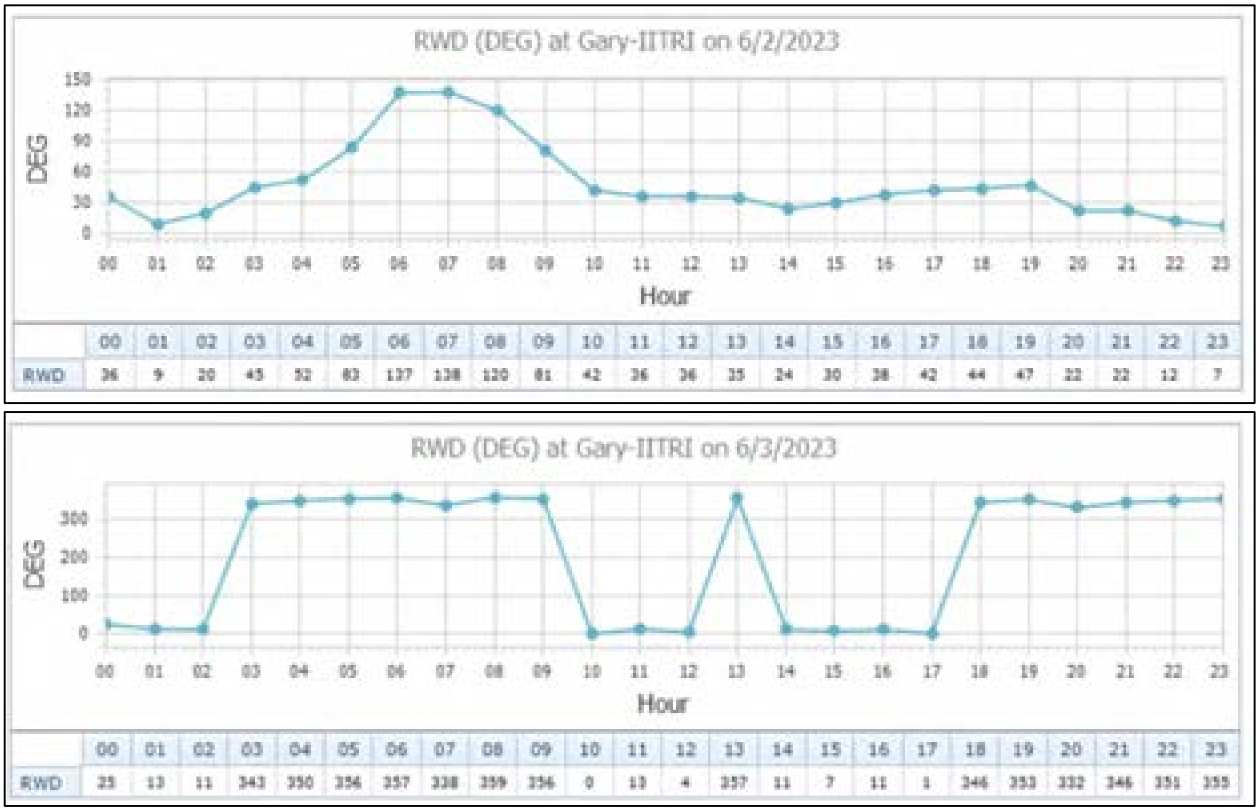


Figure 3.5.9 shows the timeseries of wind directions that shows a relatively consistent north and northeast of the winds throughout June 2 and 3. This was responsible for transporting in additional Canadian wildfire smoke during this period of time.

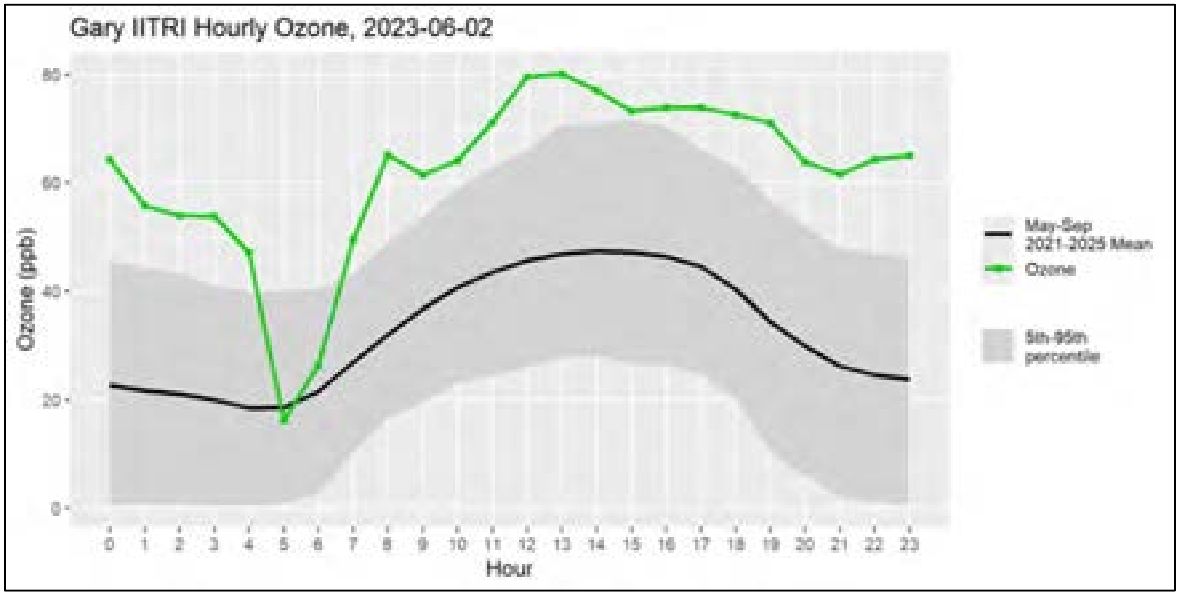
Figure 3.5.9 - Hourly Wind Directions at Gary IITRI for June 2 - 3, 2023



3.5.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for June 2 and June 3 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figures 3.5.10 through 3.5.12. For each of the days, the hourly readings at all three ozone monitors exceeded the 95th percentile, indicating the smoke impacts on ozone concentrations.

Figure 3.5.10 - Ozone Diurnal Pattern for Gary IITRI for June 2 and 3, 2023



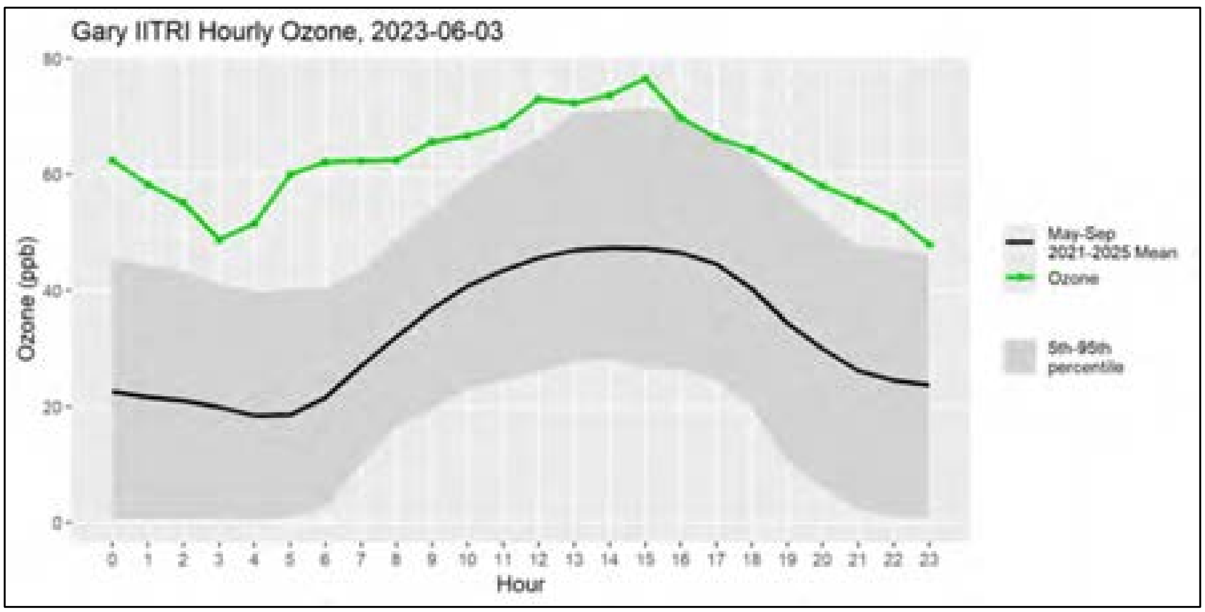
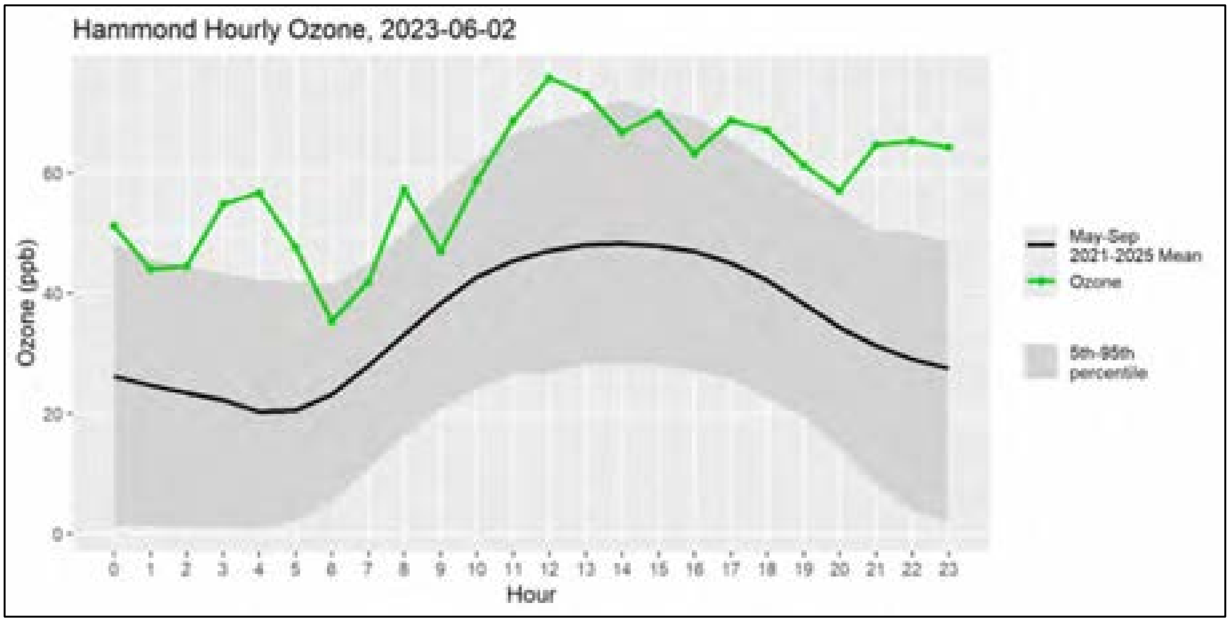


Figure 3.5.11 - Ozone Diurnal Pattern for Hammond for June 2 and 3, 2023



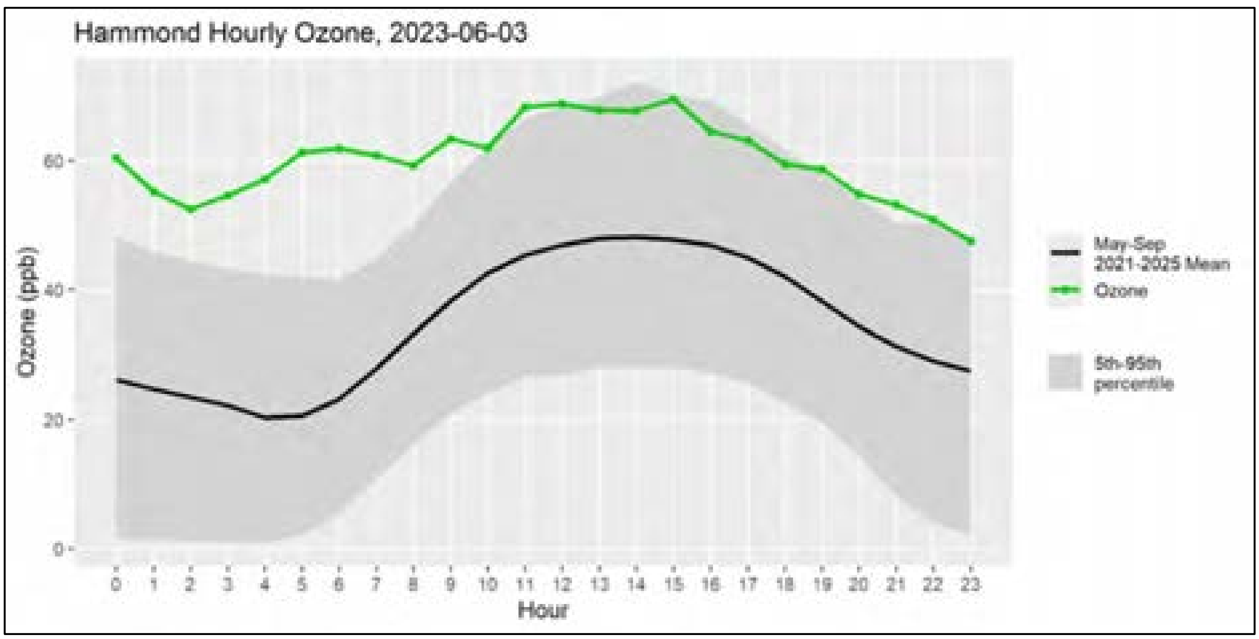
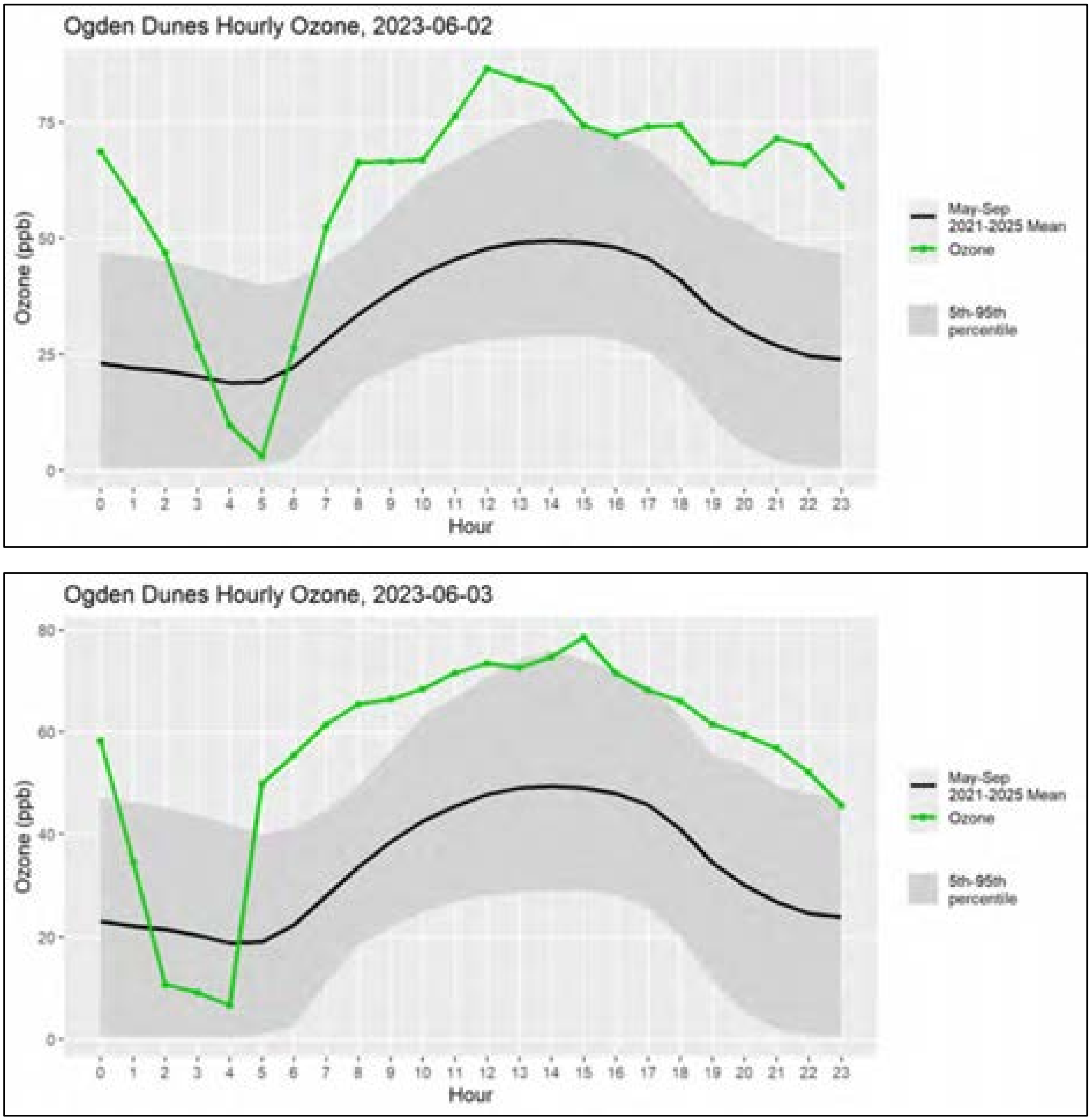
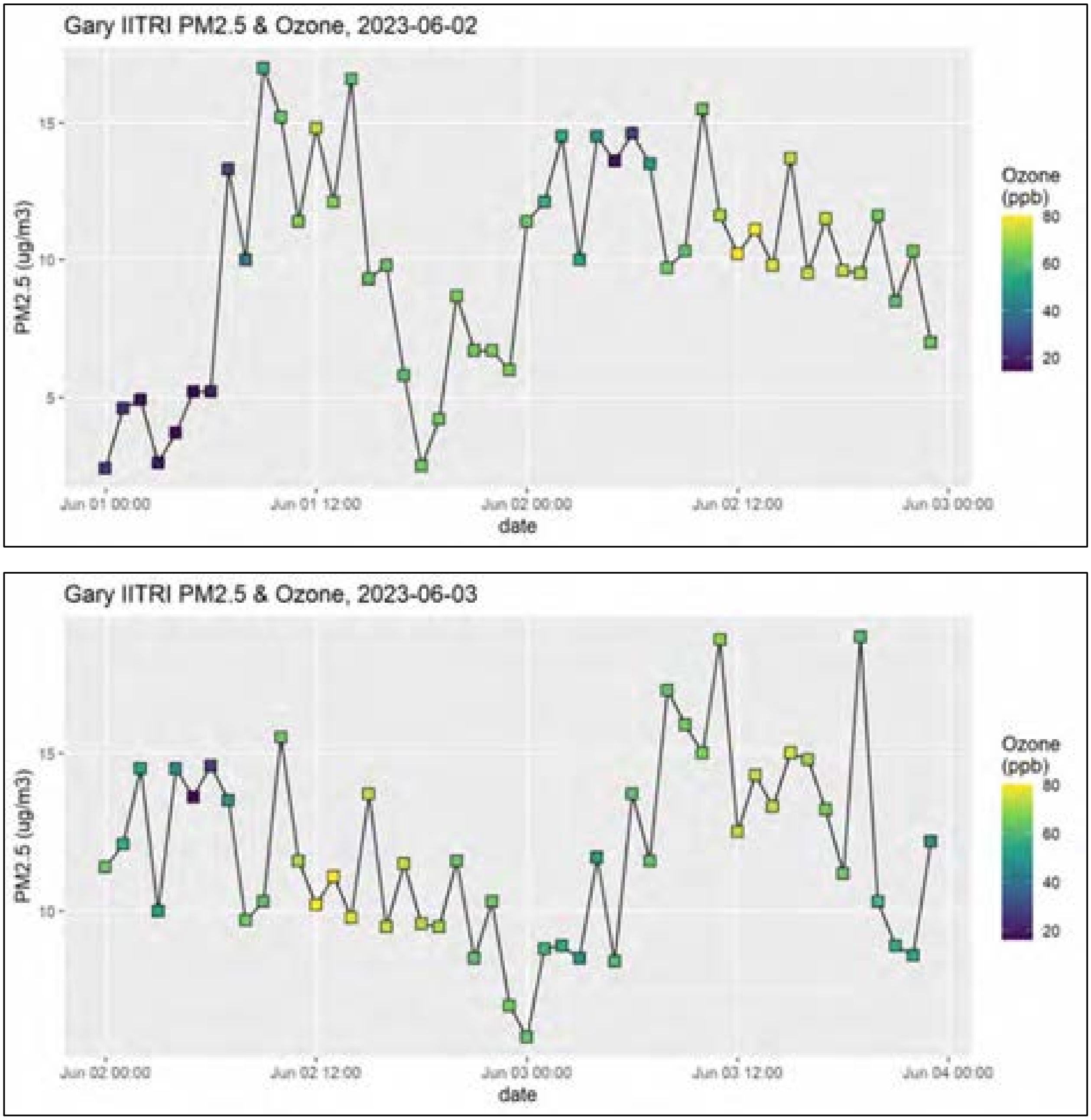


Figure 3.5.12 - Ozone Diurnal Pattern for Ogden Dunes for June 2 and 3, 2023



Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for June 2-3 as shown in Figure 3.5.13. $PM_{2.5}$ concentrations ranged from 10 - 20 μg/m^3 over the two-day period.

Figure 3.5.13 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data June 2-3, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.5.2 shows the percentage above the five-year average. Black Carbon and CO were well above the average, indicating the presence of wildfire smoke.

Table 3.5.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
6/2/2023	113%	48%	198%
6/3/2023	163%	12%	179%

3.5.4 AOD and Satellite Analyses

Figures 3.5.14 and 3.5.15 display satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product for June 2 and June 3. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of light to moderate wildfire smoke. The northwest Indiana area is indicated by the white circle in each figure.

Figure 3.5.14 - Aerosol Optical Depth (AOD) – June 2, 2023

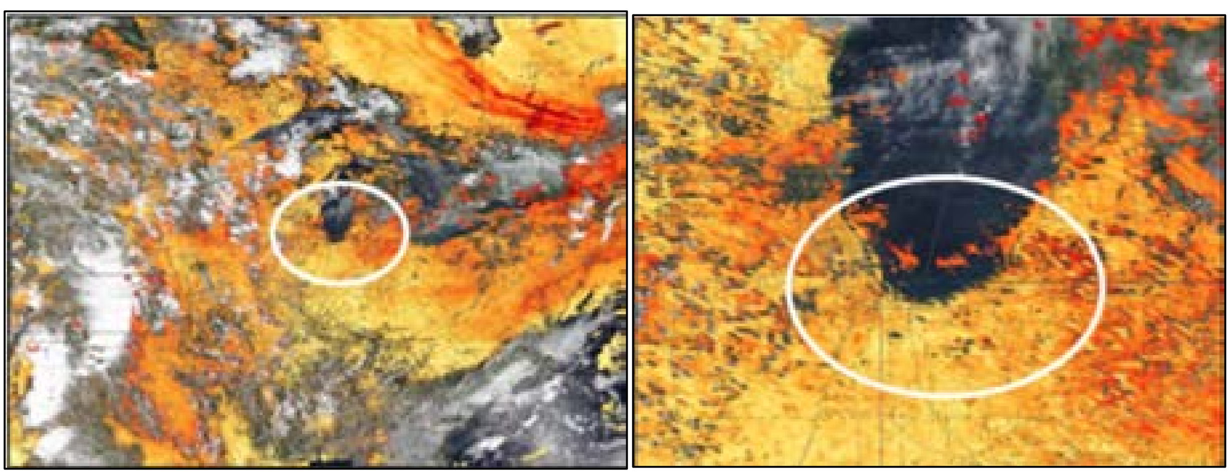
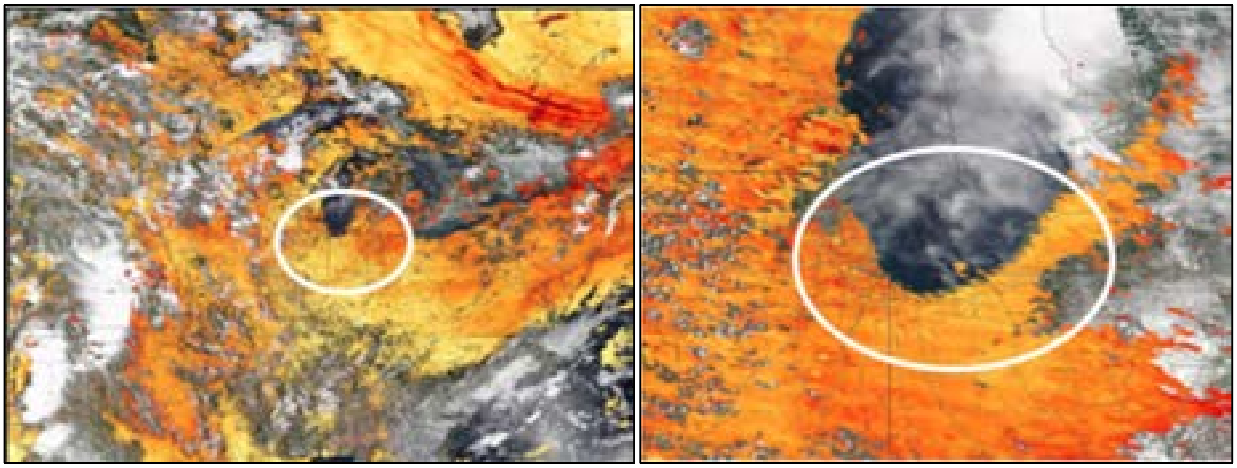


Figure 3.5.15 - Aerosol Optical Depth (AOD) – June 3, 2023



The images below captured by NOAA's GOES 18 satellite for North America taken from June 2 and June 3, show clouds and a plume of gray smoke extending from Canada to the upper Midwest states, including Indiana. The northwest Indiana area is indicated by the red circle on the satellite images Credit: NOAA NESDIS

Figure 3.5.16 - Satellite Imagery of Upper Midwest June 2, 2023

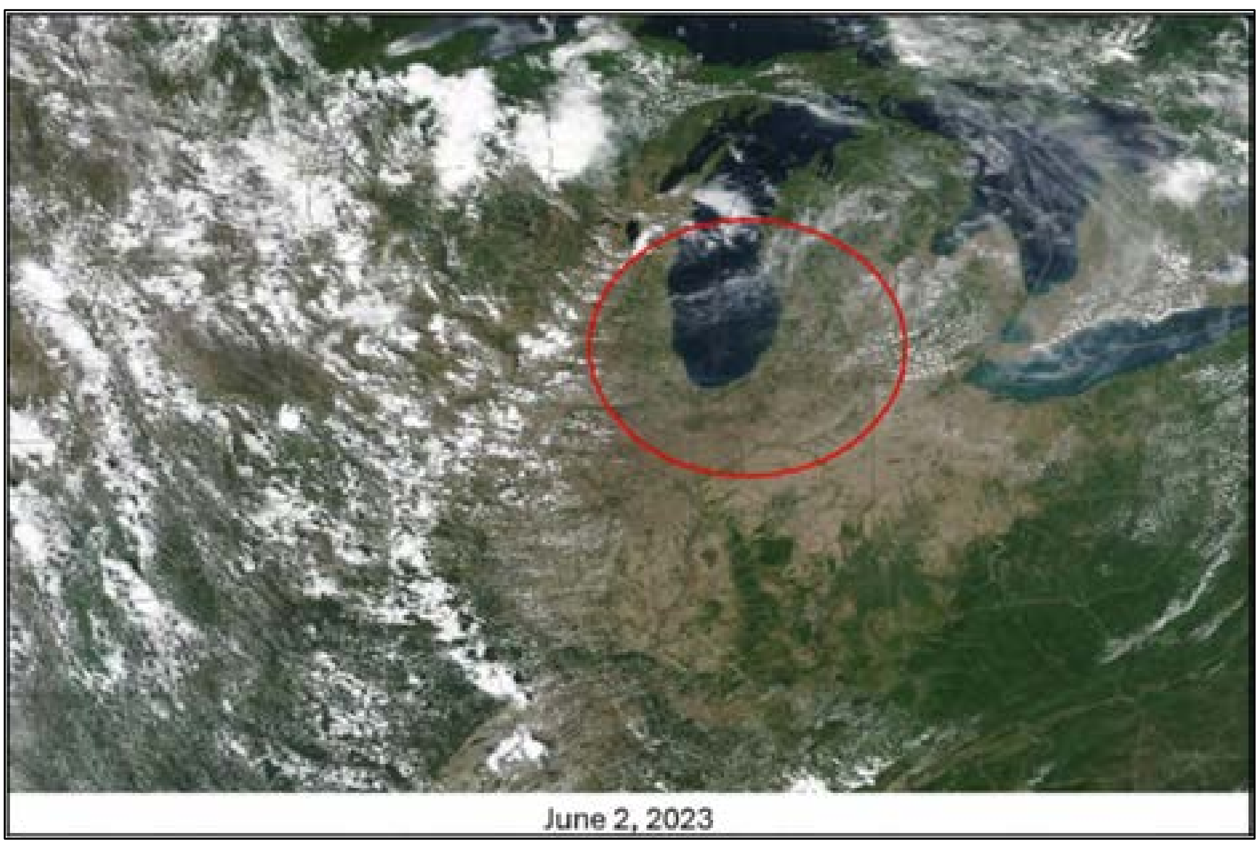
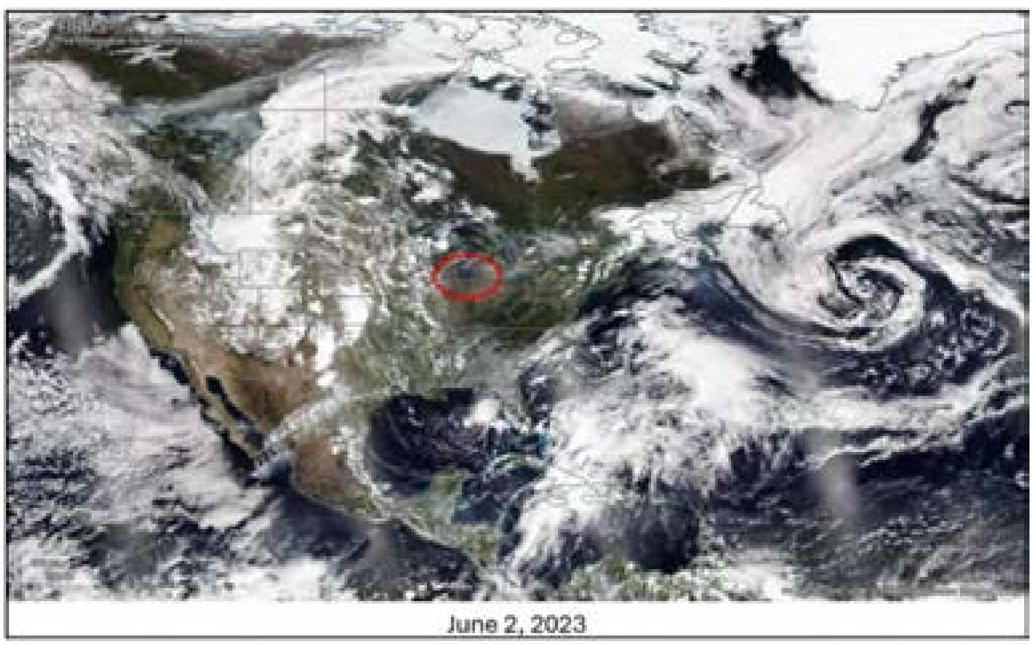


Figure 3.5.17 - Satellite Imagery[12] of Quebec and Ontario, Canada Wildfires June 3, 2023

Figure 3.5.18 - Satellite Imagery of North America- June 2, 2023



12 https://assets.science.nasa.gov/dynamicimage/assets/science/esd/eo/images/imagerecords/151000/151430/quebecfires_amo_2023154.jpg?w=720&h=480&fit=clip&crop=faces%2Cfocalpoint)

The image for June 3 shows smoke working into northern Indiana. The northwest Indiana area is indicated by the red circle on the satellite images.

Figure 3.5.19 - Satellite Imagery of Upper Midwest on June 3, 2023

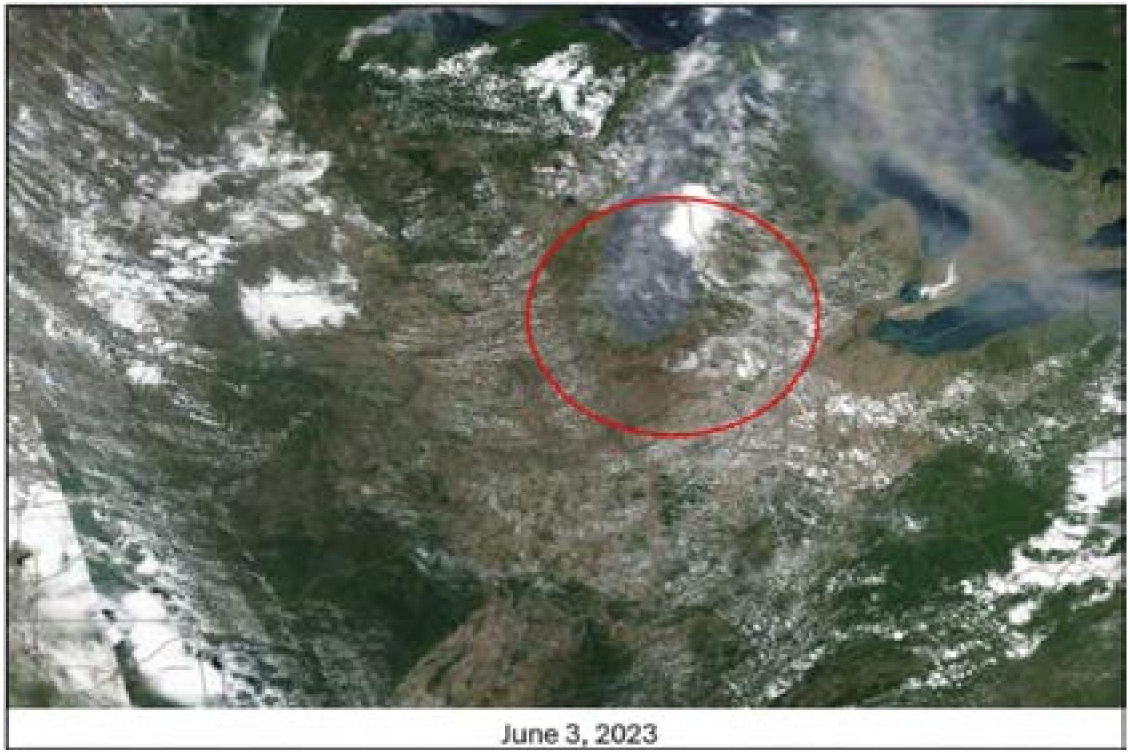
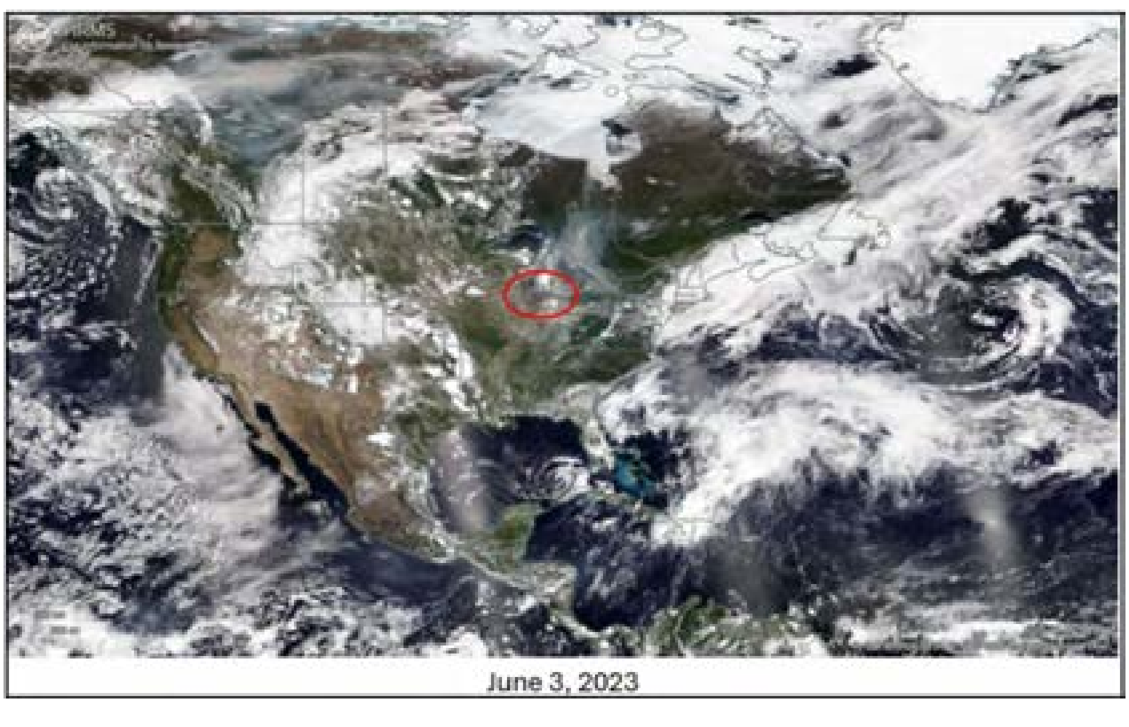


Figure 3.5.20 - Satellite Imagery of North America - June 3, 2023



3.5.5 NOAA Smoke Narrative

Friday, June 2, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 1700Z June 2, 2023

SMOKE:

Canada/Eastern CONUS/North Atlantic…

Wildfire activity in west-central Canada, now along with some activity in the southern half of Quebec, continues to produce moderate to thick smoke that blankets an area covering much of Canada, the eastern half of the CONUS, and portions of the North Atlantic. The thickest smoke resides closer to the wildfires in central and north-central Canada, extending northeast across the Northwestern Territories and Nunavut. Further thick smoke was seen from the southern parts of James Bay to across the Quebec/Ontario border as well as over parts of the Maritime Provinces that specifically was emitted by a large fire north of Sept-Iles, Quebec. **Moderate density smoke was seen over in central and northern Canada, then extending east/southeast across Canada, the Great Lakes, Great Plains, and northeastern CONUS.** In far southern Nova Scotia, a wildfire continues to produce smoke that extends east southeastward out over the Atlantic as well.

Saturday, June 3, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 1630Z June 3, 2023

SMOKE:

Canada/Eastern CONUS/North Atlantic...

Wildfire activity in west-central Canada, now along with some activity in the southern half of Quebec, continues to produce moderate to thick smoke that blankets an area covering much of Canada, the eastern half of the CONUS, and portions of the North Atlantic. The thickest smoke resides closer to the wildfires in central and north-central Canada, extending northeast across the Northwestern Territories and Nunavut. Further thick smoke was seen from numerous fires in the southern/western parts of Quebec enveloped southwestern Quebec continuing into southeastern Ontario and into parts of New York. **Moderate density smoke was seen over in central and northern Canada, then extending east/southeast across Canada, the Great Lakes, Great Plains, over the central/eastern U.S and the Atlantic Ocean off the coast eastern U.S and southeastern Canada.** Some of the smoke from the fires in Mexico and Central America is mixing in with the smoke from the Canadian wildfires somewhere over the south central and southeastern U.S., and the northern Gulf of Mexico.

3.5.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circles on Figures 3.5.21 and 3.5.22 indicate the location of the Lake and Porter County monitors. Estimated concentrations for June 2 are from 9-18 × 10^{15} molecules/cm^2 indicate strong to extreme wildfire smoke influence for June 3, estimated concentrations for June 2 are from 5-18 × 10^{15} molecules/cm^2.

Figure 3.5.21- TROPOMI Satellite Daily Formaldehyde Monitoring June 2, 2023

Figure 3.5.22- TROPOMI Satellite Daily Formaldehyde Monitoring June 3, 2023

3.5.7 AirNow Smoke Maps

In Figures 3.5.23 through 3.5.30, AirNow shows the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.5.23 - Airnow Ozone Map - June 2, 2023

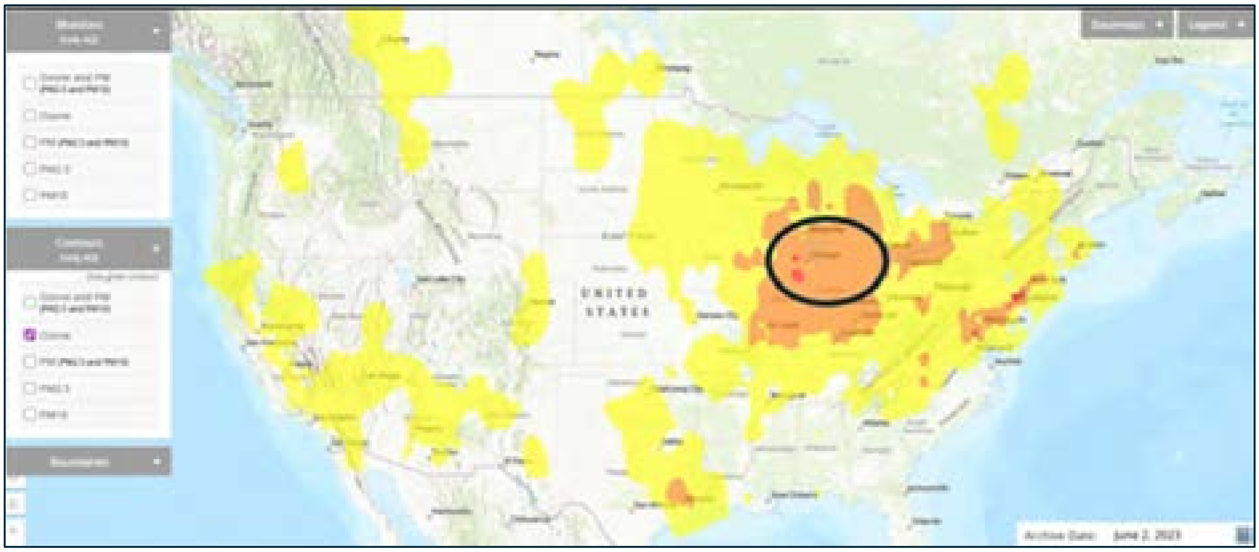


Figure 3.5.24 - AirNow Ozone Map - June 2, 2023

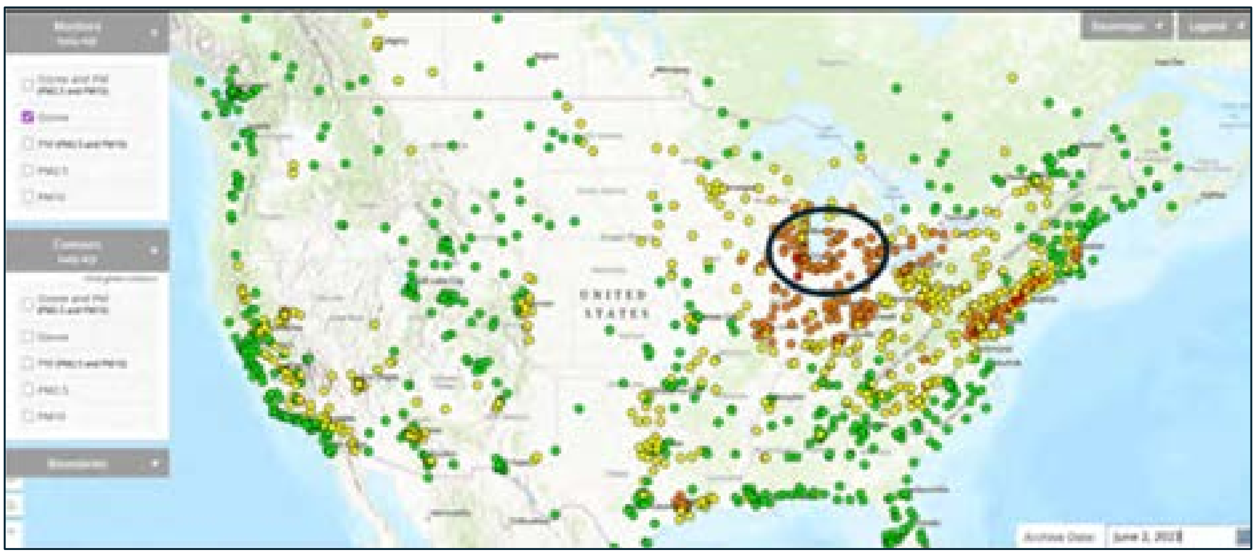


Figure 3.5.25 - AirNow $PM_{2.5}$ Map - June 2, 2023

Figure 3.5.26 - AirNow Smoke and Ozone - June 2, 2023

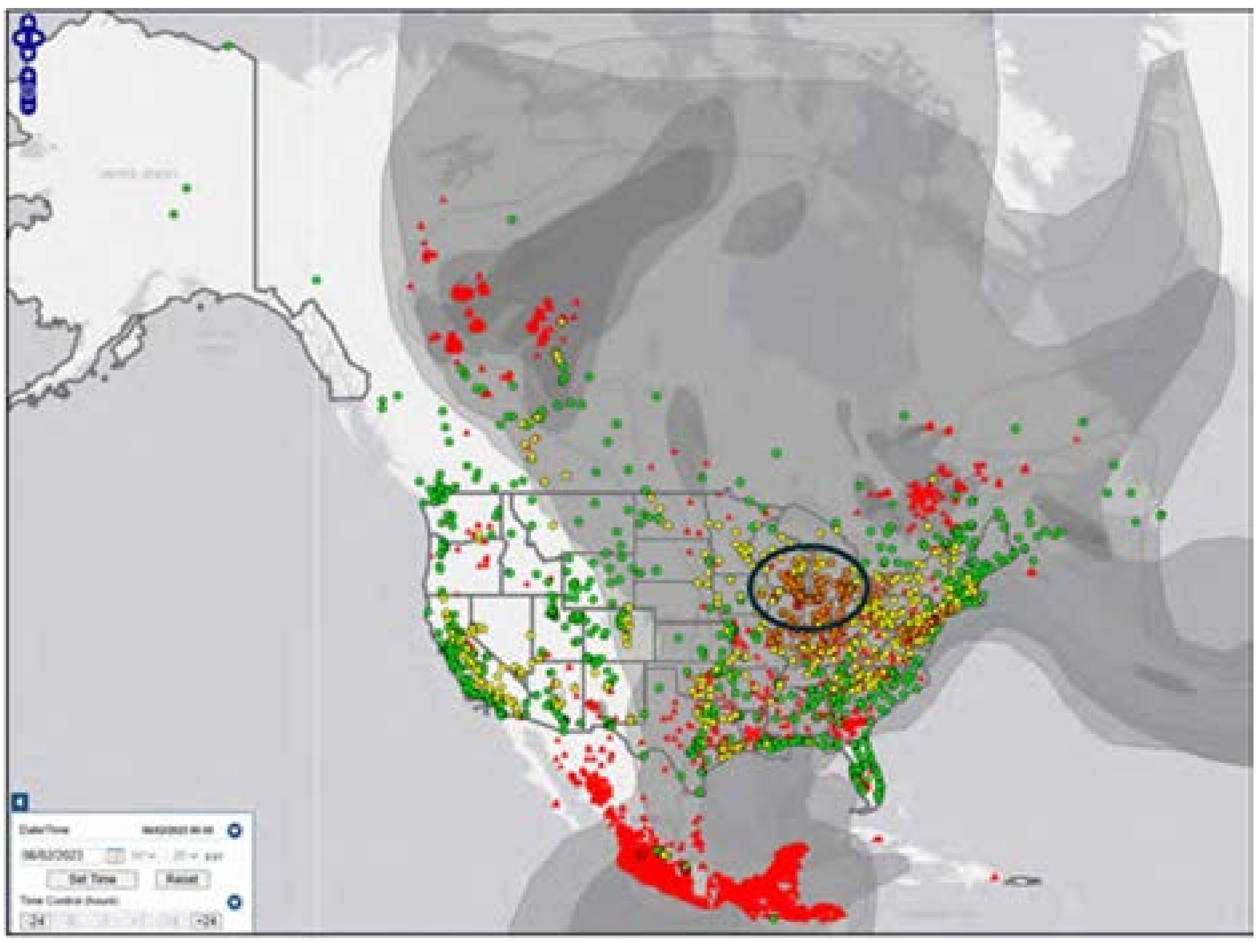


Figure 3.5.27 - Airnow Smoke Ozone and $PM_{2.5}$ June 3, 2023

Figure 3.5.28 - AirNow Ozone Map - June 3, 2023

Figure 3.5.29 - AirNow $PM_{2.5}$ Map - June 3, 2023

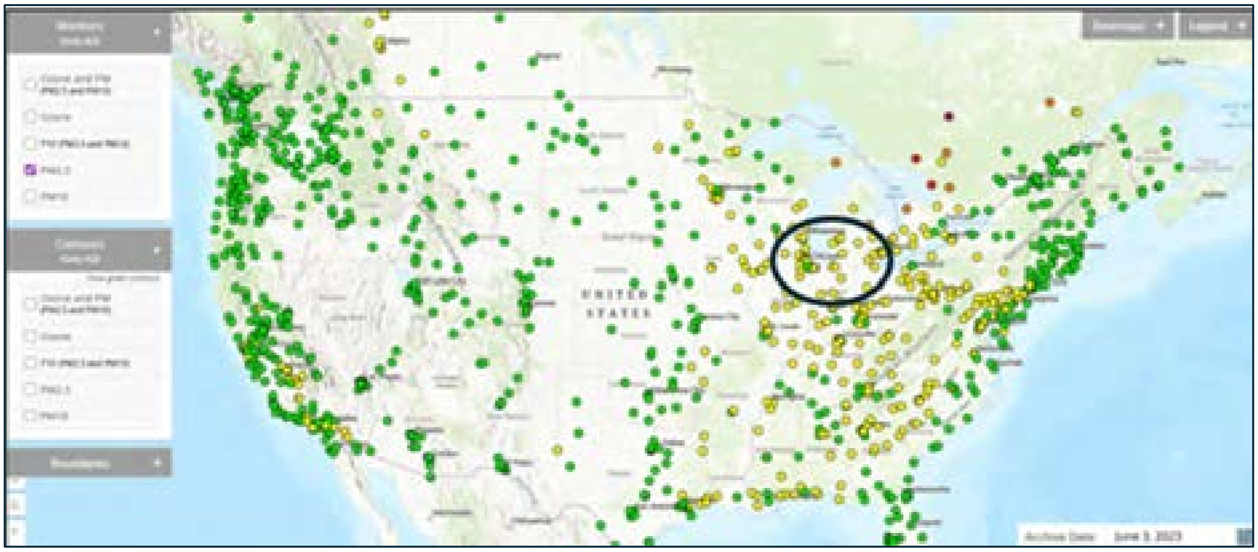
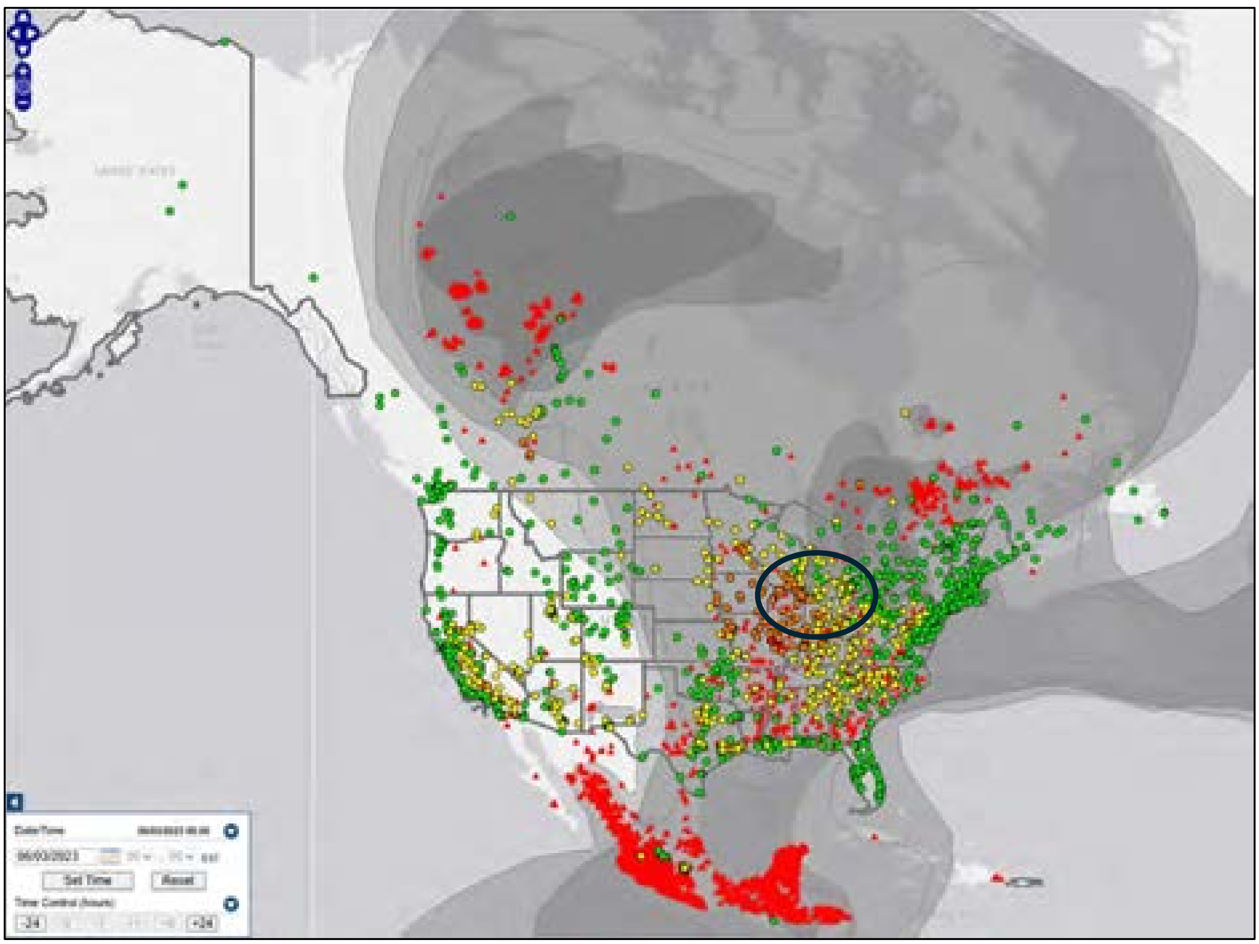


Figure 3.5.30 - AirNow Smoke and Ozone Map - June 3, 2023



3.5.8 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes.

Figures 3.5.31 through 3.5.38 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the black circles on each of the maps.

Figure 3.5.31 - GAM Smoke Maps Indicating Smoke Days June 2, 2023

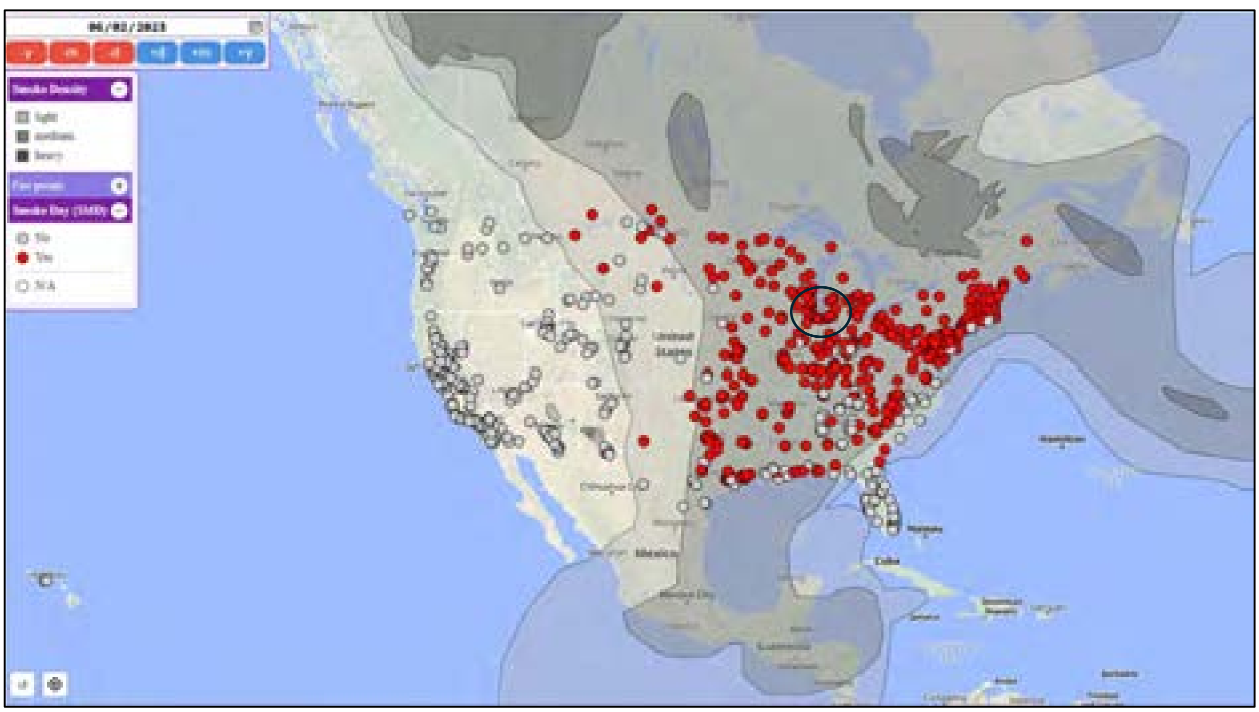


Figure 3.5.32 - GAM Smoke Maps Indicating Smoke Days June 3, 2023

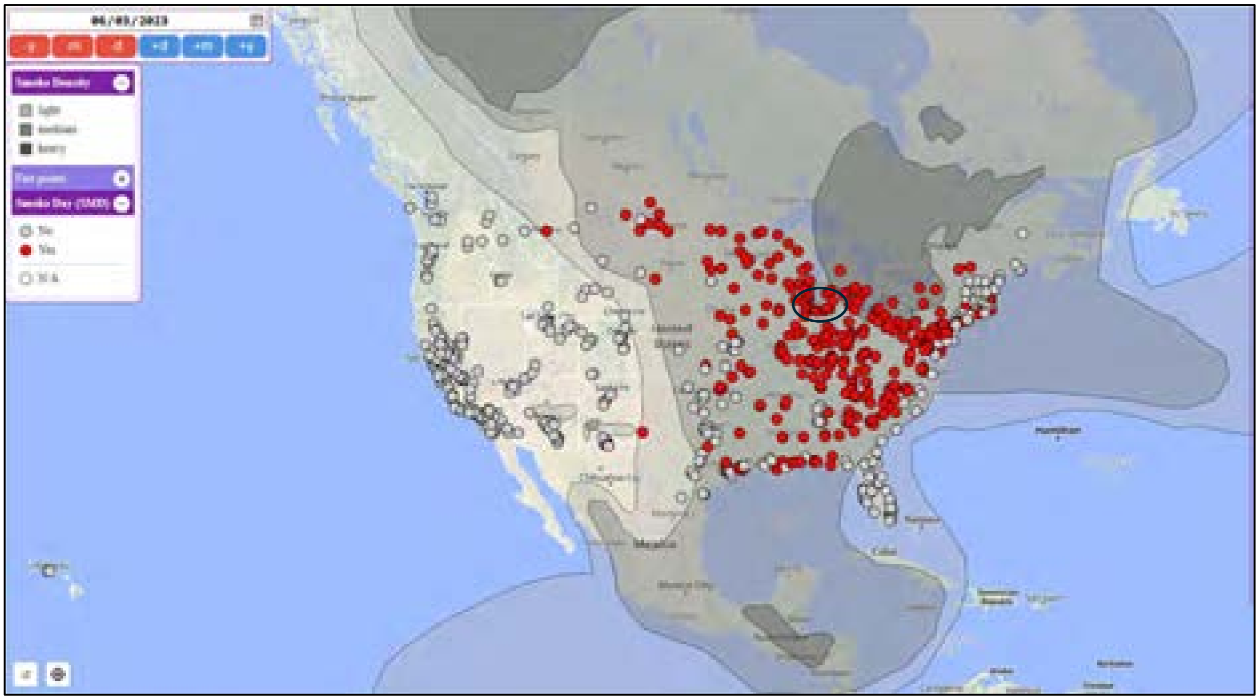


Figure 3.5.33 - GAM Observed ozone with Smoke Days June 2, 2023

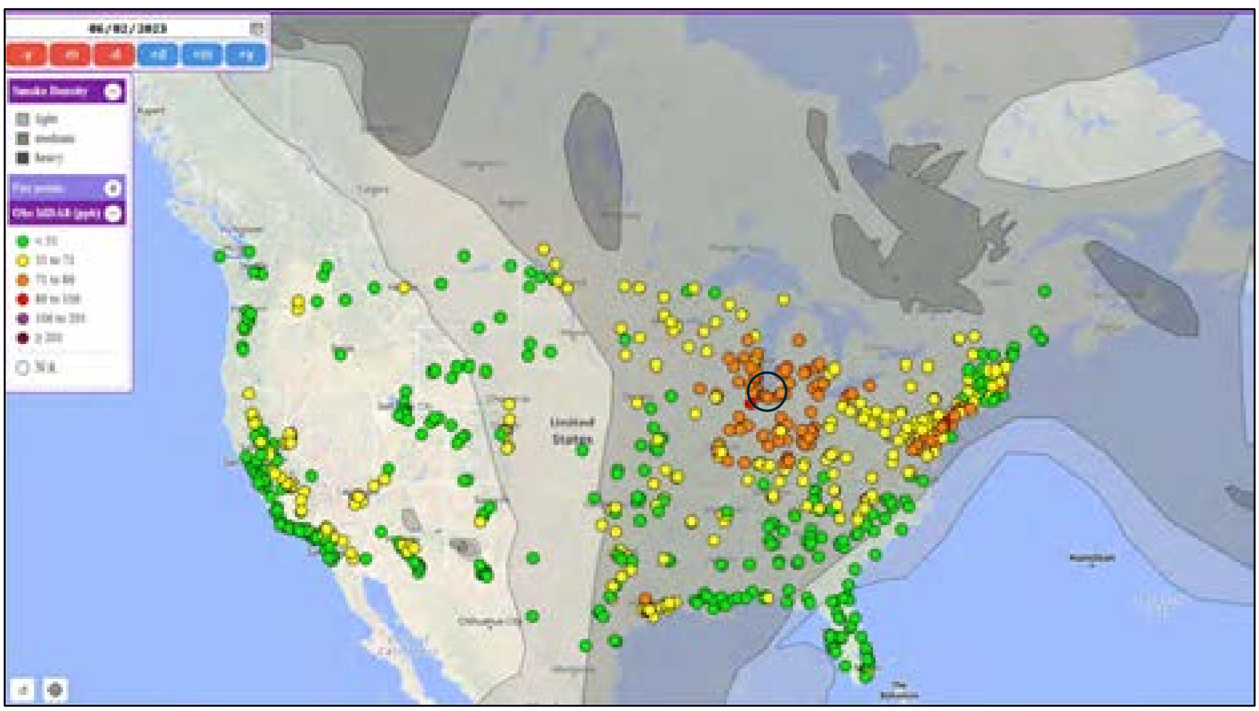


Figure 3.5.34 - GAM Observed ozone with Smoke Days June 3, 2023

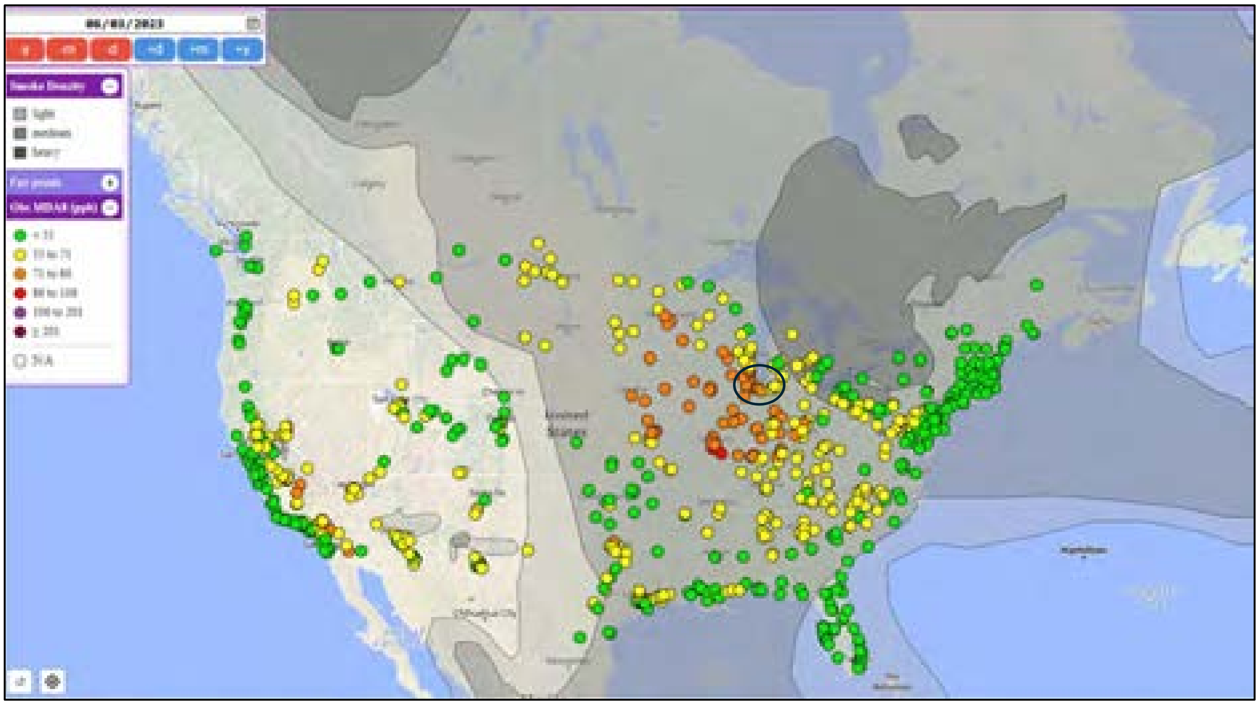


Figure 3.5.35 - GAM Smoke Estimates June 2, 2023

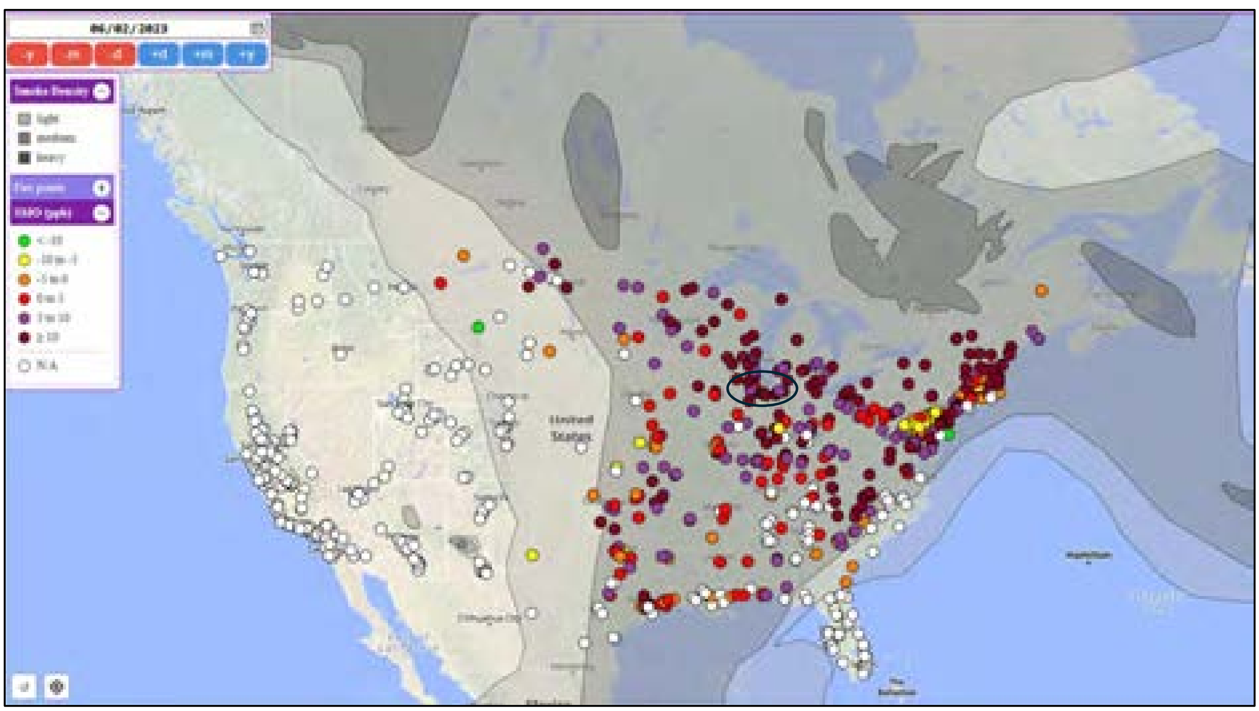


Figure 3.5.36 - GAM Smoke Estimates June 3, 2023

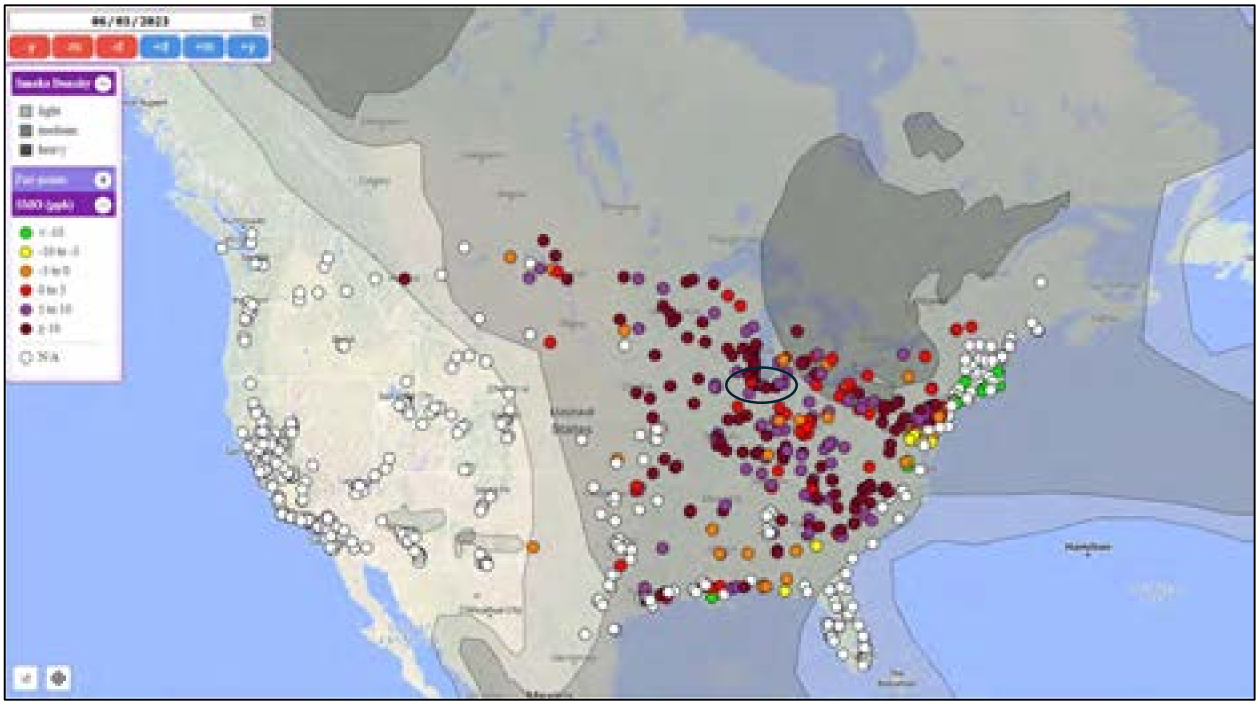


Figure 3.5.37 - EMBER Smoke Estimates June 2, 2023

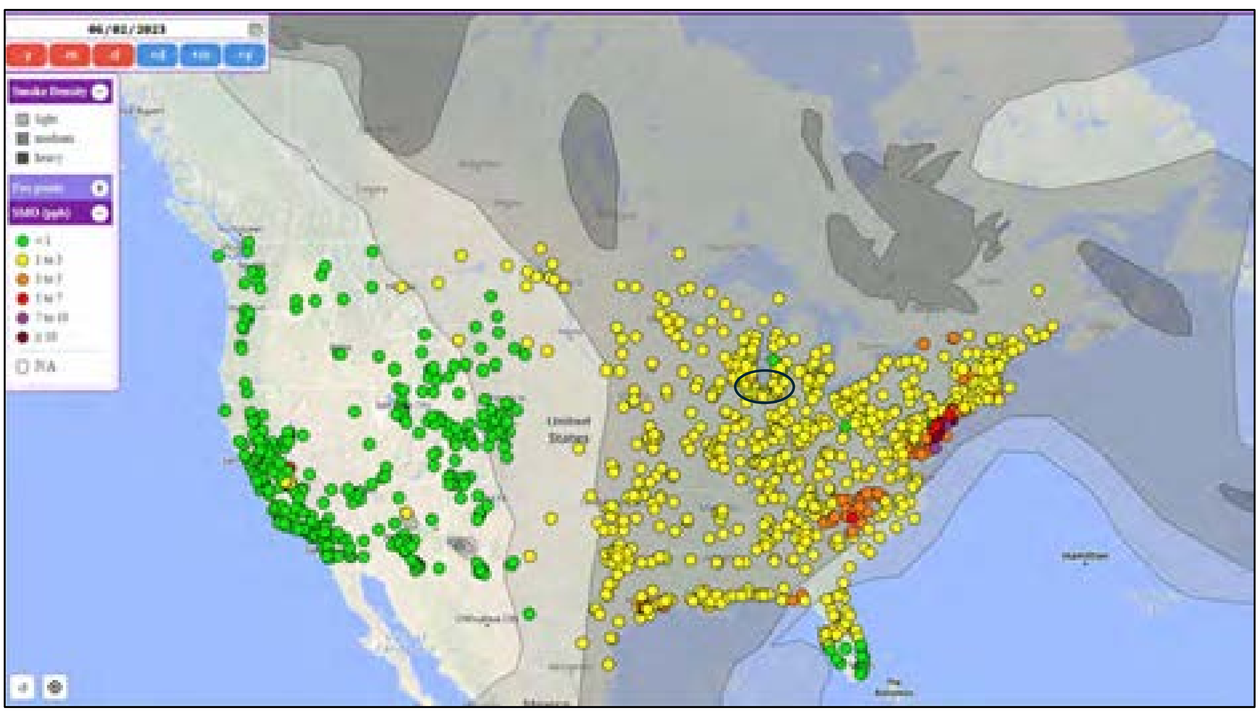


Figure 3.5.38 - EMBER Smoke Estimates June 3, 2023

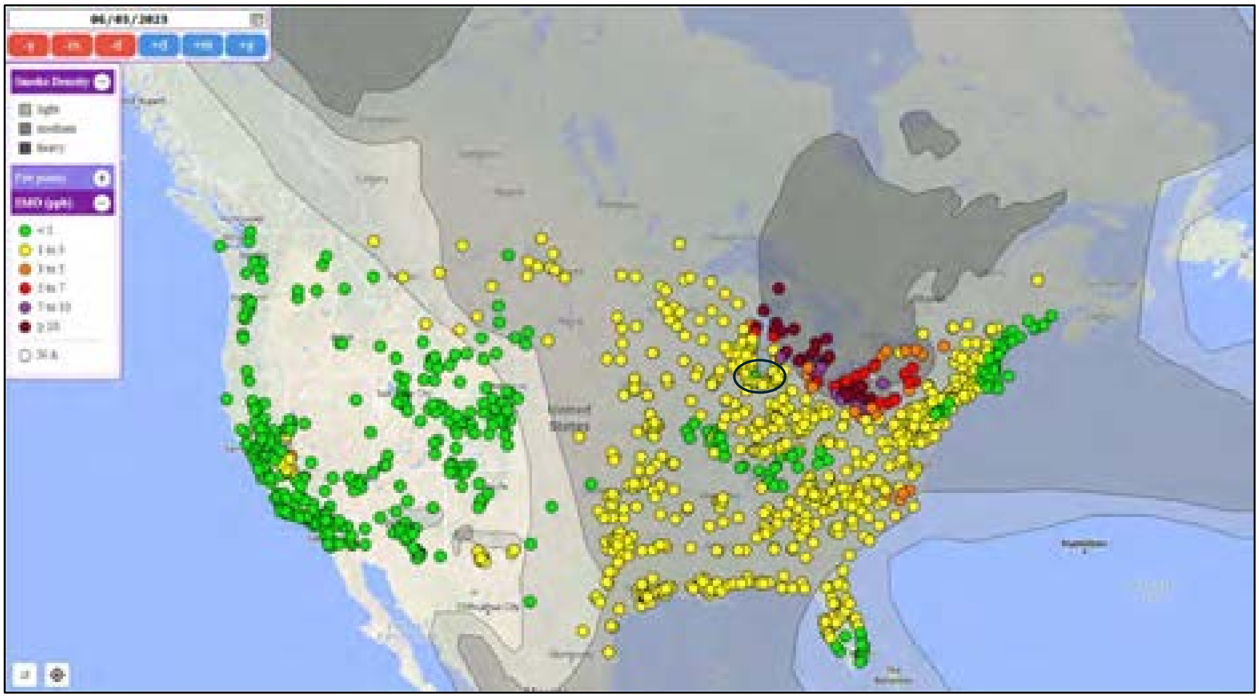


Table 3.5.2 and 3.5.3 summarize the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.5.2 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values June 2, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	74	66.1	7.9	71	3
180892008	Hammond	68	NA	NA	67	1
181270024	Ogden Dunes	77	65.5	11.5	71	6
181270026	Valparaiso	79	66.7	12.3	66	13

Table 3.5.3 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values June 3, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	70	64.3	5.7	71	-1
180892008	Hammond	66	NA	NA	62	4
181270024	Ogden Dunes	71	62.3	8.7	71	0
181270026	Valparaiso	71	59.8	11.2	63	8

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on June 2 and 3, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.5.3 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 19 ppb lower than the MDA8 ozone concentrations observed on June 2 with the maximum matching day MDA8 ozone concentration of 80.9 ppb. On June 3, the average ozone concentration on the matching days was 20 ppb lower and the maximum matching day MDA8 ozone concentration of 72 ppb. Both maximum days were smoke influenced and not included in the average.

Table 3.5.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 2, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	77	80.9*	58.9

* Indicates Matching days were influenced by wildfire smoke

Table 3.5.5 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 3, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	71	72*	51.2

* Indicates Matching days were influenced by wildfire smoke

3.5.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red), as well as higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. June 2 and 3 three-day back trajectories indicate smoke from the east being drawn down to northwest Indiana. The trajectories in Figure 3.5.43 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over wildfire smoke, pulling from fires in eastern Canada. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.5.39 – Back Trajectories from June 2 (50, 100 and 500 meters - 72 hours)

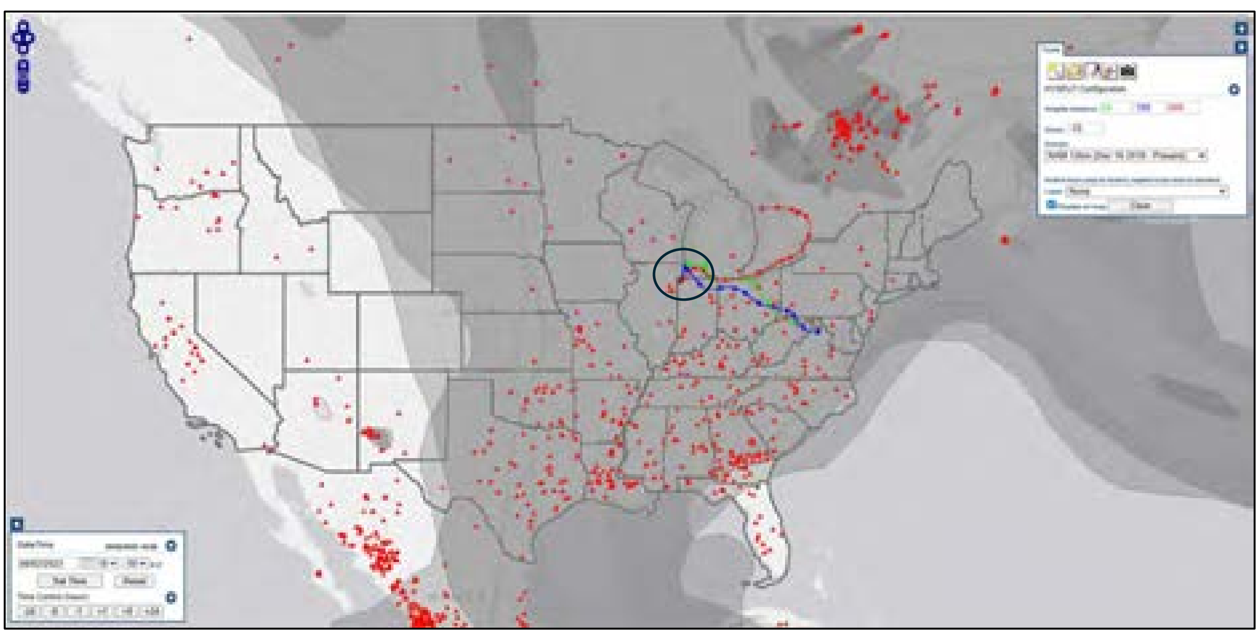


Figure 3.5.40 - Back Trajectories from June 2 (1000, 2000 and 3000 meters - 72 hours)

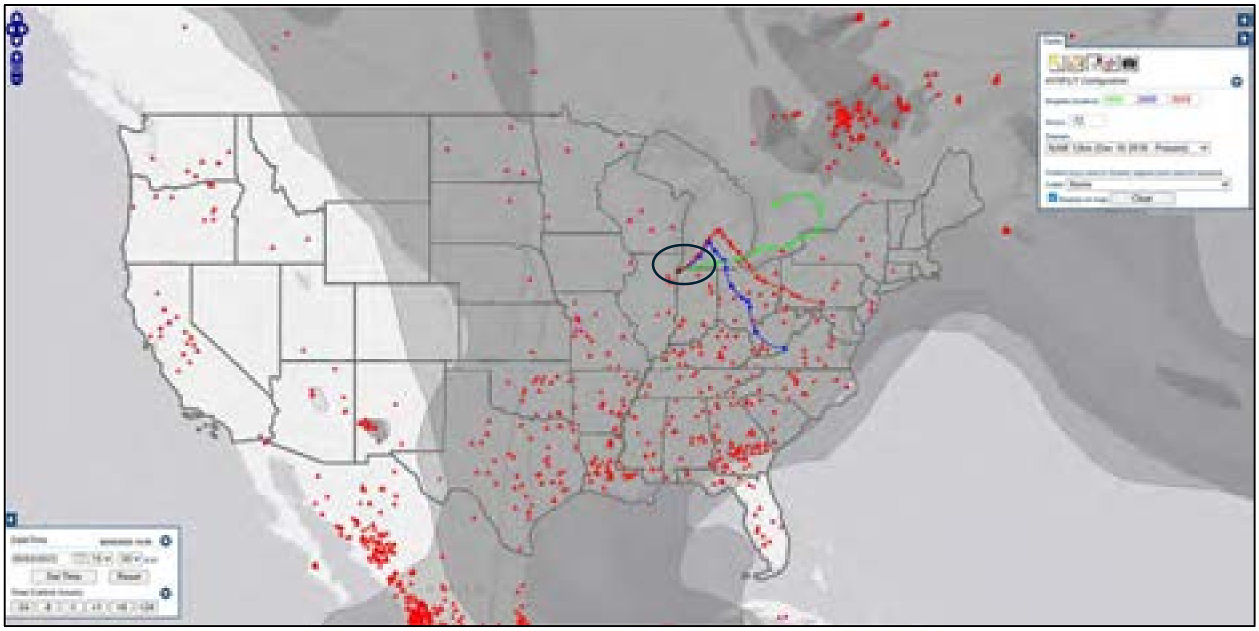


Figure 3.5.41 - Back Trajectories from June 3 (50, 100 and 500 meters - 72 hours)

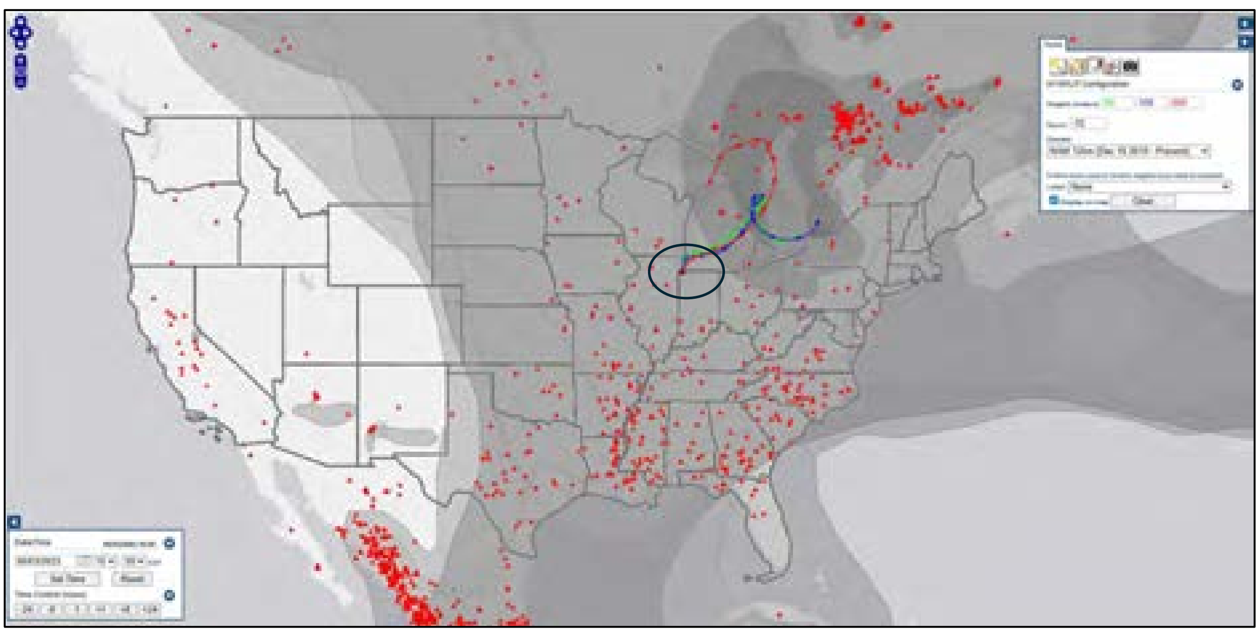


Figure 3.5.42 - Back Trajectories from June 3 (1000, 2000 and 3000 meters - 72 hours)

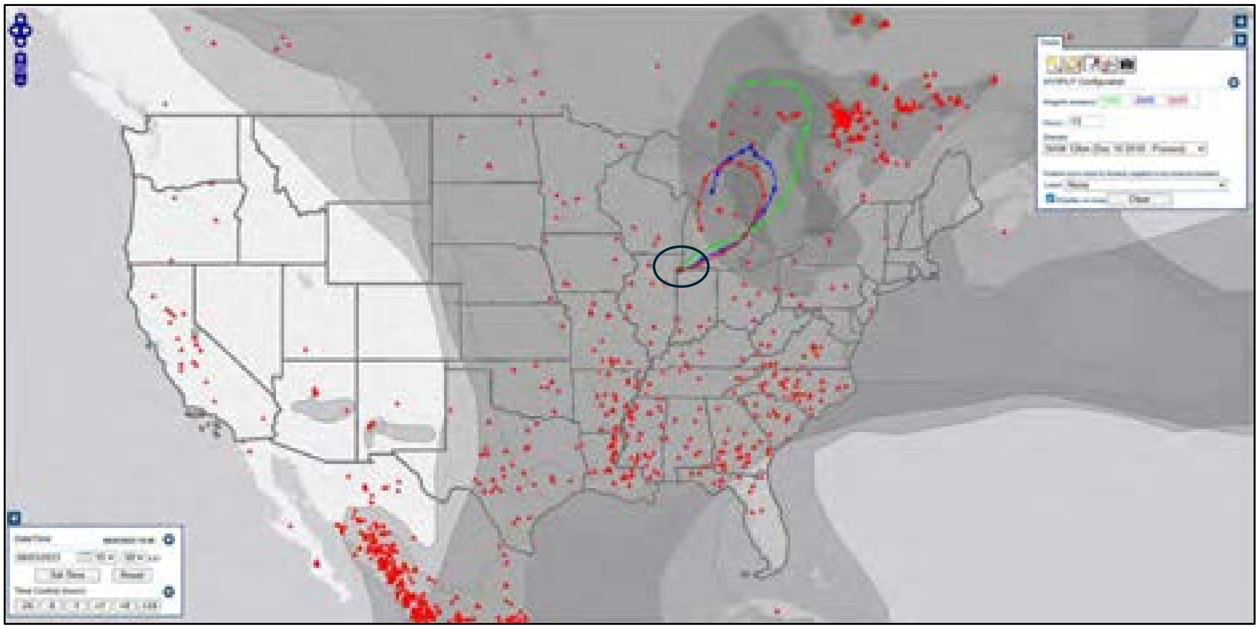


Figure 3.5.43 - Long-Range Back Trajectories from June 2 (100, 500 and 1000 meters - 168 hours)

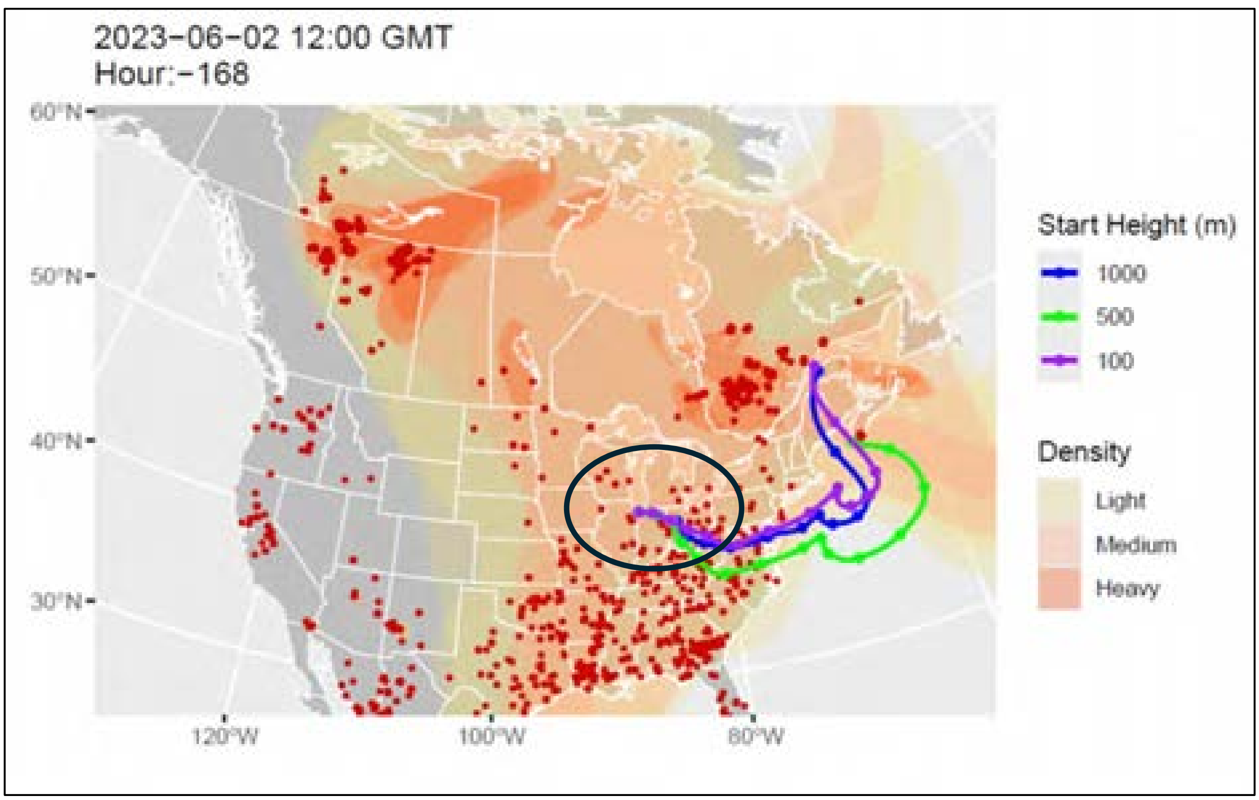
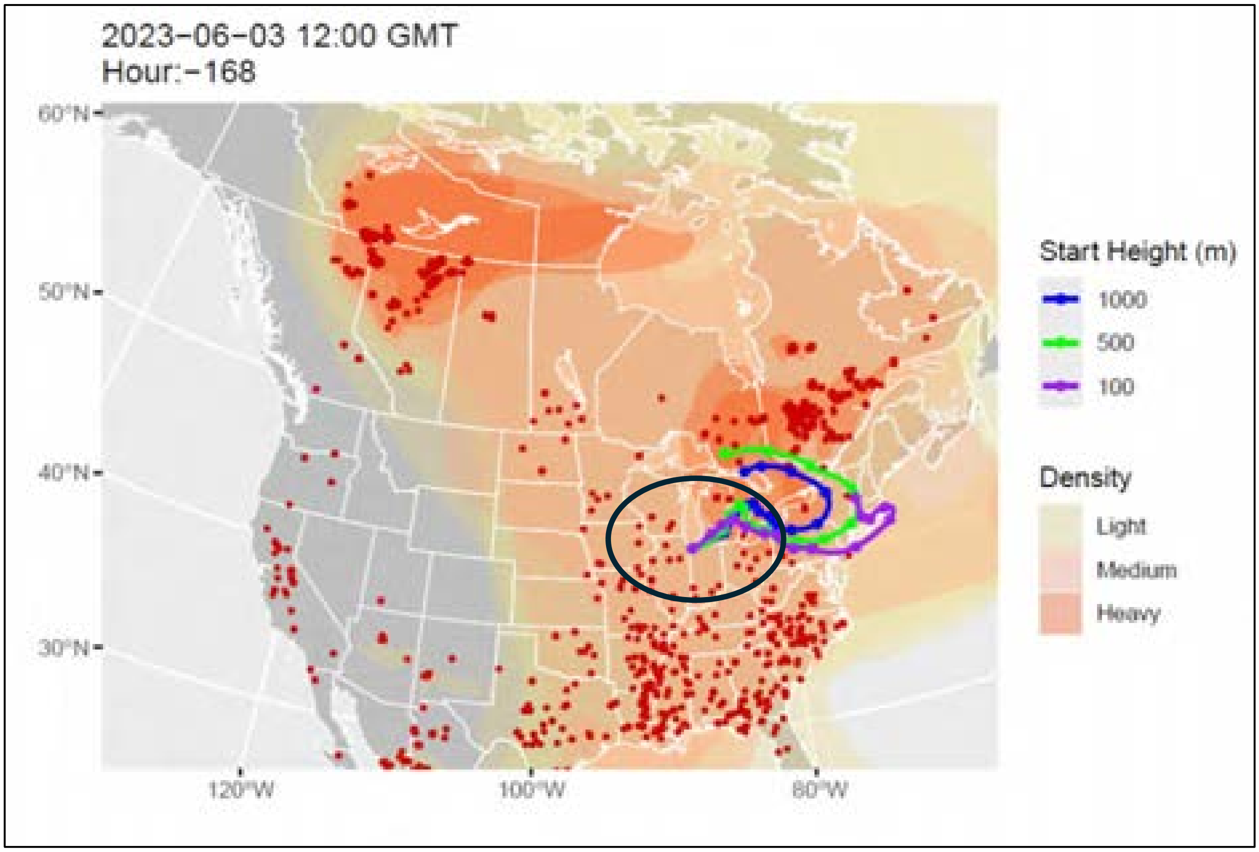


Figure 3.5.44 - Long-Range Back Trajectories from June 3 (100, 500 and 1000 meters - 168 hours)



3.5.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figures 3.5.44 and 3.5.45 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.5.44 HRRR Smoke Model June 2, 2023

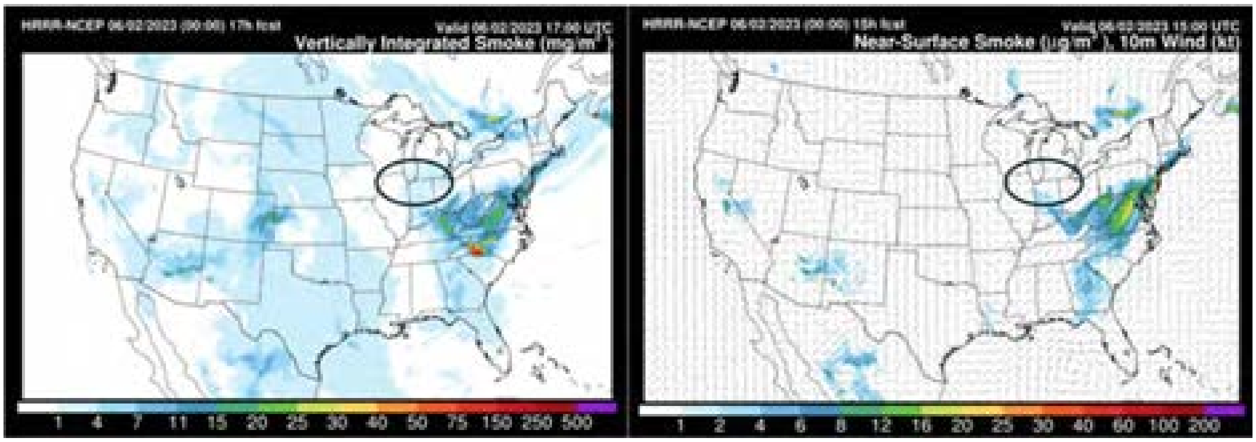
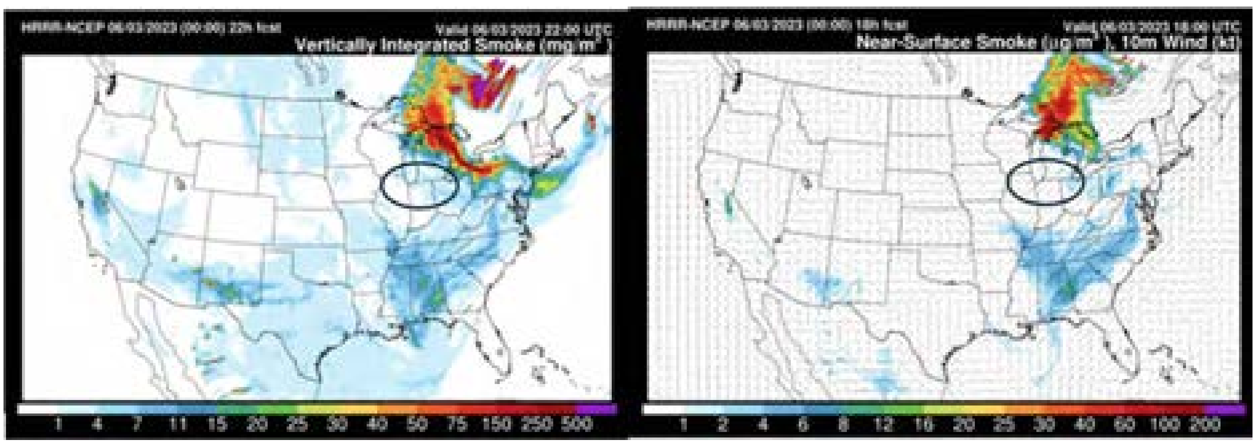


Figure 3.5.45 HRRR Smoke Model June 3, 2023



3.5.12 Media Mentions

Wildfire map spotlight: Barrington Lake Wildfire

Wildfires spread in eastern Canada, forcing evacuations in coastal Quebec

Québec Fires, QC, Started Early June 2023

What's believed to have sparked the Canadian wildfires

Wildfire Smoke Transport from Canada to US

High ozone levels, wildfire smoke spur air quality alerts in Chicago

3.5.13 Summary of Requested Exclusions of June 2–3, 2023

Table 3.5.5 - Summary Table - Gary IITRI

Event Date	**June 2, 2023**	**June 3, 2023**
MDA8 Ozone Concentration (PPB)	74	70
Does Ozone Concentration exceed the 95th Percentile?	Yes	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes	Yes
GAM predicted MDA8 ozone (PPB)	64.3	66.1
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	3	-1
Matching day MDA8 ozone (max., avg.) (PPB)	80.9*, 58.9	72.3*, 51.2
HYSPLIT indicated wildfire regions	Barrington Lake Fire, Sept-Iles Fire, Lebel-sur-Quevillon Fire and	
Do HRRR Models indicate smoke?	Yes	Yes
Media Mentions	Yes	Yes
Clear causal relationship established?	Yes	Yes

3.6 June 10, 2023 Ozone Event

3.6.1 Executive Summary

On June 10, 2023, Northwest Indiana experienced ozone exceedances across some of the Lake and Porter County monitors, with values ranging from 62 to 77 ppb, surpassing the 70 ppb NAAQS at multiple locations. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian fires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 1-14 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to James Bay Priority Fires, Quebec.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of June 10, 2023, as an exceptional event under U.S. EPA guidelines.

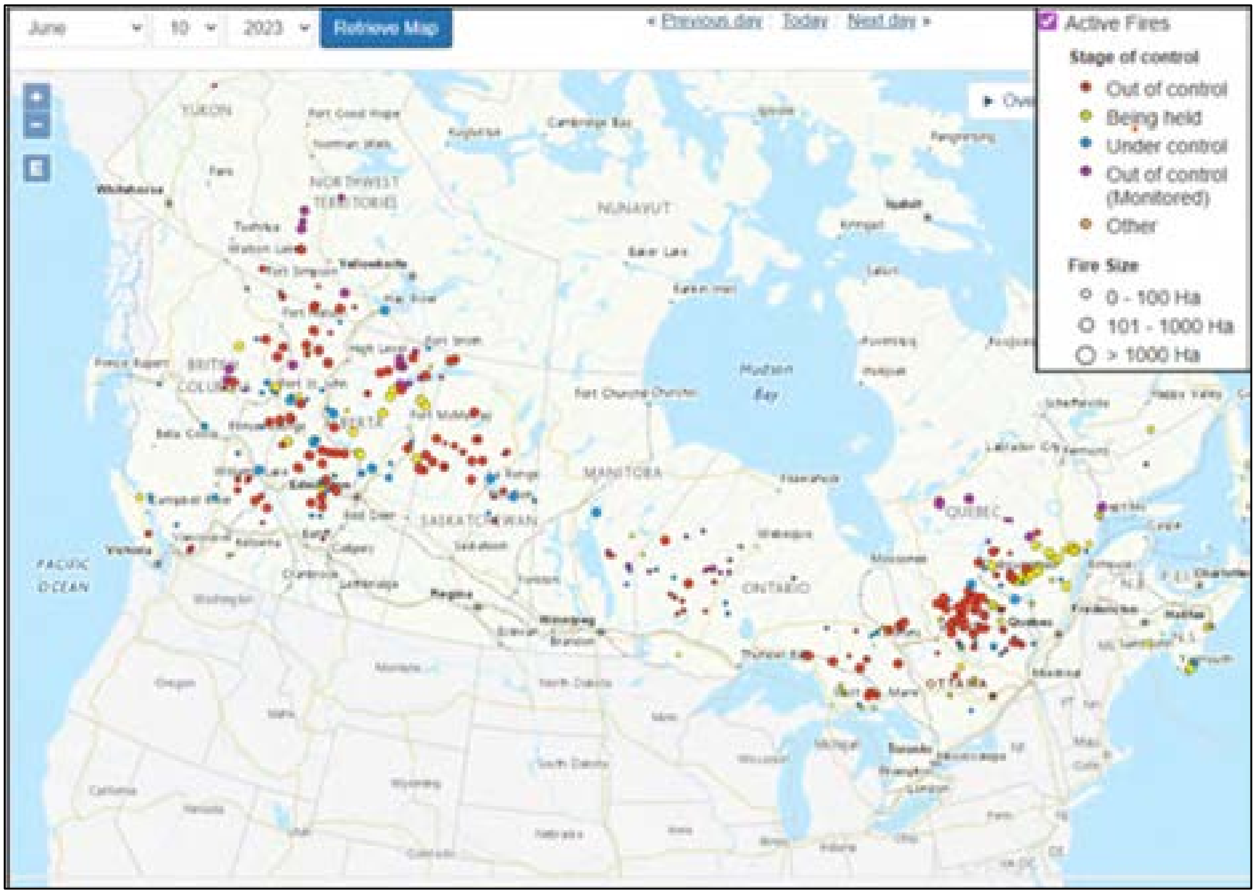
Table 3.6.1 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

Date	Gary-IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
6-10-2023	76	70	77	62

On June 10, 2023, multiple Canadian wildfires, as shown in Figure 3.6.1, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in mid-June included the:

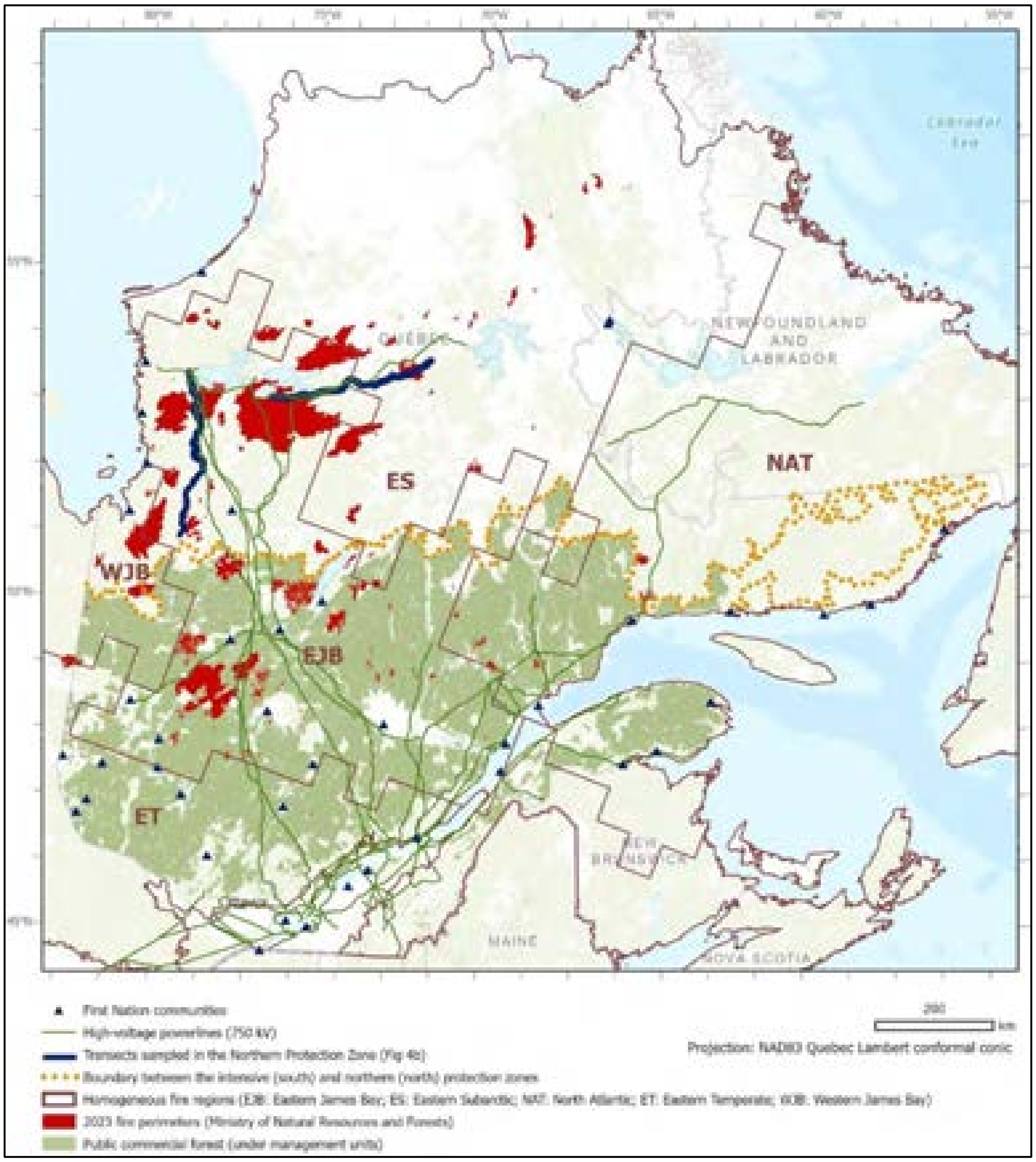
- James Bay Priority Fires, which began on June 1, 2023, when a historic lightning outbreak ignited 182 separate fires across northern Quebec, many near the Cree communities of Eastmain, Wemindji, and Waskaganish. Extreme drought, high winds, and low humidity allowed several fires to expand rapidly, with many reaching 20,000–100,000+ hectares.

Figure 3.6.1 – Canadian Wildfires June 10, 2023



Source: [Canadian Wildland Fire Information System | Interactive map]

Figure 3.6.2 – Quebec Province Wildfires June 10, 2023



3.6.2 Meteorological Episode Overview

For June 10, 2023, there was board upper-level ridging over the northern Plains while a persistent trough remained over southeast Canada. This set-up ushered in wildfire smoke from southeastern Canada that was pulled southwest as surface high pressure systems over the northeastern U.S. Remnant wildfire smoke remained over the Midwest as the area experienced light to moderate smoke under surface high pressure with moderate subsidence. Temperatures were in the low to mid 80's ^{o}F as winds turned from the north to the south, circulating the remnant smoke. Figure 3.6.3 (June 9th) and Figure 3.6.4 (June 10) show surface, 850 mb and 500 mb weather maps, depicting surface and upper air features that enhanced smoke transport into the northwest Indiana area.

Figure 3.6.3 - Surface, 850 and 500 mb Plots from 12Z on June 9, 2023

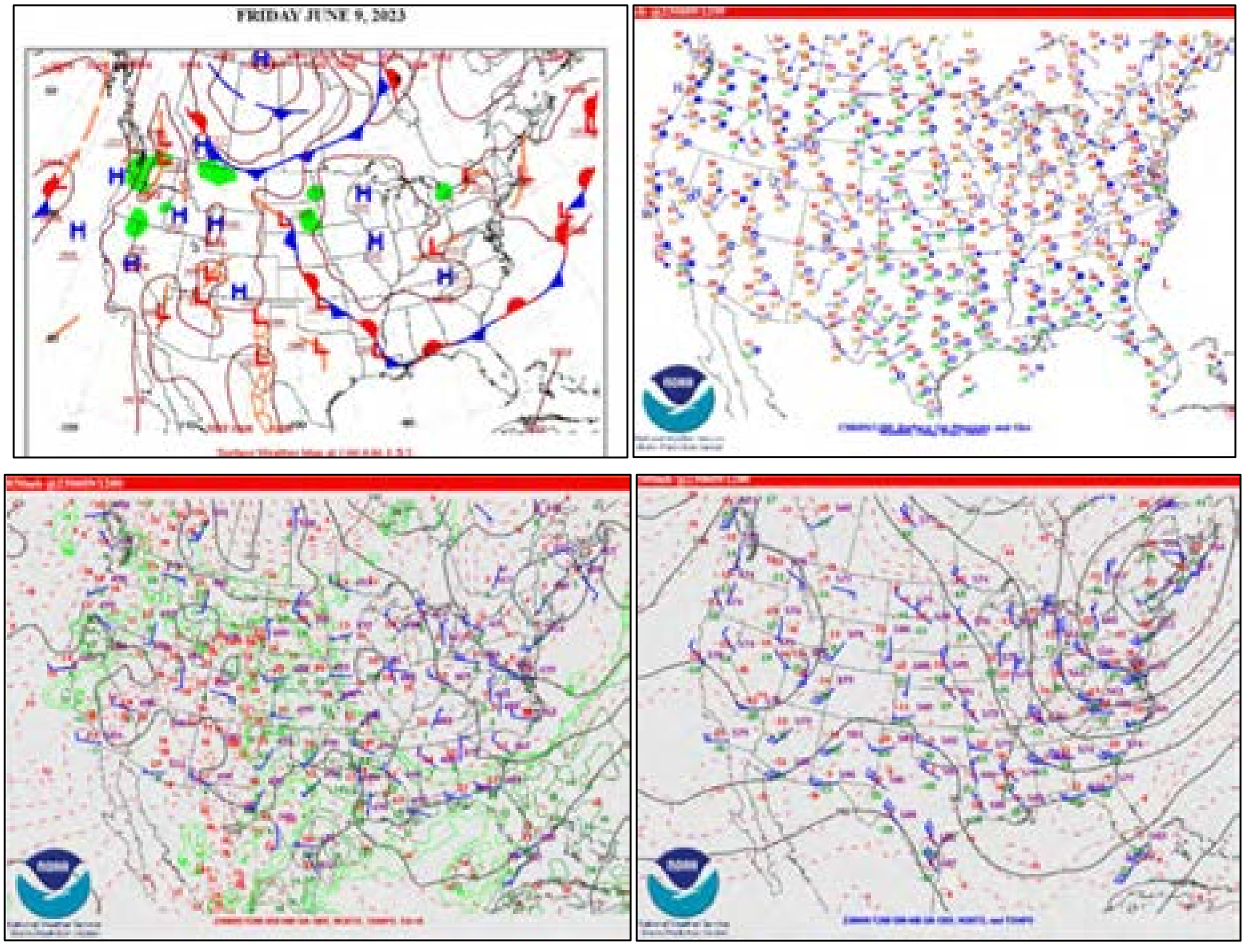
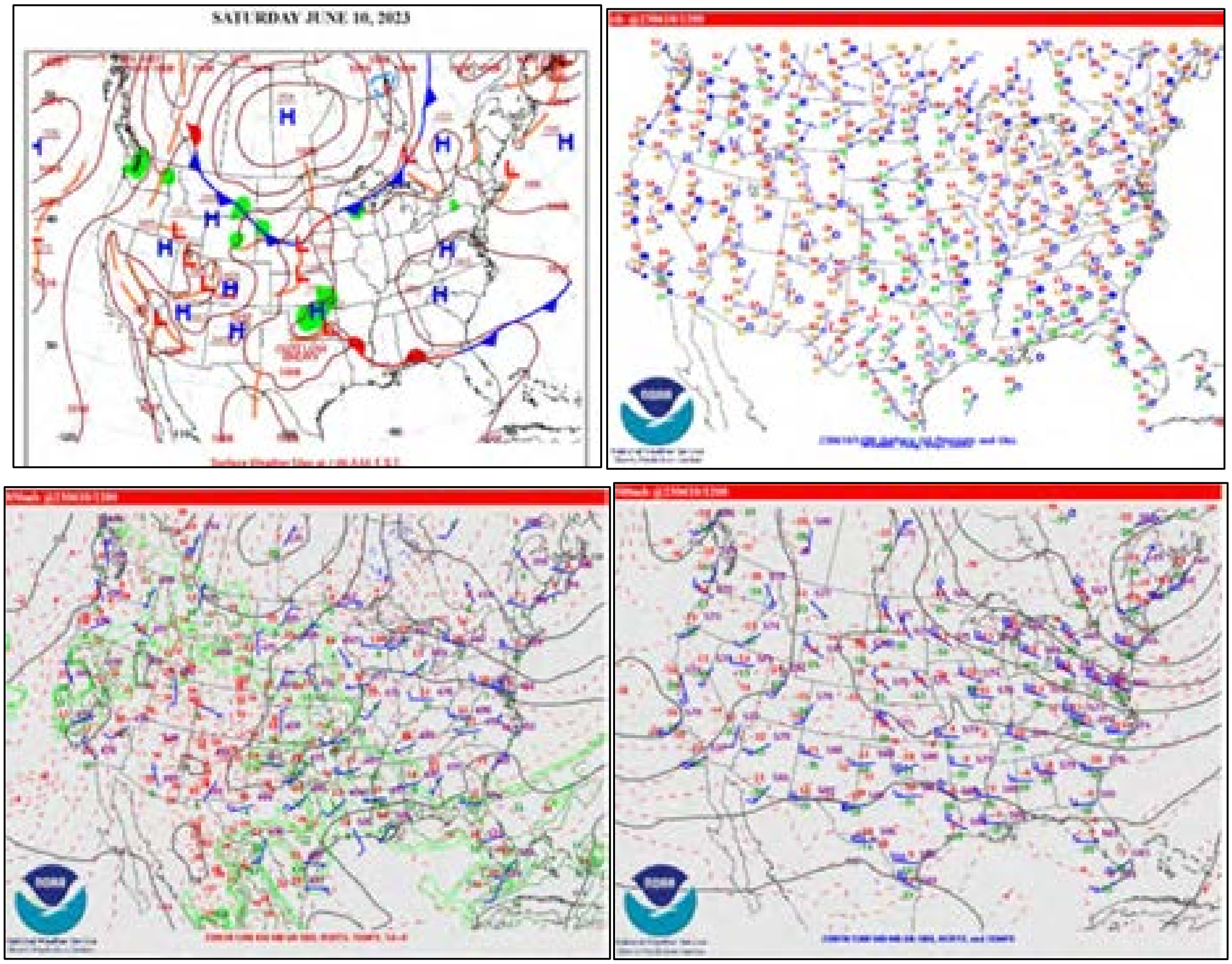
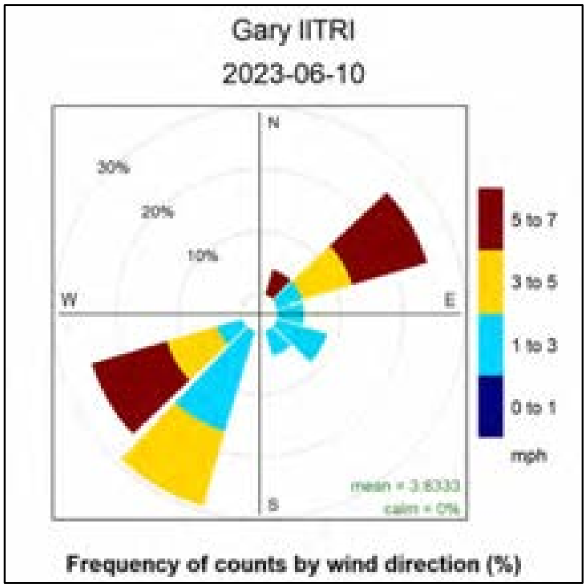


Figure 3.6.4 - Surface, 850 and 500 mb Plots from 12Z on June 10, 2023



In Figure 3.6.5, wind rose and pollution rose analyses were taken from the Gary IITRI meteorological station for June 10. Wind directions on the 10 were varied, with the first half of the day seeing winds primarily from southwest and the second half of the day seeing winds primarily from the northeast. The pollution rose with Ogden Dunes ozone indicates that higher ozone measurements occurred when winds were primarily from the northeast. This is consistent with back trajectories from this date, which show transport from smoke covered areas in Canada, passing through points of fire activity in Ontario in the days prior. There was also high surface pressure over the region and relatively light winds. Skies were hazy, indicating smoke aloft in addition to the smoke at the surface.

Figure 3.6.5 – Gary IITRI Windrose **Figure 3.6.6 –Ogden Dunes Pollution Rose**



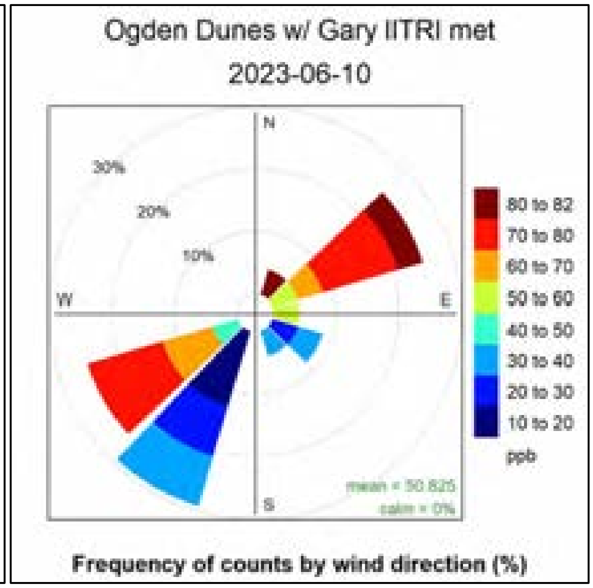
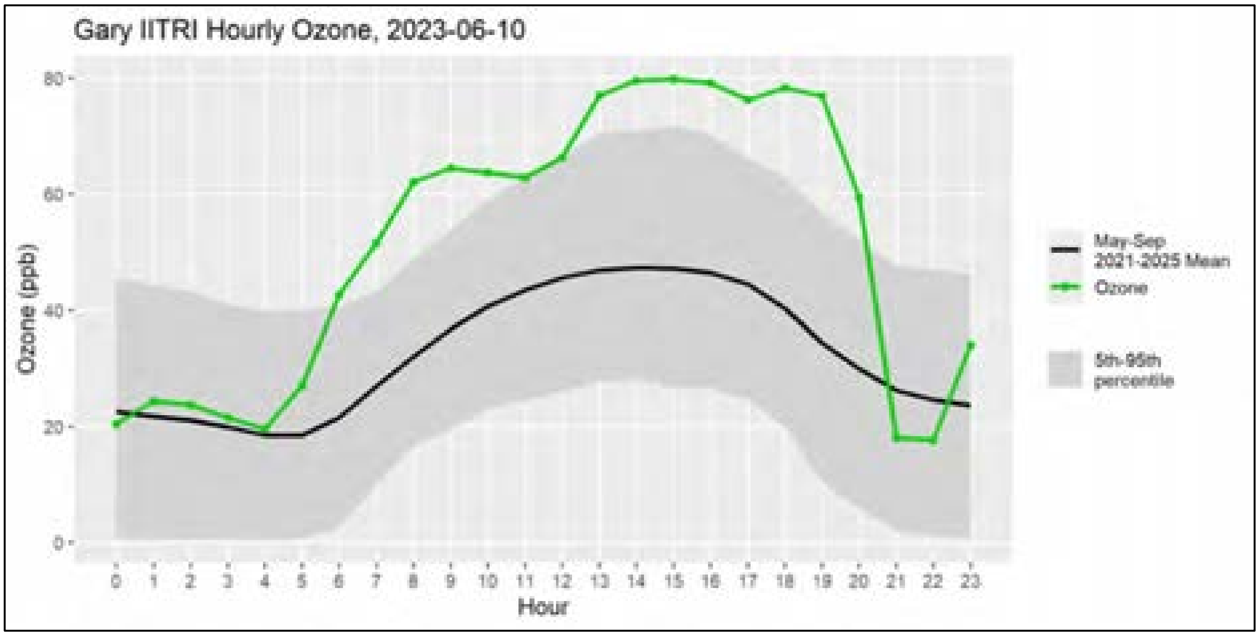


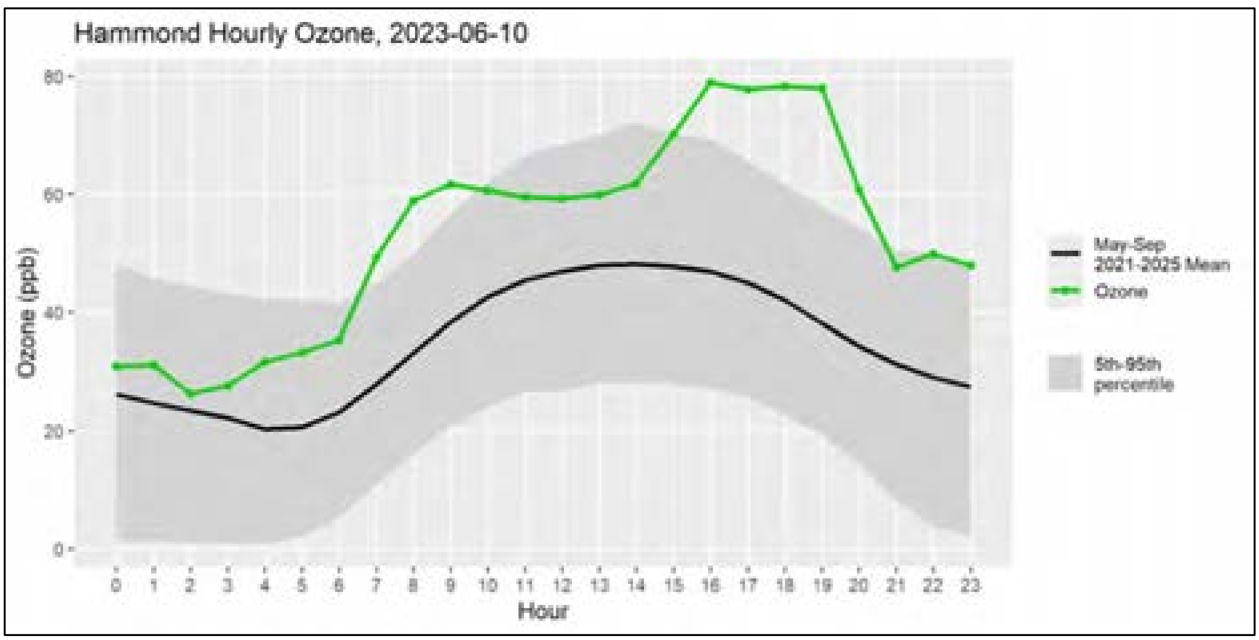
Figure 3.6.7 - Hourly Wind Directions at Gary IITRI for June 10, 2023

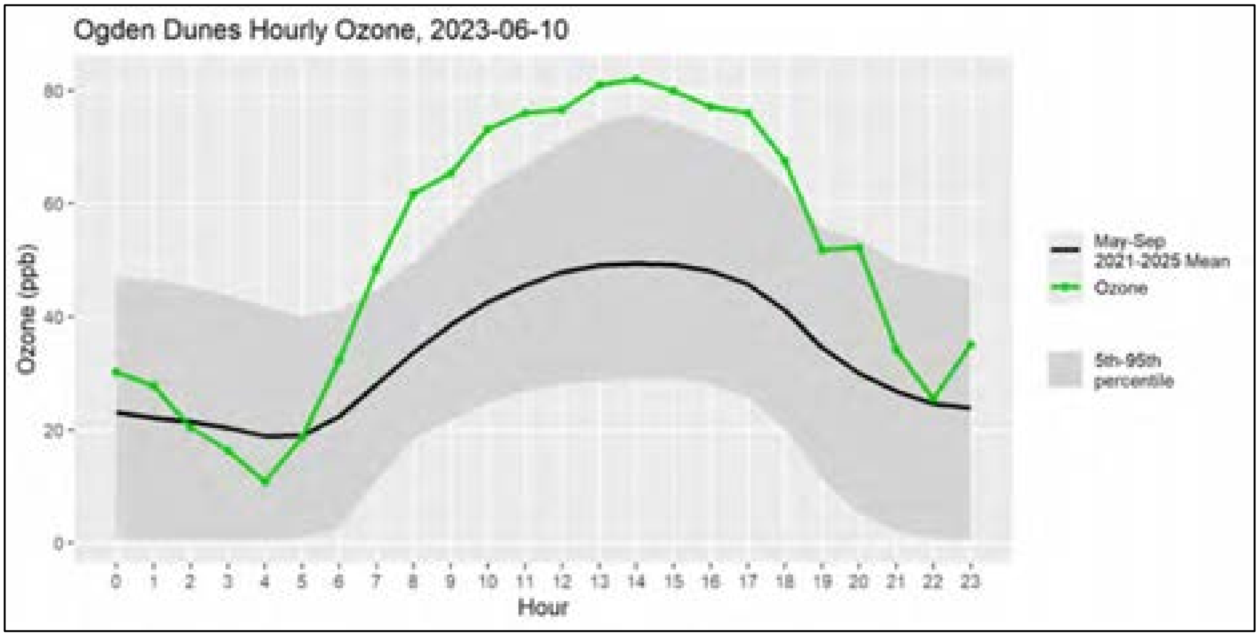
3.6.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for June 10, 2023, for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.6.8. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.6.8 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes

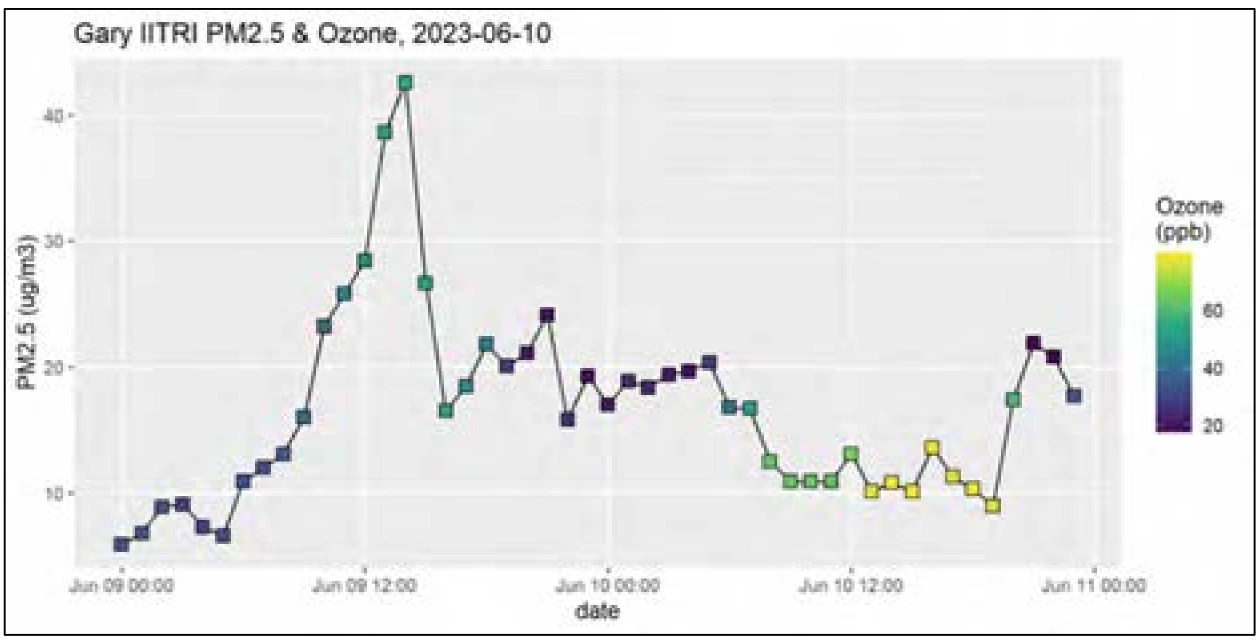






Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for June 10 as shown in Figure 3.6.9. $PM_{2.5}$ concentrations ranged from 9-22 ug/m^3.

Figure 3.6.9 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data June 10, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.6.2

shows the percentage above the five-year average. All three pollutants were well above the average, indicating the presence of wildfire smoke on this day.

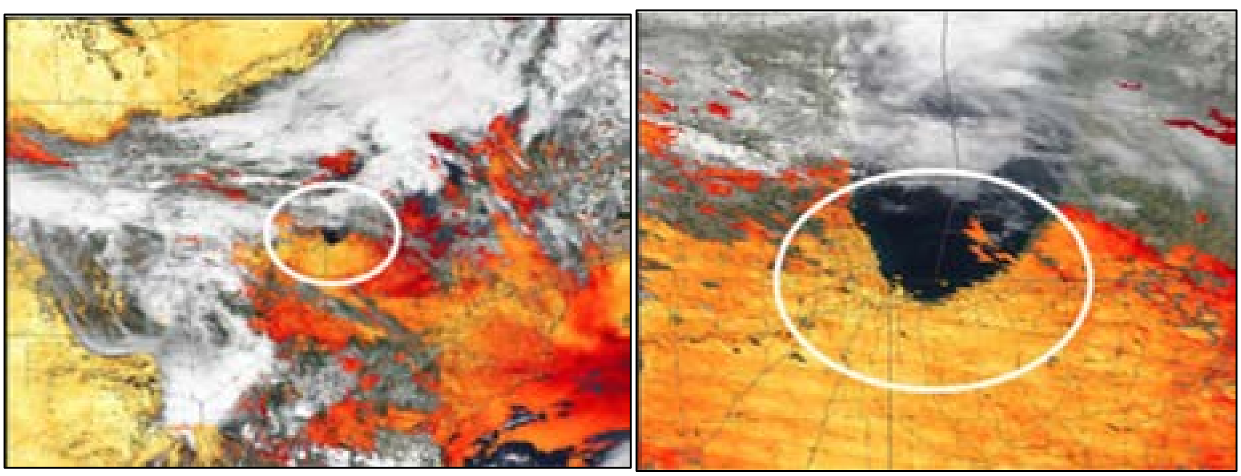
Table 3.6.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
6/10/2023	124%	117%	207%

3.6.4 AOD and Satellite Analyses

Figure 3.6.10 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of smoke. The northwest Indiana area is indicated by the white circle in each figure.

Figure 3.6.10 – Aerosol Optical Depth (AOD) – June 10, 2023



The image below captured by NOAA's GOES 18 satellite for North America taken on June 10 shows clouds and a plume of gray smoke extending from Canada to the upper Midwest states, including Indiana. The northwest Indiana area is indicated by the red circle on the satellite image Credit: NOAA NESDIS

Figure 3.6.11 – Satellite Imagery of Upper Midwest on June 10, 2023

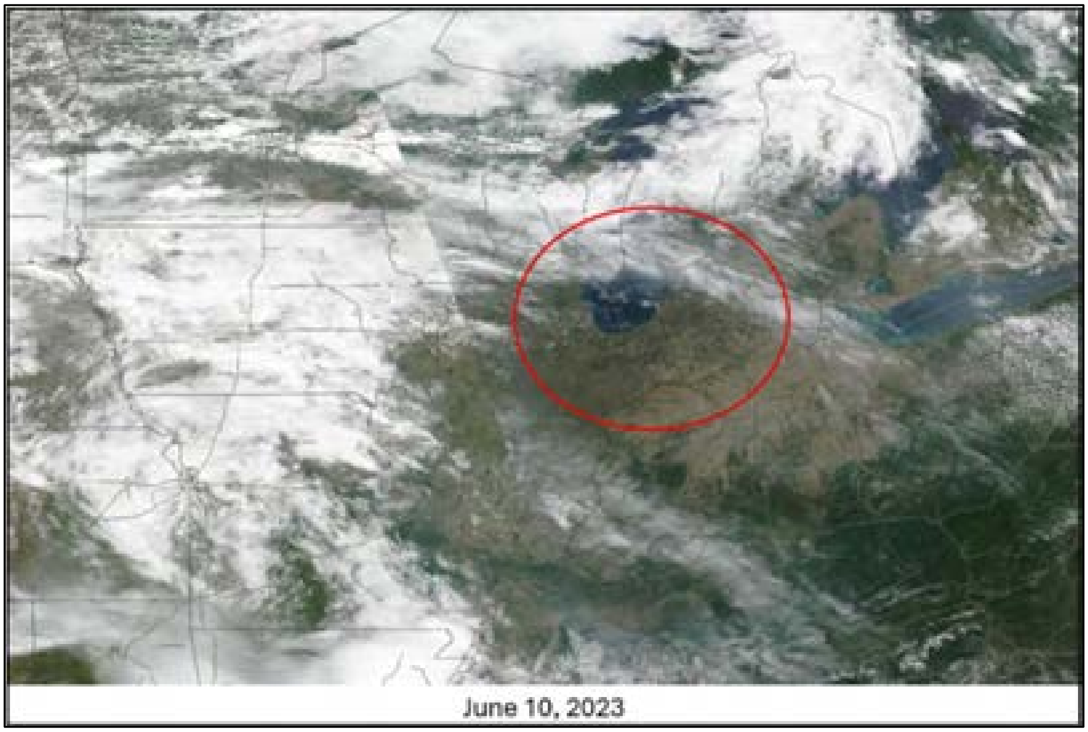
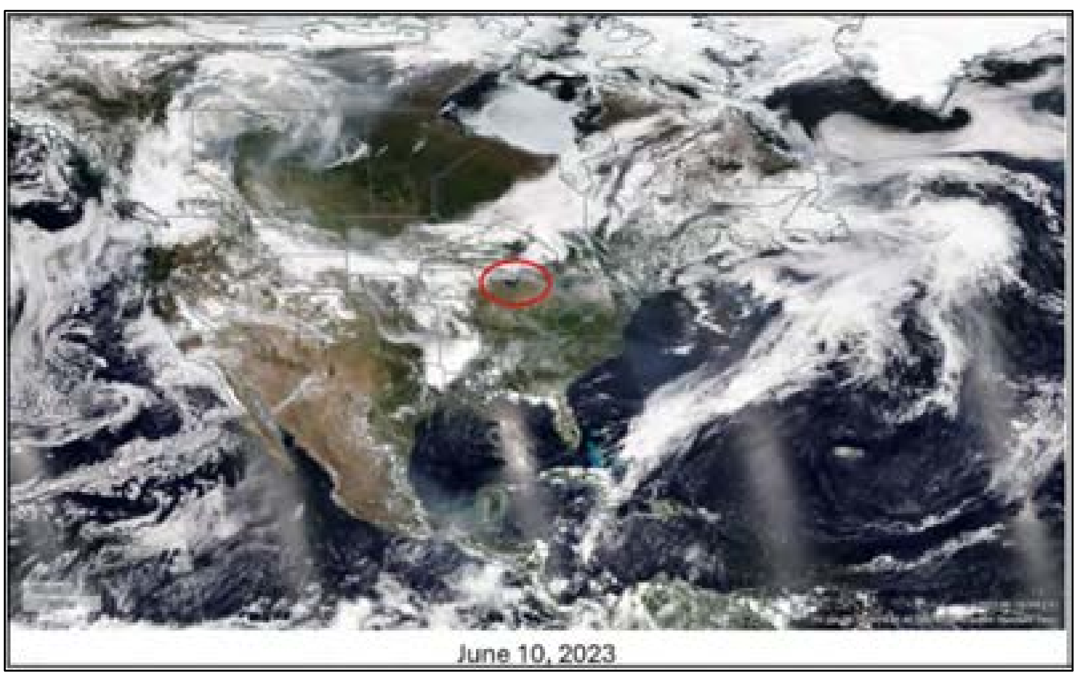


Figure 3.6.12 – Satellite Imagery of United States on June 10, 2023



3.6.5 NOAA Smoke Narrative

Saturday, June 10, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1500Z June 10, 2023

SMOKE:

Canada, Central and Eastern United States and the northwestern Atlantic Ocean…

Wildfires throughout Saskatchewan, Alberta, British Columbia, and the southern Northwest Territories continued to produce large amounts of light to medium-density smoke extending from southeastern Yukon to northern Montana, the Dakotas, and Minnesota and southern Ontario. Heavy density smoke was concentrated over the NW Territories, British Columbia, Alberta, and Saskatchewan. Due to heavy cloud coverage, it was difficult to the full extent of smoke over most of Ontario and Quebec. **Light smoke from these fires also extended across all of the Canadian territories and over Hudson Bay, and additional areas of the central, southern and eastern U.S**. This smoke then became combined with smoke mainly emitted from fires in Ontario and Quebec, with light to moderate-density smoke extending from the over the Atlantic Ocean southeast of New England and Nova Scotia.

3.6.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.6.13 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 5-16 × 10^{15} molecules/cm^2 indicate moderate to extreme wildfire smoke influence.

Figure 3.6.13- TROPOMI Satellite Daily Formaldehyde Monitoring

3.6.7 AirNow Smoke Maps

AirNow shows in Figure 3.6.14 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.6.14 - AirNow Smoke Ozone and $PM_{2.5}$

Figure 3.6.15 - AirNow Ozone Map

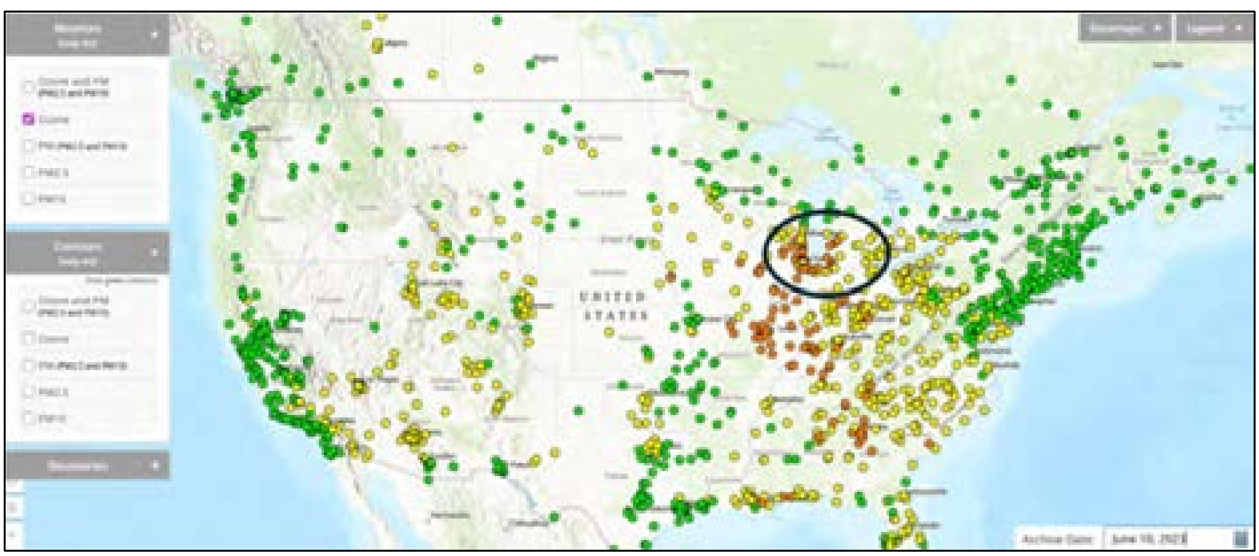
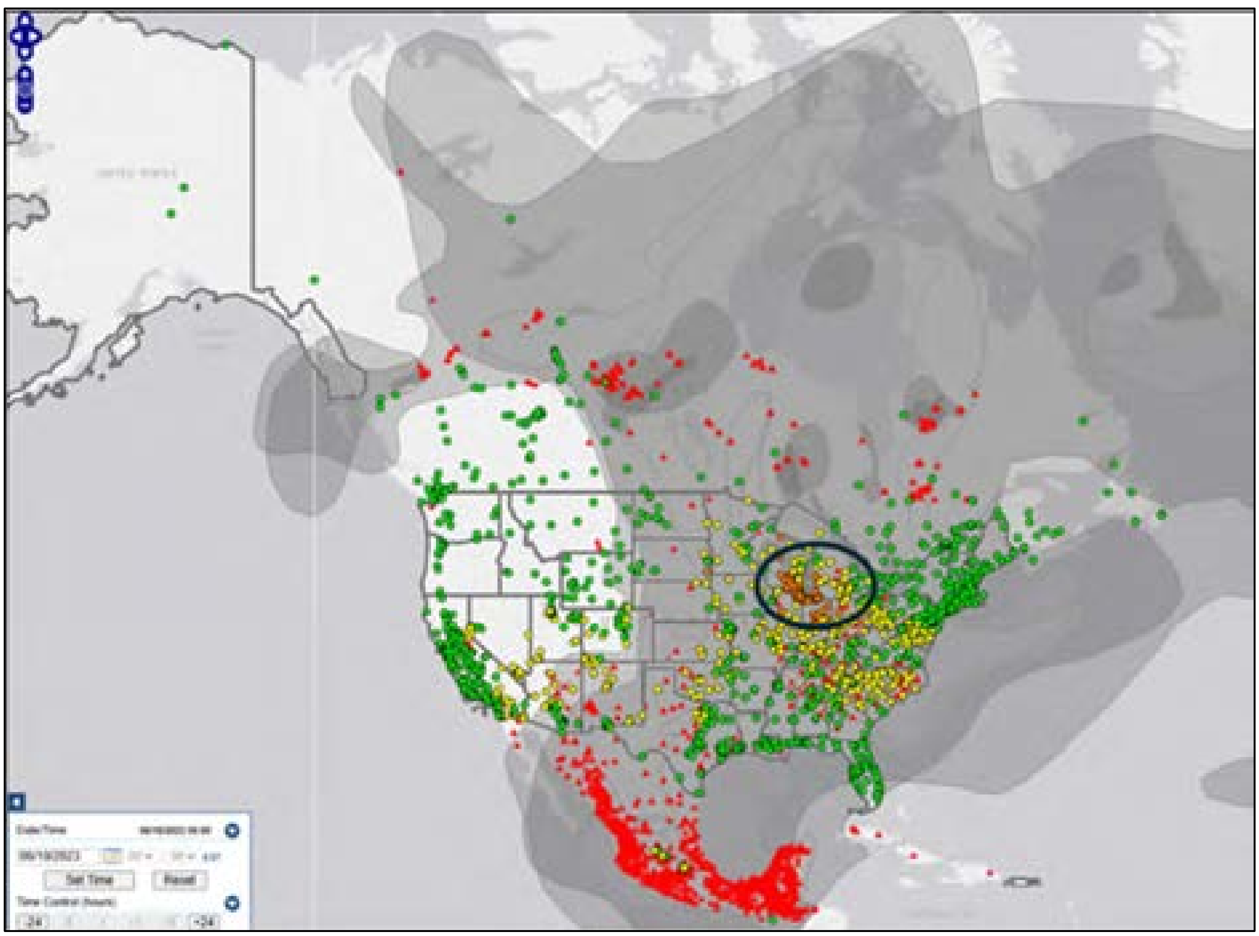


Figure 3.6.16 - AirNow $PM_{2.5}$ Map

Figure 3.6.17 - AirNow Smoke and Ozone Map



3.6.8 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes.

Figures 3.6.18 through 3.6.21 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the black circles on each of the maps.

Figure 3.6.18 - GAM Smoke Maps Indicating Smoke Days June 10, 2023

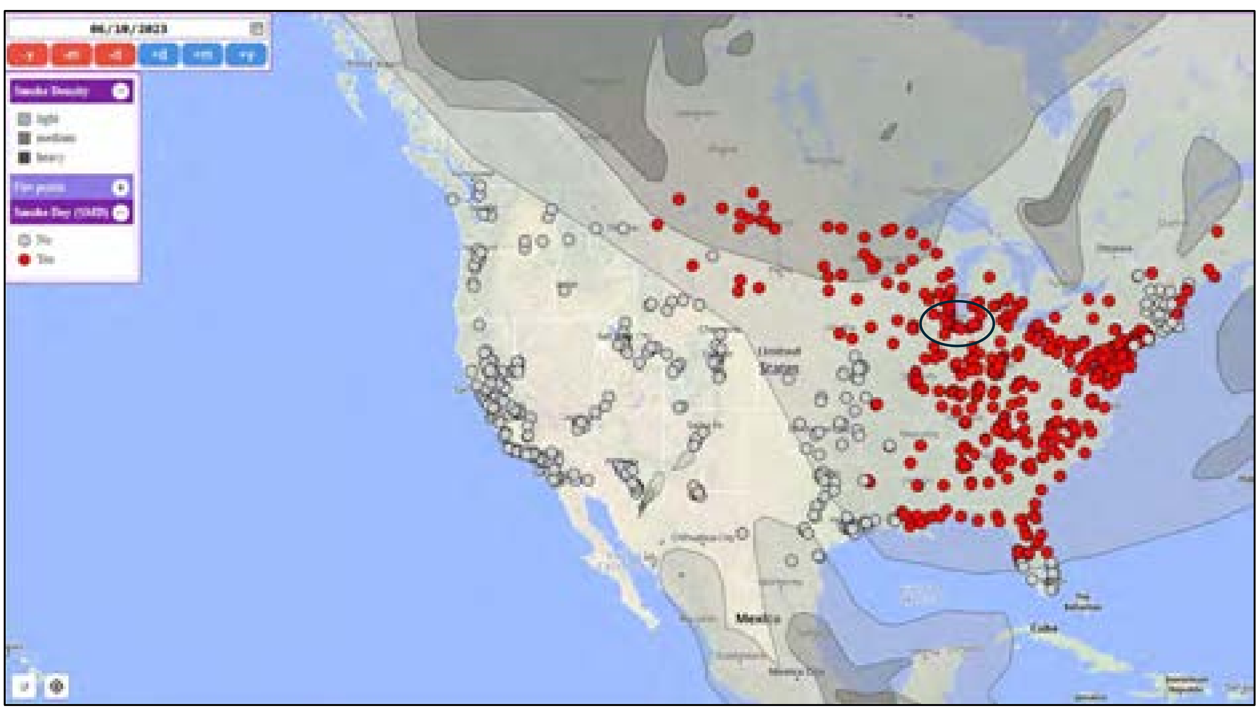


Figure 3.6.19 - GAM Observed ozone with Smoke Days June 10, 2023

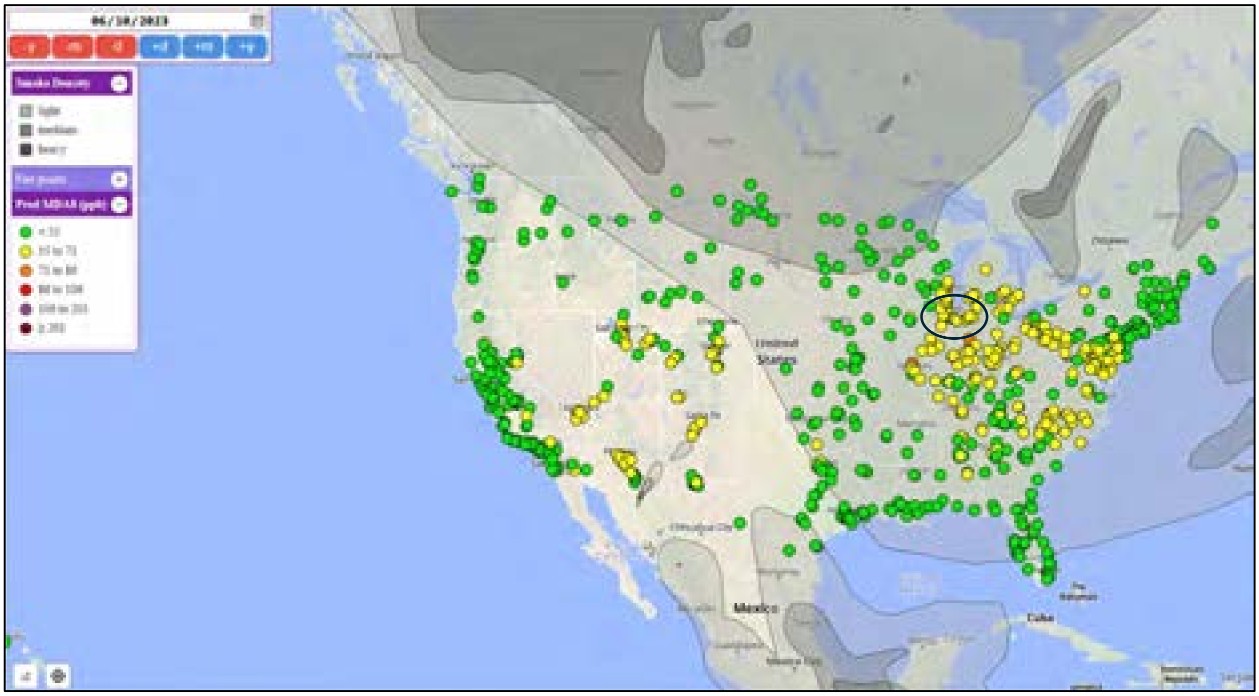


Figure 3.6.20 - GAM Smoke Estimates June 10, 2023

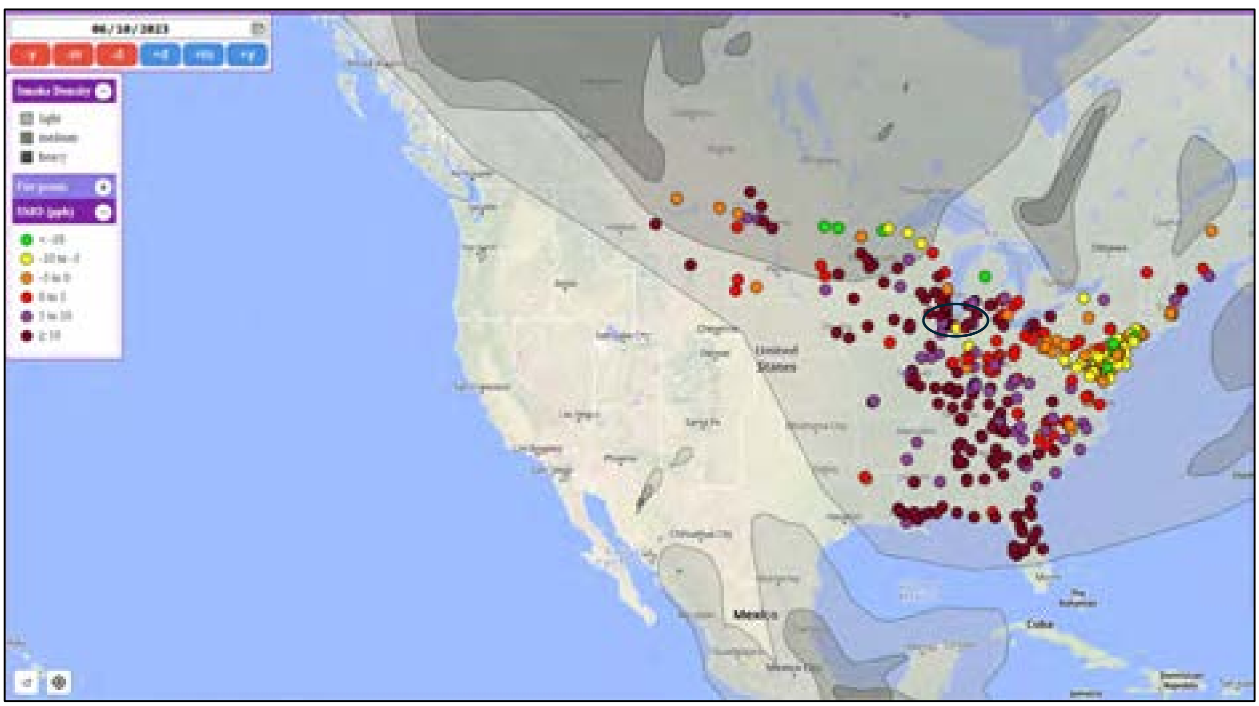


Figure 3.6.21 - EMBER Smoke Estimates June 10, 2023

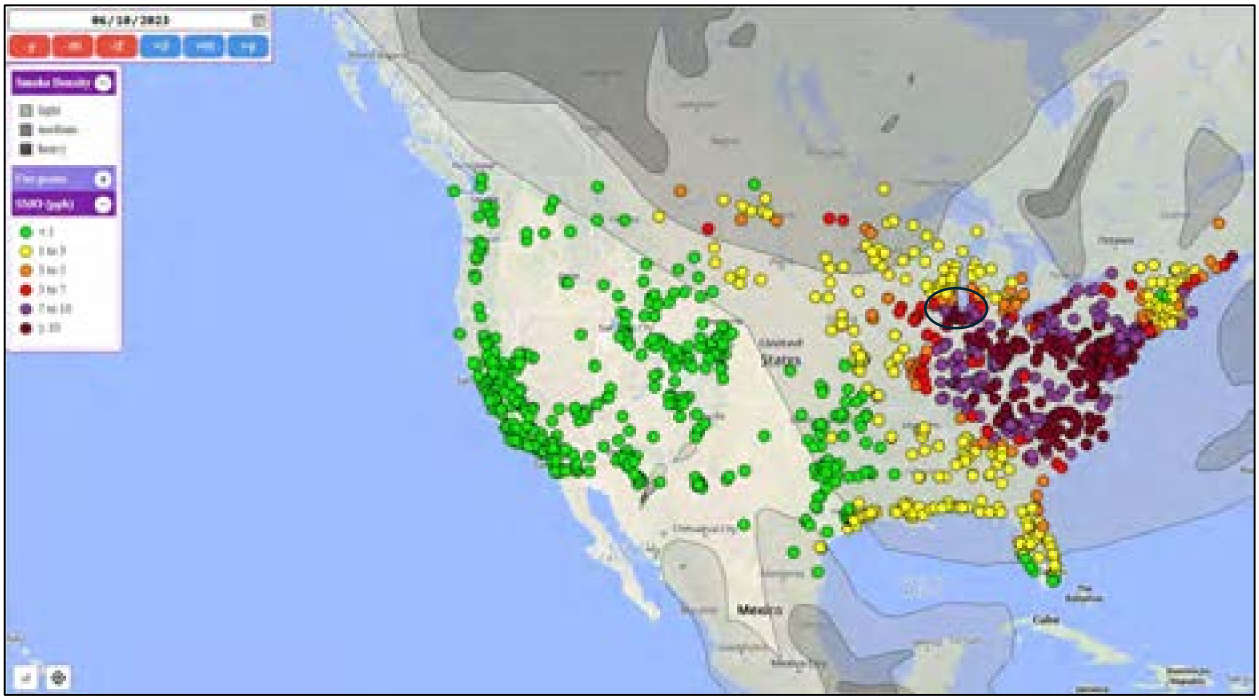


Table 3.6.2 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.6.2 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values June 10, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	76	62.3	13.7	64	12
180892008	Hammond	70	NA	NA	67	3
181270024	Ogden Dunes	77	63.5	13.5	64	13
181270026	Valparaiso	62	69.5	-7.5	61	1

3.6.9 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on June 10, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.6.3 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 16.5 ppb lower than the MDA8 ozone concentrations observed on June 10 with the maximum matching day MDA8 ozone concentration was smoke influenced at 76.1 ppb.

Table 3.6.3 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 10, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	77	76.1*	60.5

* Indicates Matching days were influenced by wildfire smoke

3.6.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red). And higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. On June 10 three-day back trajectories indicate smoke from eastern Canada being drawn down to northwest Indiana. The trajectories in Figure 3.6.24 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over the wildfires in Canada. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.6.22 – Back Trajectories from June 10 (50, 100 and 500 meters - 72 hours)

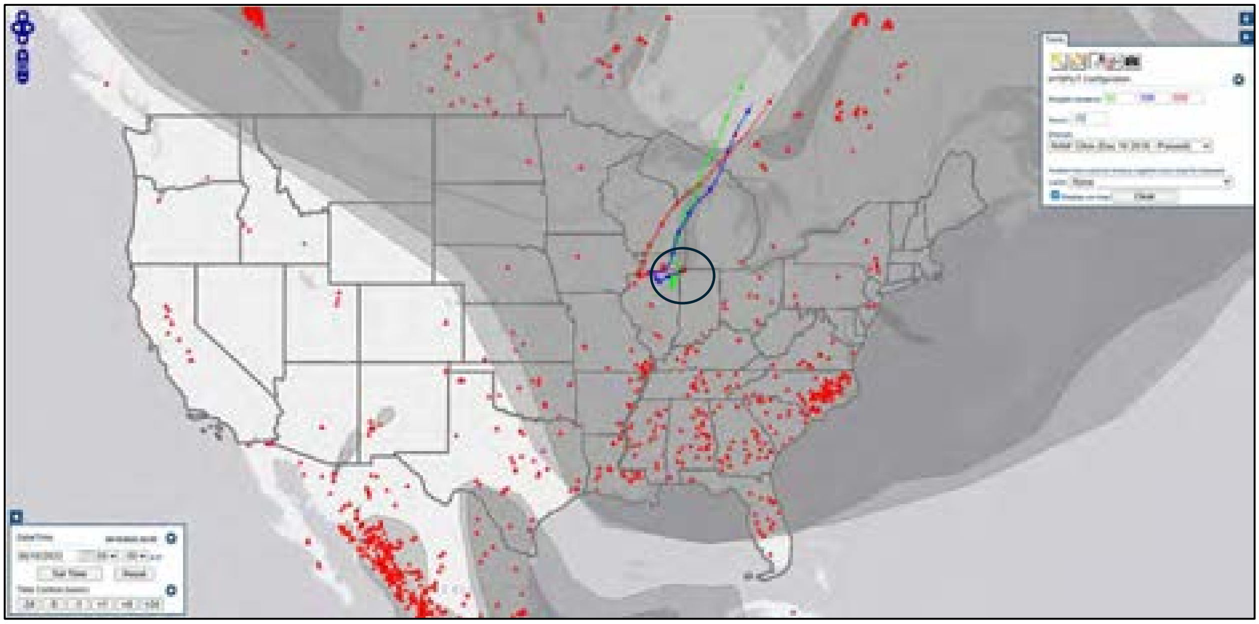


Figure 3.6.23 - Back Trajectories from June 10 (1000, 2000 and 3000 meters - 72 hours)

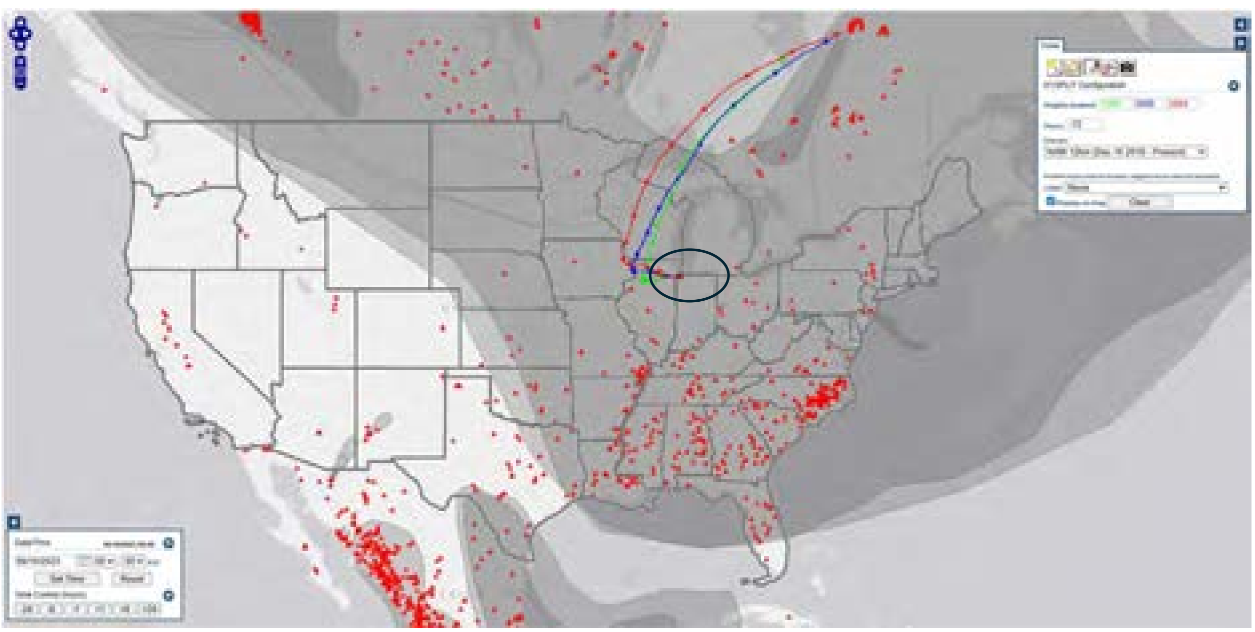
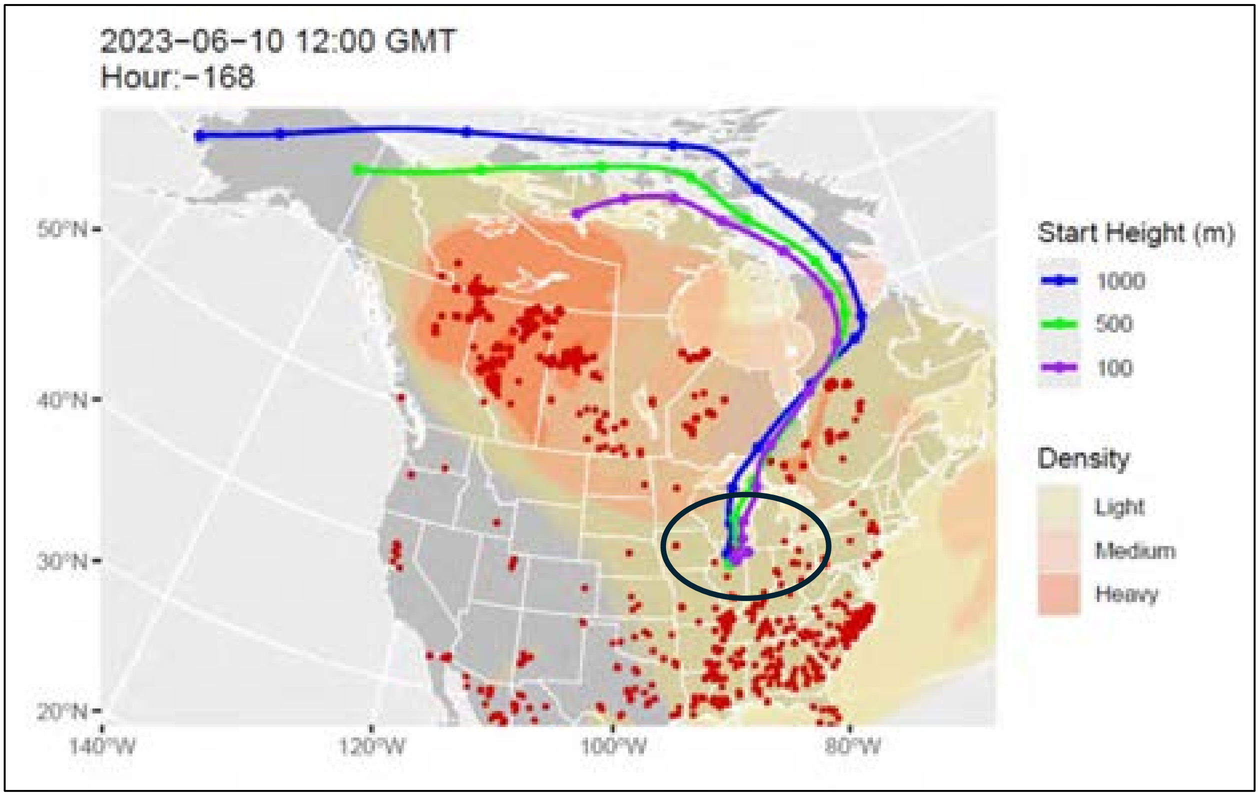


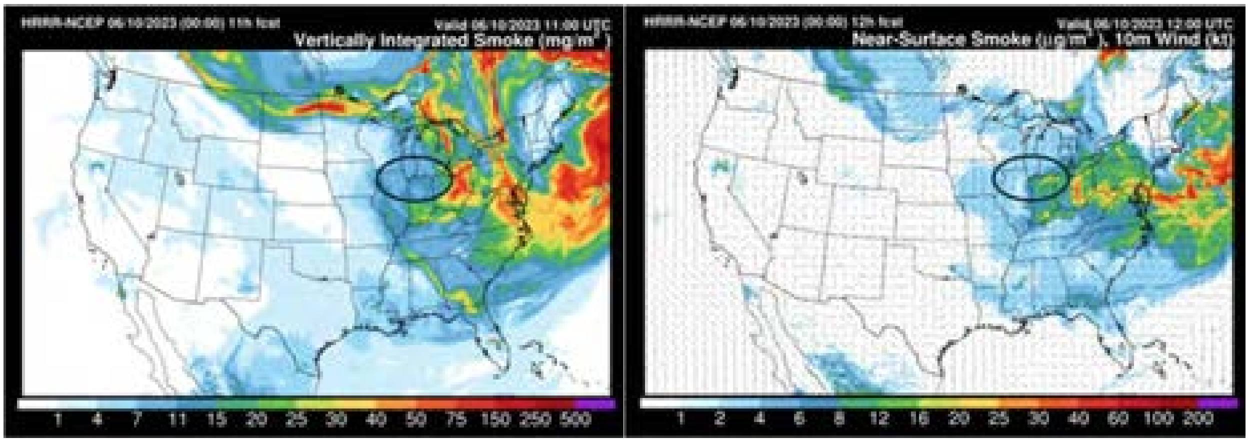
Figure 3.6.24 - Long-Range Back Trajectories from June 10 (100, 500 and 1000 meters - 168 hours)



3.6.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Figure 3.6.25 indicates wildfire smoke impacts in the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.6.25 HRRR Smoke Model



3.6.12 Media Mentions

Canadians fighting wildfires see hope in improving weather conditions

Maps, satellite images show 2023 Canadian wildfire smoke enveloping parts of U.S. with unhealthy air

Canada's wildfire season is off to an 'unprecedented' start. Here's what it could mean for the US

Canada wildfire crews try to control the uncontrollable

How wildfire smoke will affect Indiana this weekend | WTHR Weather Blog

The "Canadian" Wildfires of 2023

The 2023 wildfire season in Québec: an overview of extreme conditions, impacts, lessons learned, and considerations for the future

3.6.13 Summary of Requested Exclusion of June 10, 2023

Table 3.6.4 - Summary Table - Gary IITRI

Event Date	**June 10, 2023**
MDA8 Ozone Concentration (PPB)	76
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone (PPB)	62.3
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	12
Matching day MDA8 ozone (max., avg.) (PPB)	60.5, 60.5
HYSPLIT indicated wildfire regions	James Bay Priority Fires, Quebec
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

3.7 June 18 – 19, 2023 Ozone Event

3.7.1 Executive Summary

On June 18 and 19, 2023, Northwest Indiana experienced ozone exceedances across all Lake and Porter County monitors, with values ranging from 69 to 77 ppb, surpassing the 70 ppb NAAQS for at least one day at each site. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 5-20 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to James Bay Priority Fires, Quebec, Western-edge Wabakimi Fire, Sioux Lookout 33 Fire Ontario and Nipigon 13 and 19 Fires, Ontario.
- June 17 was concurred for Lake County $PM_{2.5}$ Exceptional Event demonstration. June 18 and 19 have informational flags for $PM_{2.5}$

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of June 18 and 19 as an exceptional event under U.S. EPA guidelines.

Table 3.7.1 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

Date	Gary-IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
June 18, 2023	77	77	75	76
June 19, 2023	74	69	76	76

On June 18 and 19, multiple Canadian wildfires, as shown in Figures 3.7.1 and 3.7.2, contributed ground level smoke that caused all four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in late June included the:

- James Bay Priority Fires, which began on June 1, 2023, when a historic lightning outbreak ignited 182 separate fires across northern Quebec, many near the Cree communities of Eastmain, Wemindji, and Waskaganish. Extreme drought, high winds, and low humidity allowed several fires to expand rapidly, with many reaching 20,000–100,000+ hectares.
- Western-edge Wabakimi Fire, which began in early June 2023 along the western boundary of Wabakimi Provincial Park in northwestern Ontario. Although the exact ignition source was not publicly confirmed, reports do not identify whether lightning or human activity caused the blaze. The fire grew rapidly through late June, reaching approximately 41,000 hectares by June 24, and was listed as “not under control” due to aggressive fire behaviour and continuous hot, dry conditions.
- Sioux Lookout 33 Wildfire, which was discovered on June 11, 2023, near the western edge of Wabakimi Provincial Park and quickly became one of northwestern Ontario’s major “Fires of Note.” Although the ignition cause was never formally identified, the region was experiencing significant lightning-driven ignition events during this period. The fire displayed rapid expansion through June and early July, growing from an early estimate of 41,548 hectares to 60,394 hectares by July 6, remaining “not under control.”
- Nipigon 13 and 19 Fires, which started in mid-June 2023 west of Ogoki Lake. The fires were suspected to be lightning related and burned 48,000 hectares between the two fires.

Figure 3.7.1 – Canadian Wildfires June 18, 2023

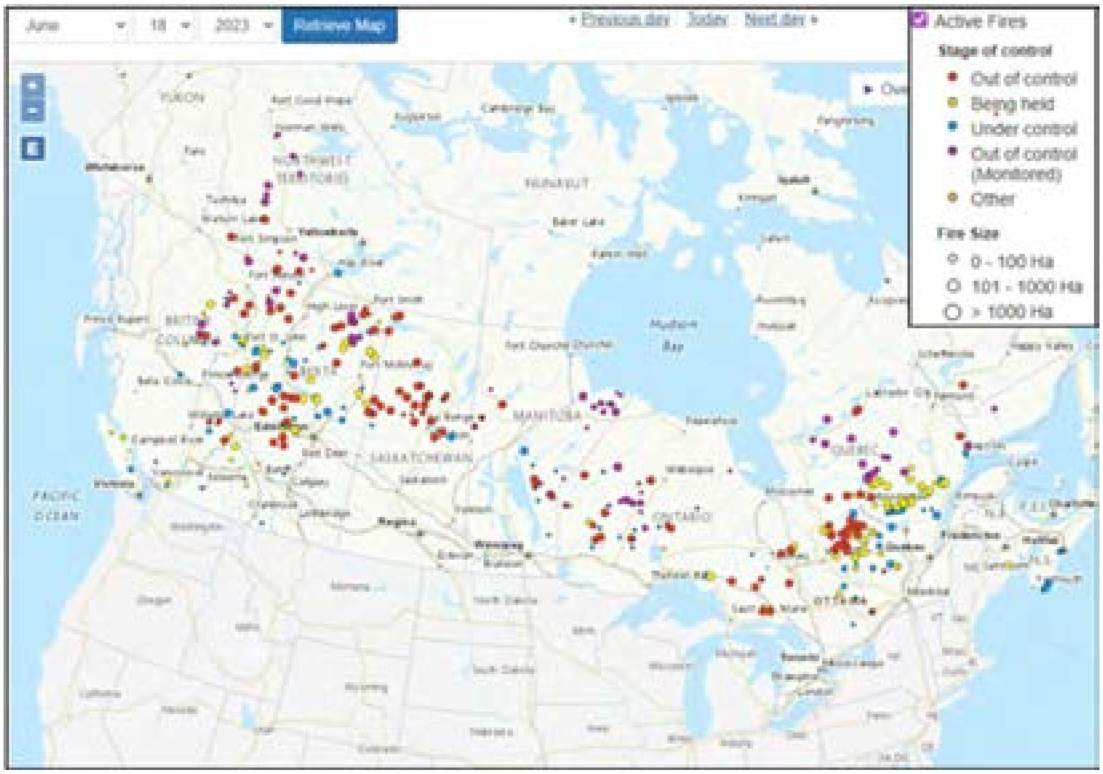


Figure 3.7.2 – Canadian Wildfires June 19, 2023

Source: https://cwfis.cfs.nrcan.gc.ca/interactive-map?zoom=0.8&center=400000%2C1000000&month=5&day=23&year=2023#iMap

3.7.2 Meteorological Episode Overview

Surface high pressure slid east over the upper Midwest under a broad upper air ridge as a sharp trough remained over southeastern Canada for June 18. This surface high pressure began to dissipate on June 19 as an upper air trough developed over the central U.S. and moved eastward along the Ohio River Valley. With the temperatures reaching the mid-80s °F and winds shifting south-southeast, then east-southeast, more light to moderate smoke was pulled into the area from the southeast Canadian wildfires around the cyclonic flow from the upper level low. Lower humidity levels helped to make even more conducive ozone conditions which produced elevated levels of ozone throughout the area. The gradient between the surface high pressure and upper-level low allowed the easterly winds to bring more smoke into northwest Indiana. Figure 3.7.3 shows the surface, 850 mb, and 500 mb maps of the conditions on June 17 to help set up the smoke events. Figures 3.7.4 and Figure 3.7.5 shows surface, 850 mb and 500 mb maps of the weather conditions on June 18 and June 19.

Figure 3.7.3 - Surface, 850, and 500 mb Plots from 12Z on June 17, 2023

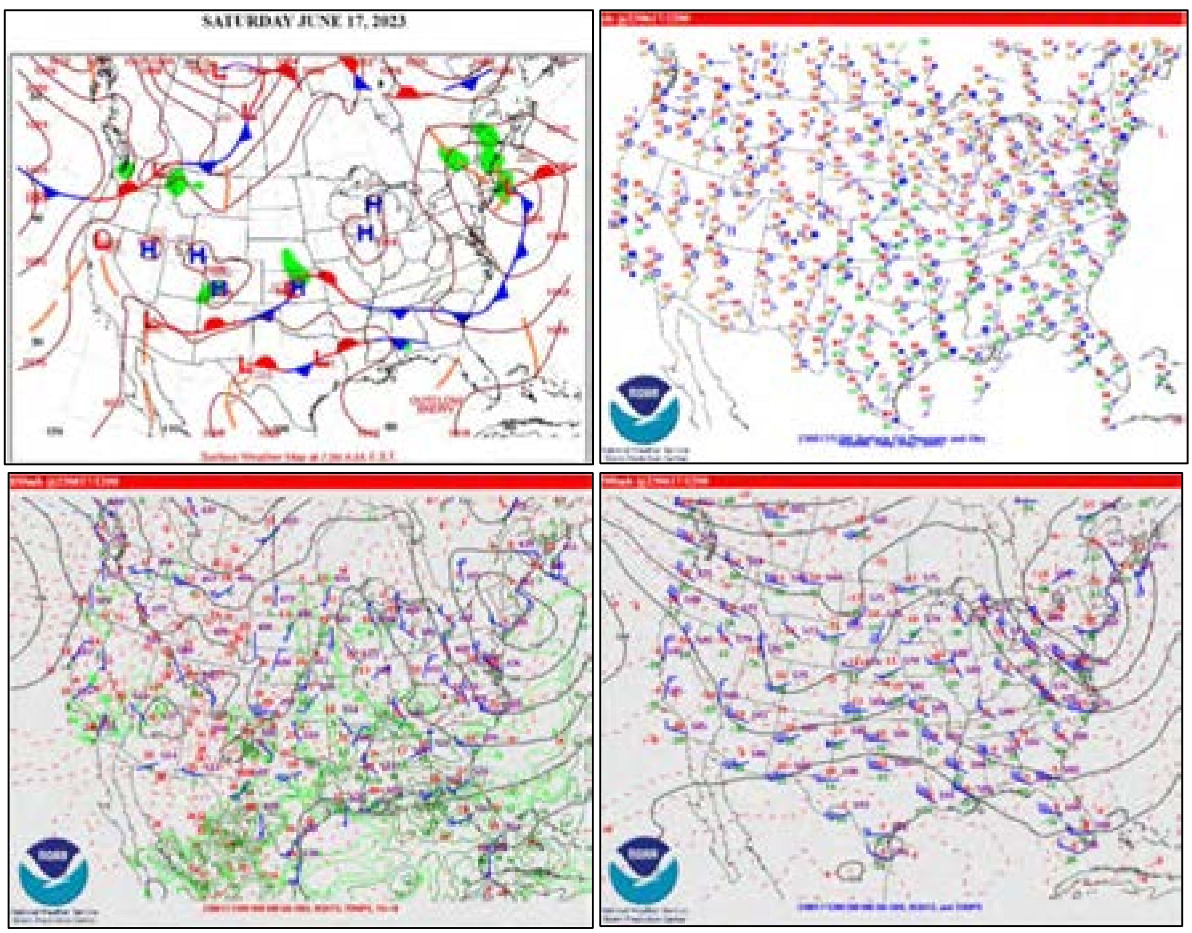


Figure 3.7.4 - Surface, 850, and 500 mb Plots from 12Z on June 18, 2023

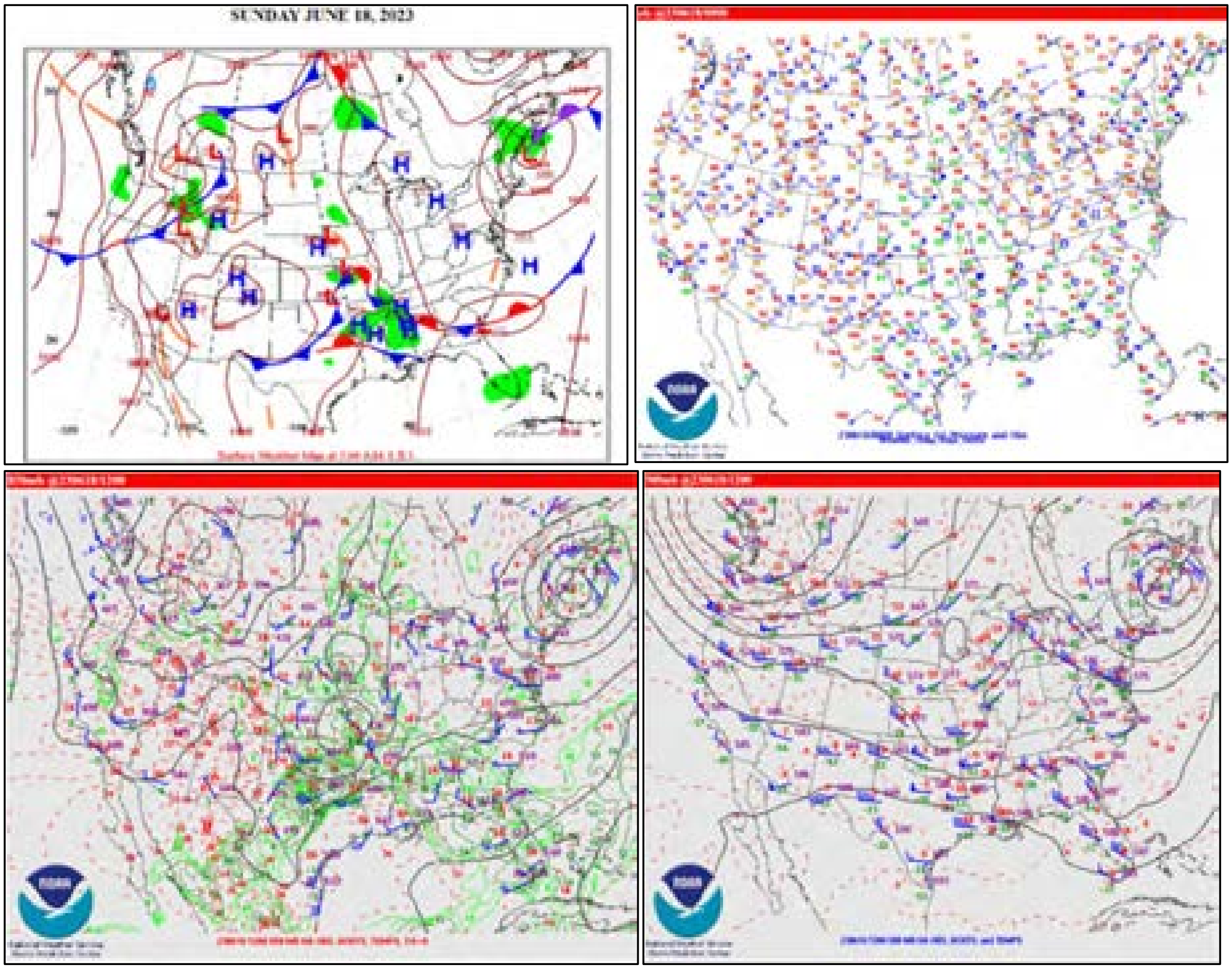


Figure 3.7.5 - Surface, 850, and 500 mb Plots from 12Z on June 19, 2023

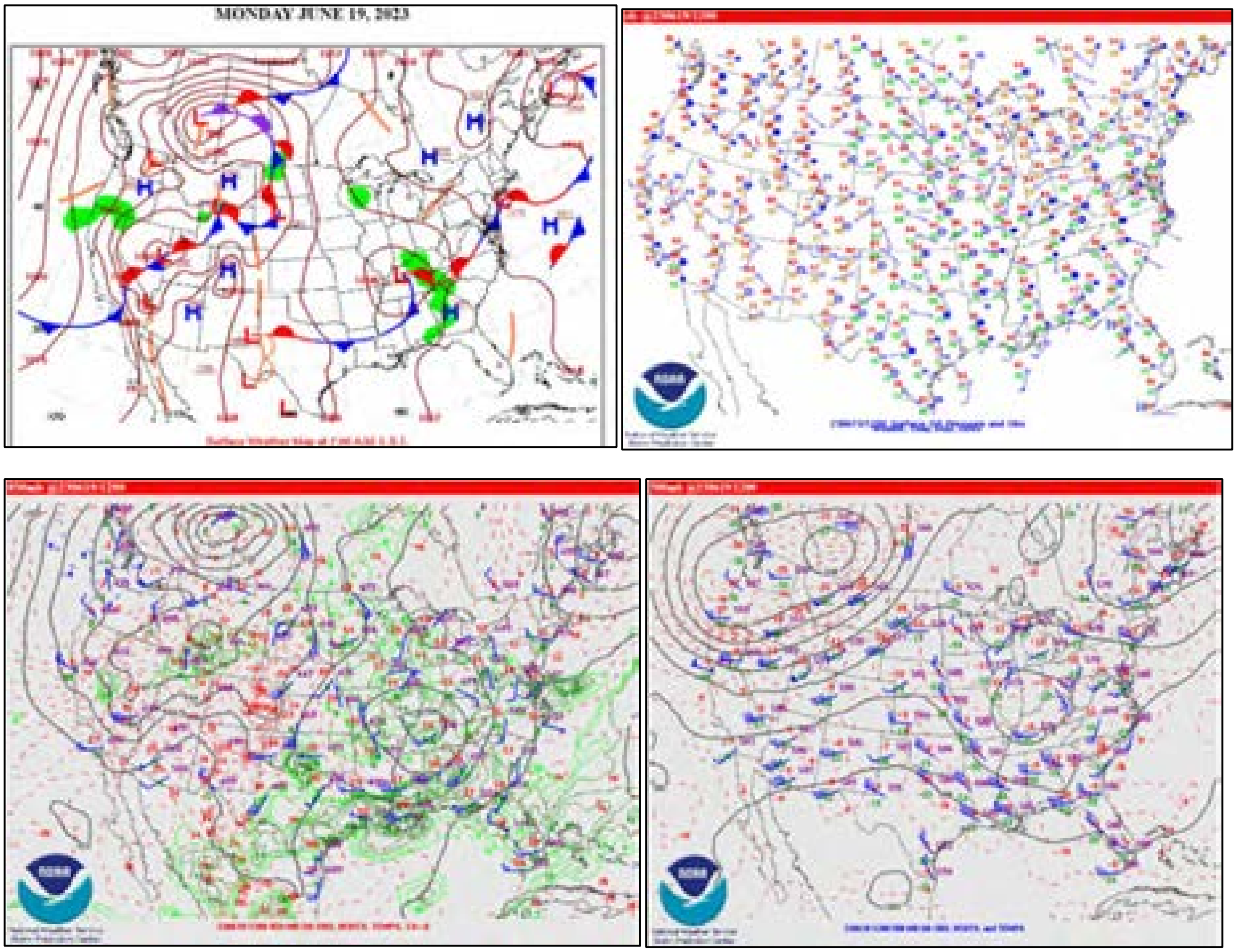
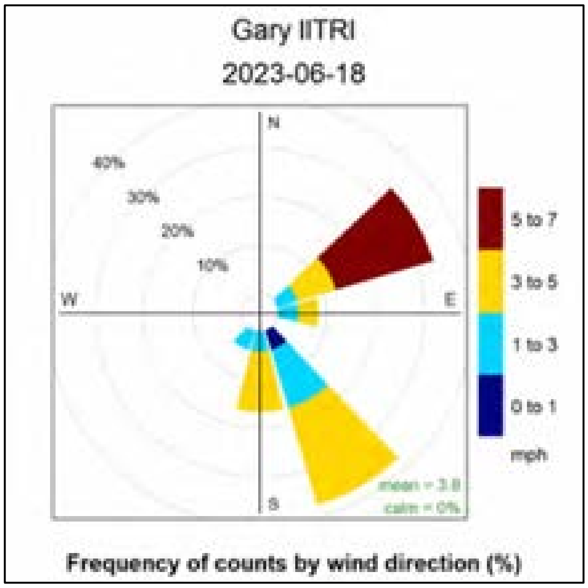
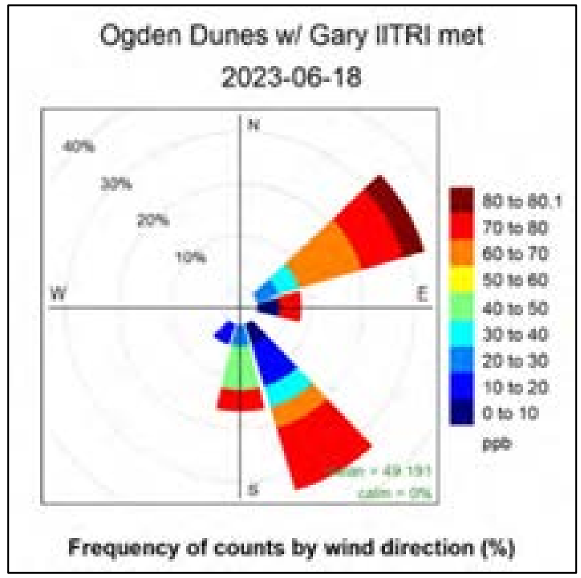
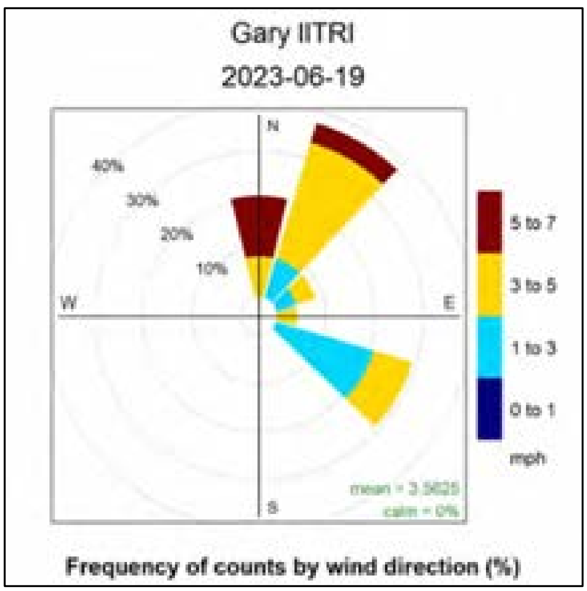


Figure 3.7.6 shows the wind rose and Figure 3.7.7 shows the pollution rose analyses taken from the Gary IITRI meteorological station. Wind directions on the 18 were primarily from the northeast and southeast. The pollution rose, using Ogden Dunes ozone, indicates that the highest ozone readings were from the northeast. The 19 had similar results, with the majority of the winds and ozone coming from the northeast with some smoke impacts from the southeast as well. This is consistent with the back trajectories, which show transport from the north, moving over areas covered in smoke and over points of wildfire activity. There was persistent high surface pressure and Rex Block conditions during this time, contributing to stagnant conditions and a buildup of pollutants. Temperatures were high and skies were sunny, contributing to ozone production.

Figure 3.7.6 –Gary IITRI Windrose **Figure 3.7.7–Ogden Dunes Pollution Rose**







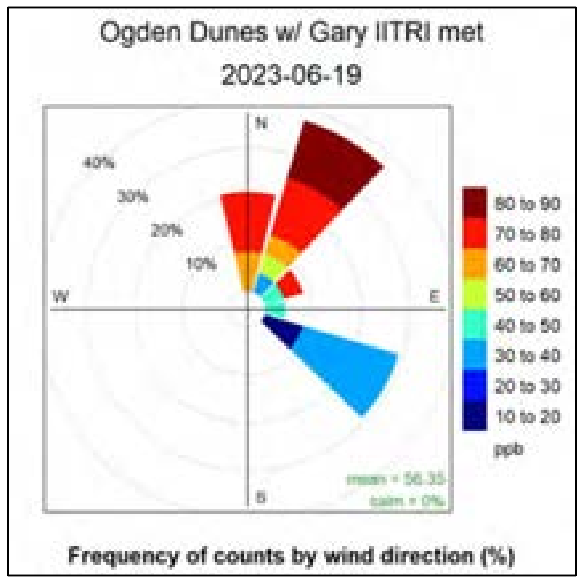
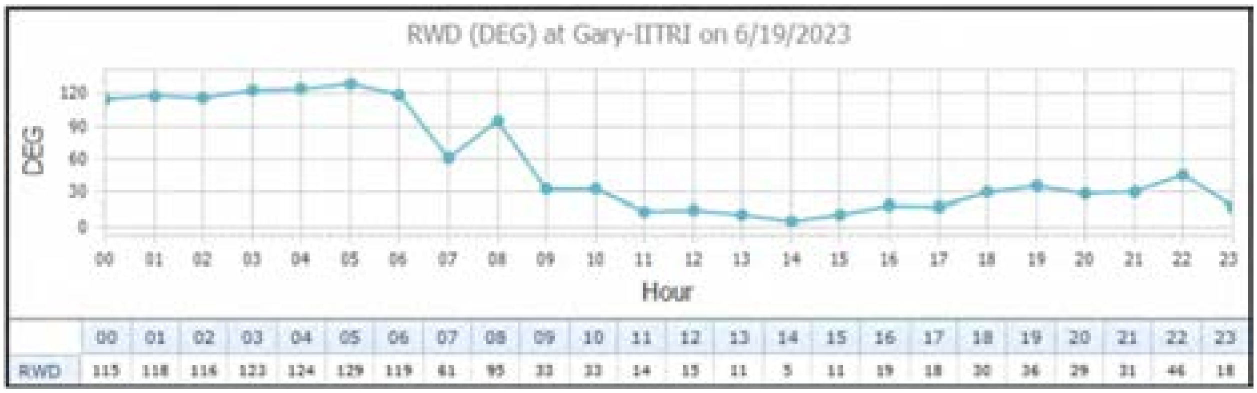


Figure 3.7.8 - Hourly Wind Directions at Gary IITRI for June 18, 2023

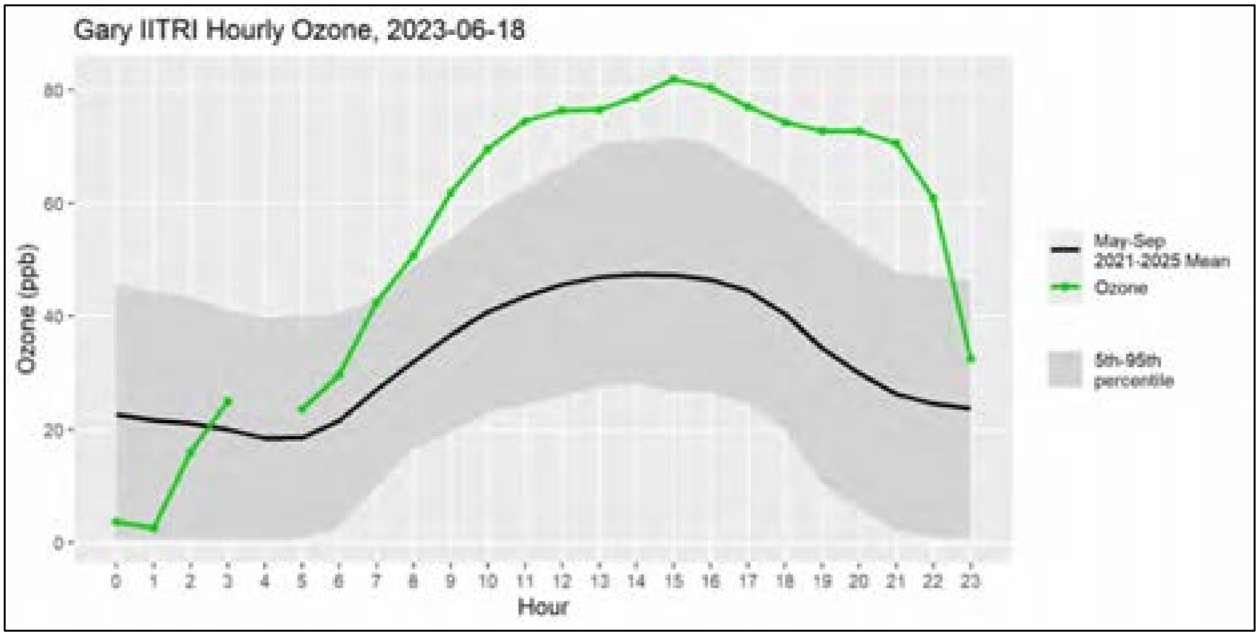
Figure 3.7.9 - Hourly Wind Directions at Gary IITRI for June 19, 2023



3.7.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for June 18 and June 19 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.7.10 for Gary IITRI, Figure 3.7.11 for Hammond and Figure 3.7 .12 for Ogden Dunes. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.7.10 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes



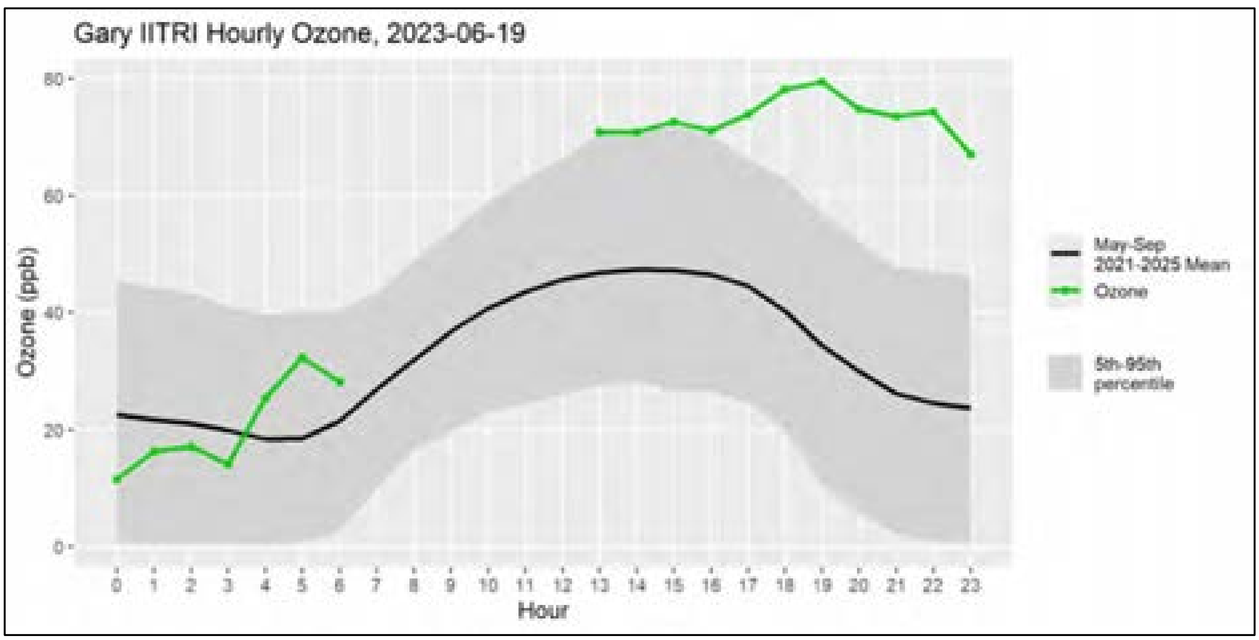
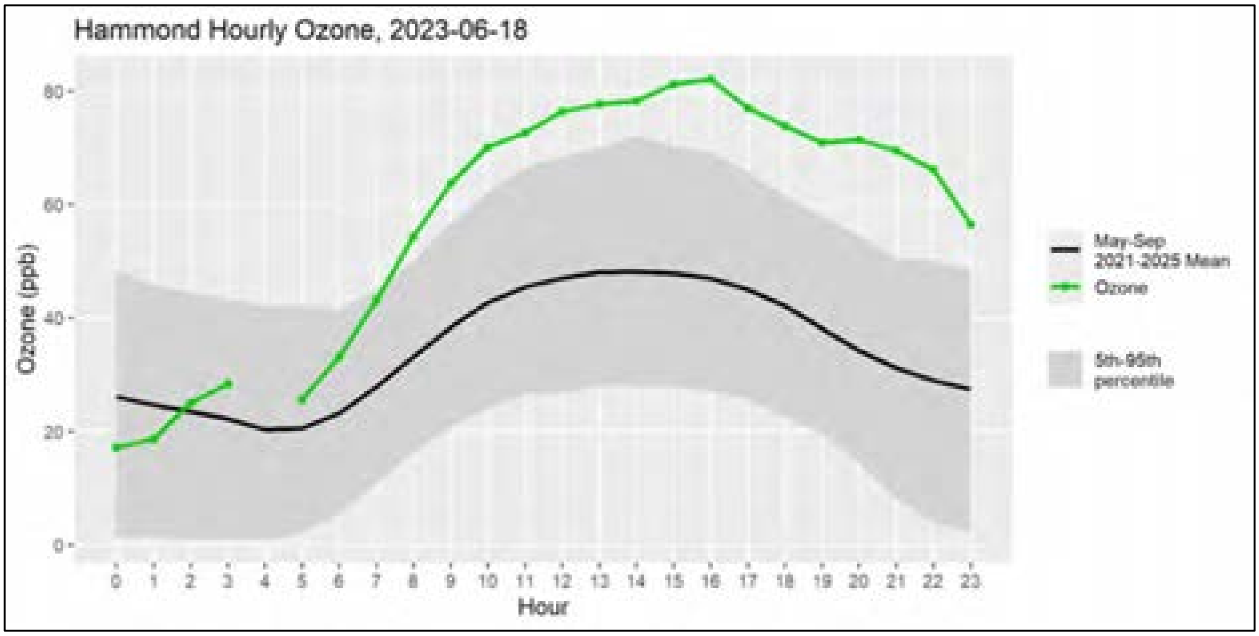


Figure 3.7.11 - Ozone Diurnal Pattern for Hammond



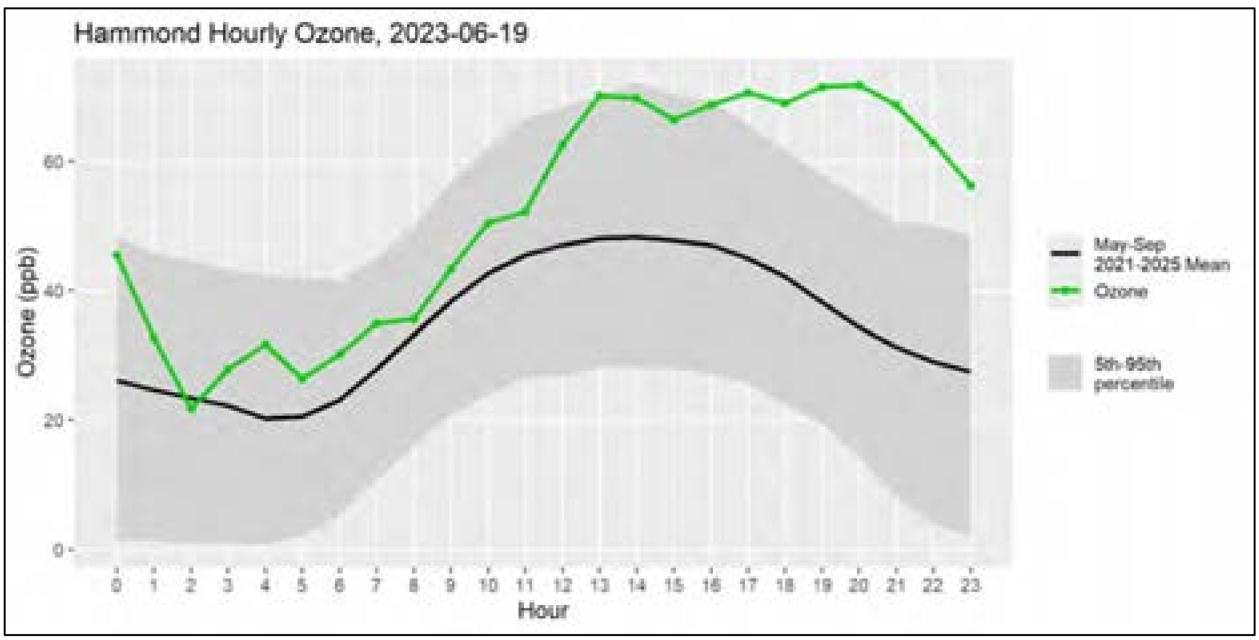
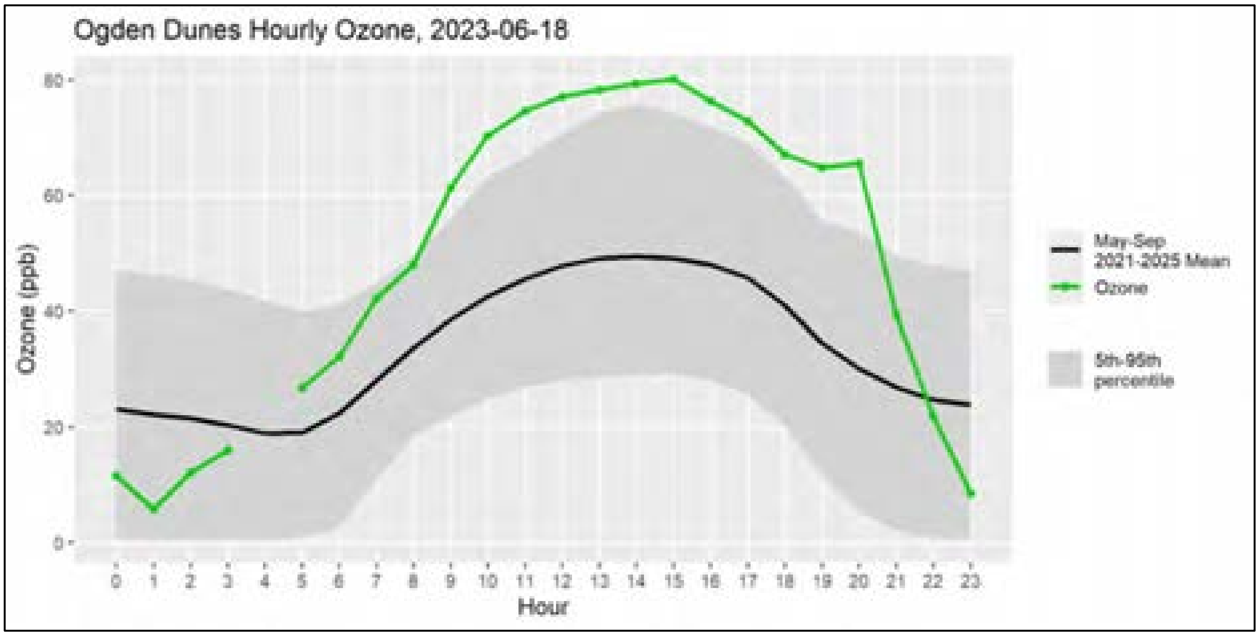
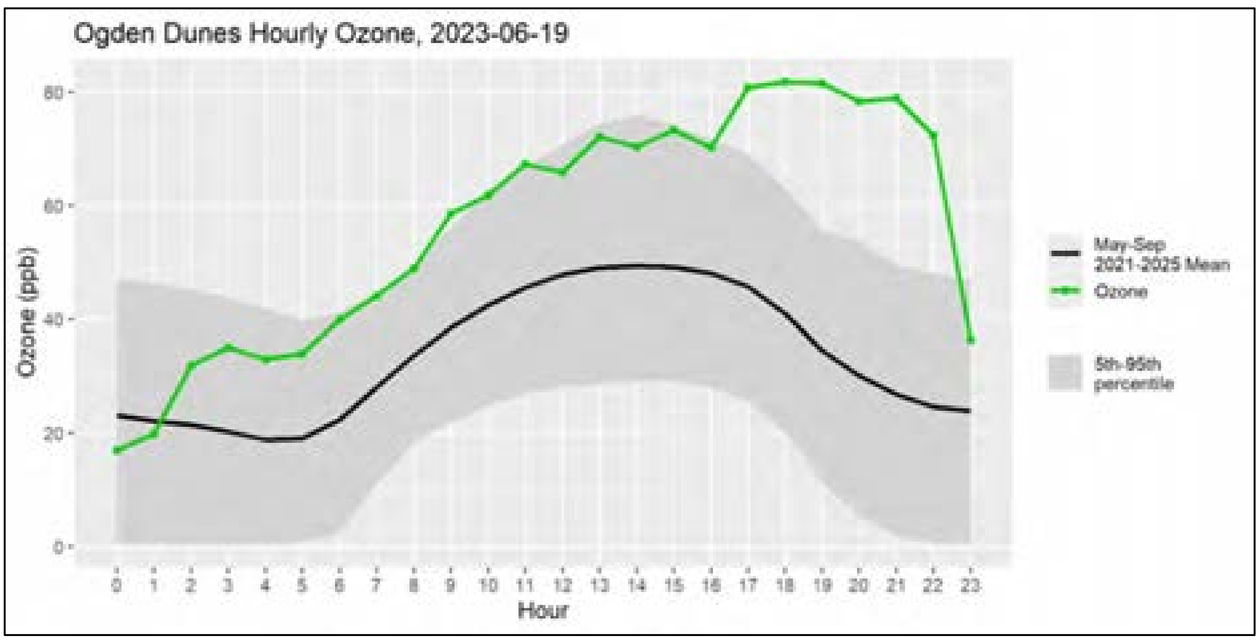


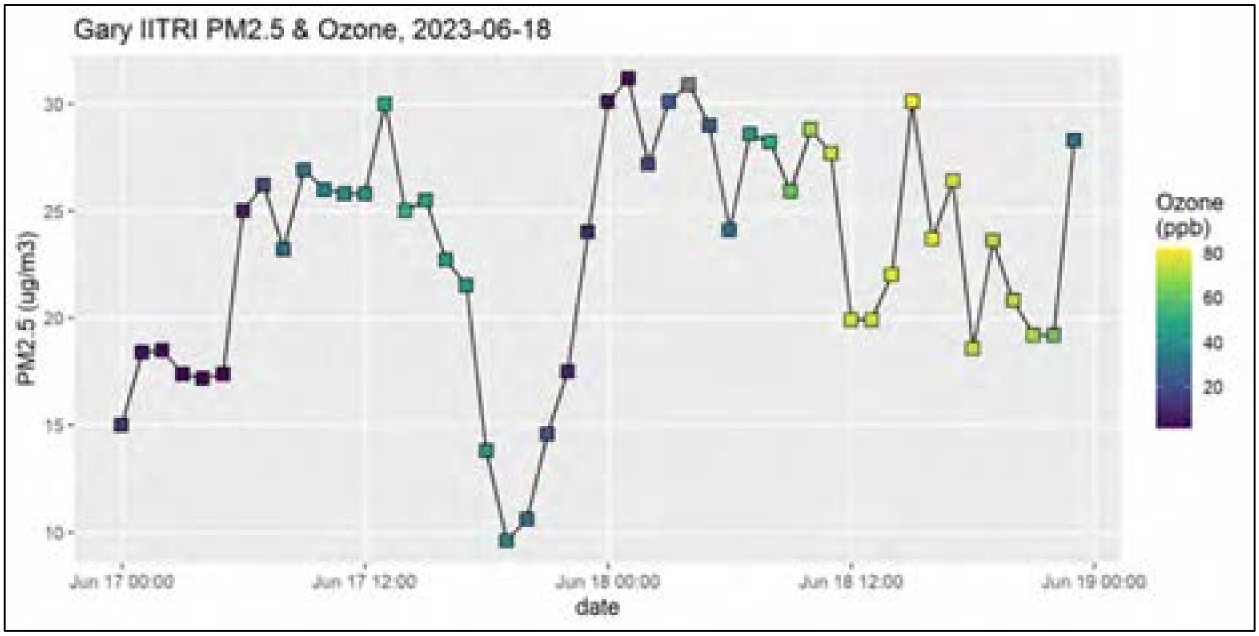
Figure 3.7.12 - Ozone Diurnal Pattern for Ogden Dunes

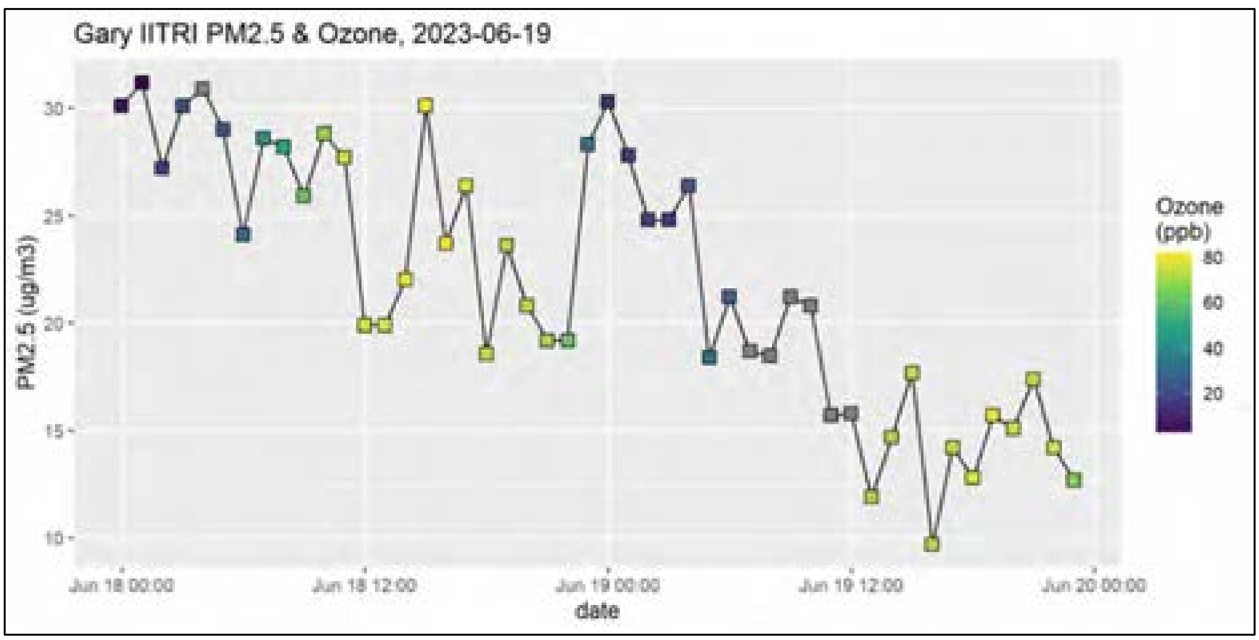




Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for June 18 - 19 as shown in Figure 3.7.13. $PM_{2.5}$ concentrations ranged from 10 - 32 µg/m^3.

Figure 3.7.13 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly data June 18 - 19, 2023





IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.3.2 shows the percentage above the five-year average. Black carbon was well above the average, CO and NO_2 were near average for both days.

Table 3.7.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

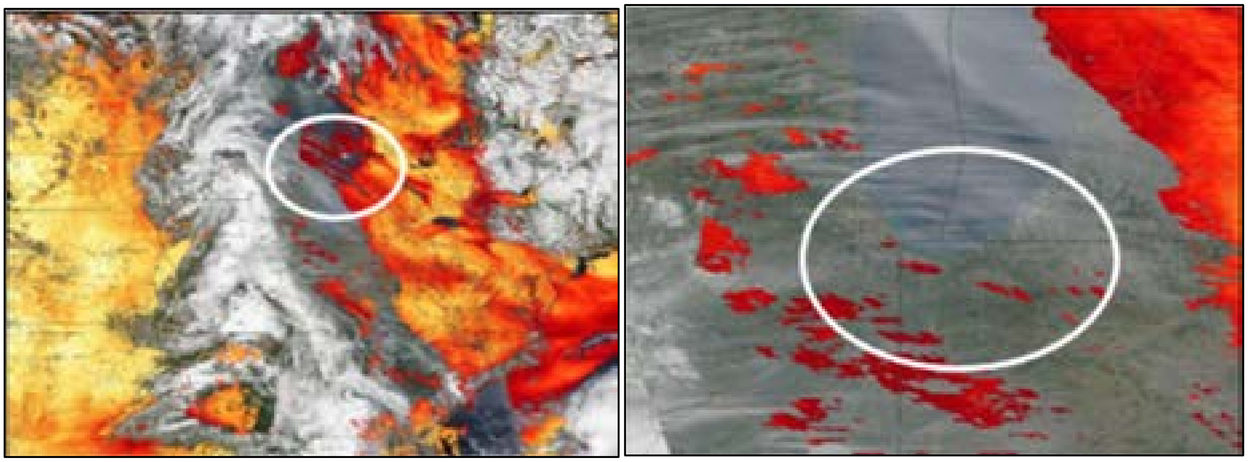
Date	Percentage CO Above 5-Year Average	Percentage NO2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
6/18/2023	111%	59%	321%
6/19/2023	102%	106%	149%

3.7.4 AOD and Satellite Analyses

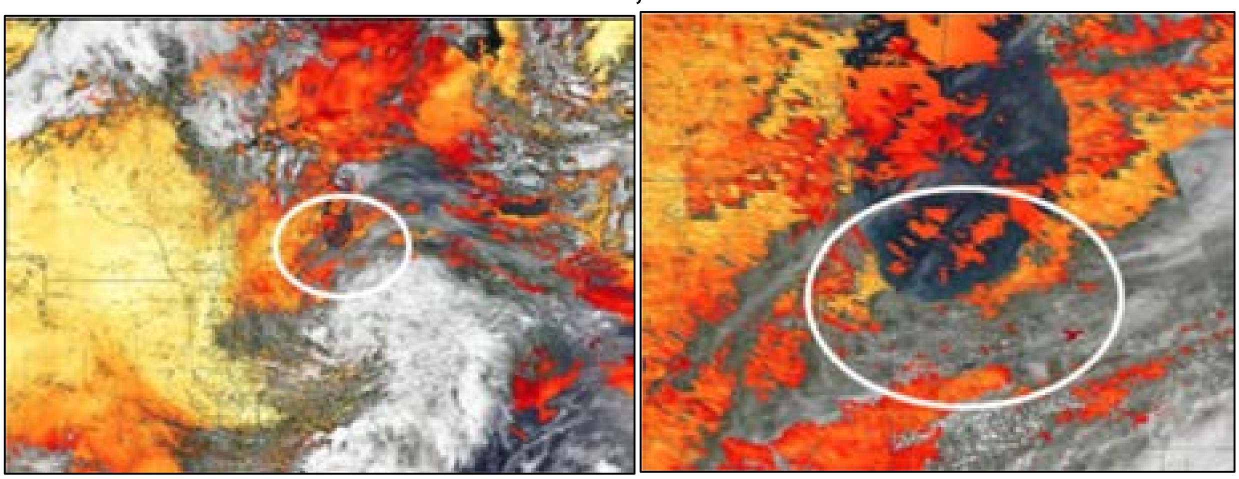
Figure 3.7.14 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of smoke. The northwest Indiana area is indicated by the white circle in each figure.

Figure 3.7.14 - Aerosol Optical Depth (AOD) – June 18 - 19, 2023

June 18, 2023



June 19, 2023



The images below captured by NOAA's GOES 18 satellite for North America taken on June 18 and 19 show clouds and a plume of gray smoke extending from Canada to the upper Midwest states, including Indiana. Figure 3.7.15 shows the June 18, 2023 satellite images with wildfire smoke evident over Lake and Porter counties. Figure 3.7.16 shows the northern hemisphere and the wildfire smoke transport from the Quebec and Ontario provinces. The northwest Indiana area is indicated by the red circle on the satellite image Credit: NOAA NESDIS

Figure 3.7.15 - Satellite Imagery of Upper Midwest June 18, 2023

Figure 3.7.16 - Satellite Imagery of Northern Hemisphere on June 19, 2023

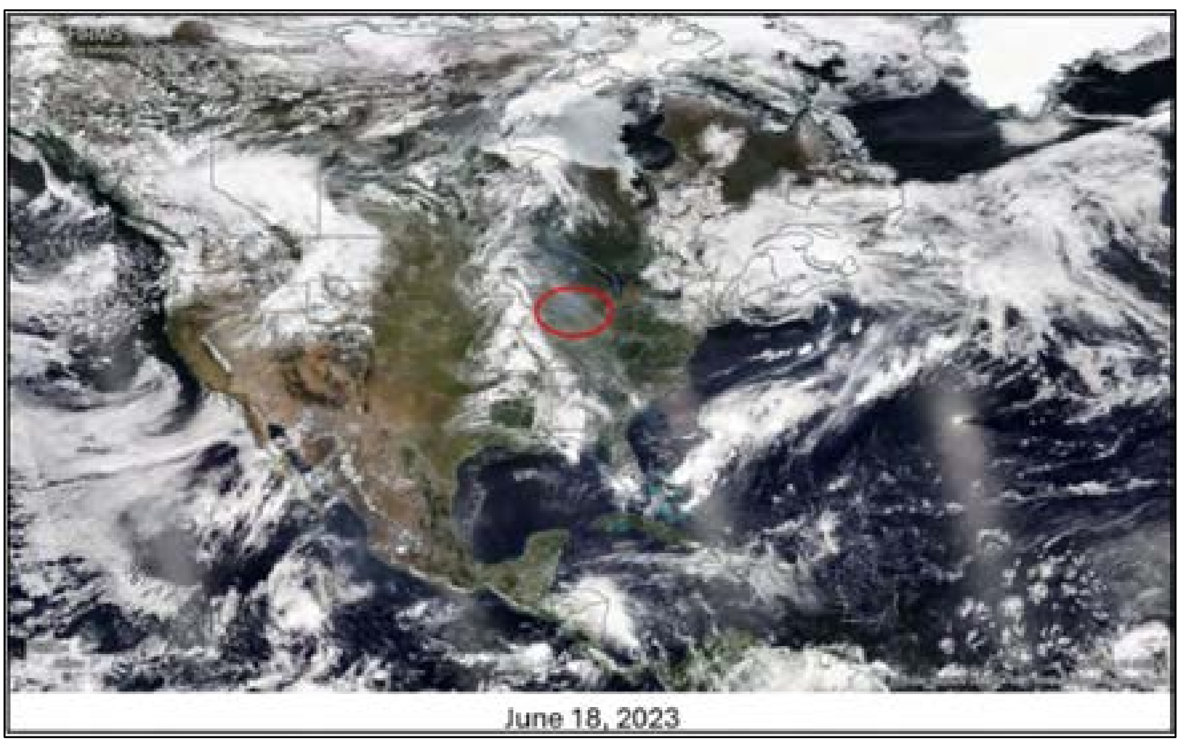


Figure 3.7.17 shows the Upper Midwest satellite image for June 19 while Figure 3.7.18 shows smoke worked into northern Indiana from the Canadian wildfires. The northwest Indiana area is indicated by the red circle on the satellite images.

Figure 3.7.17 - Satellite Imagery of Upper Midwest on June 19, 2023

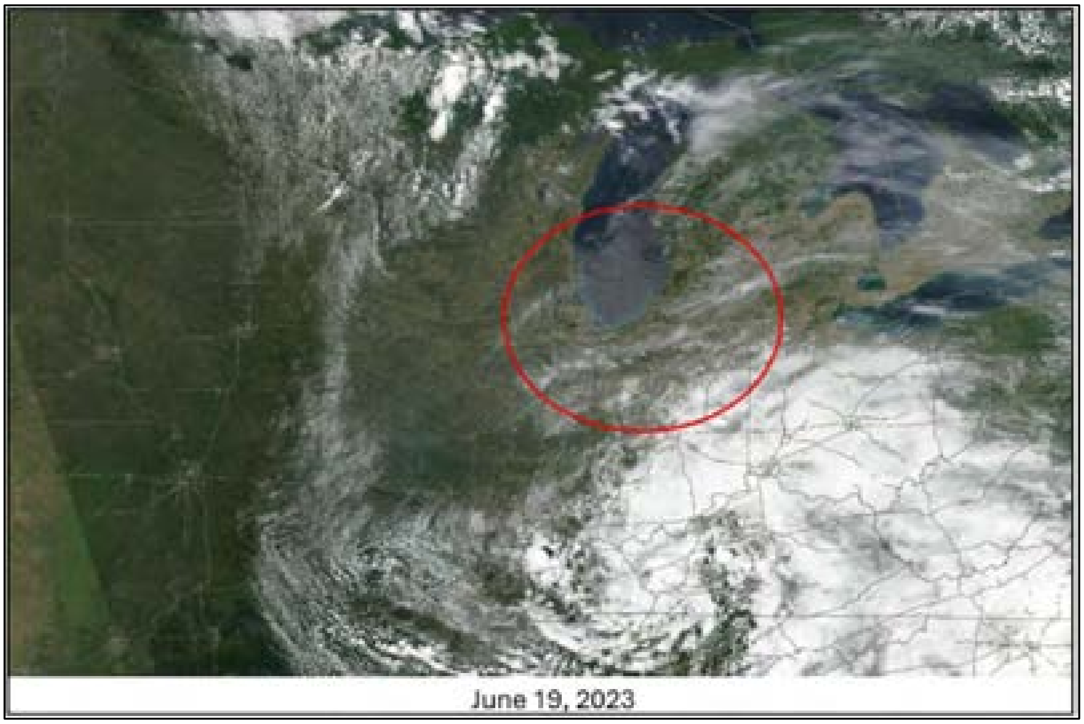
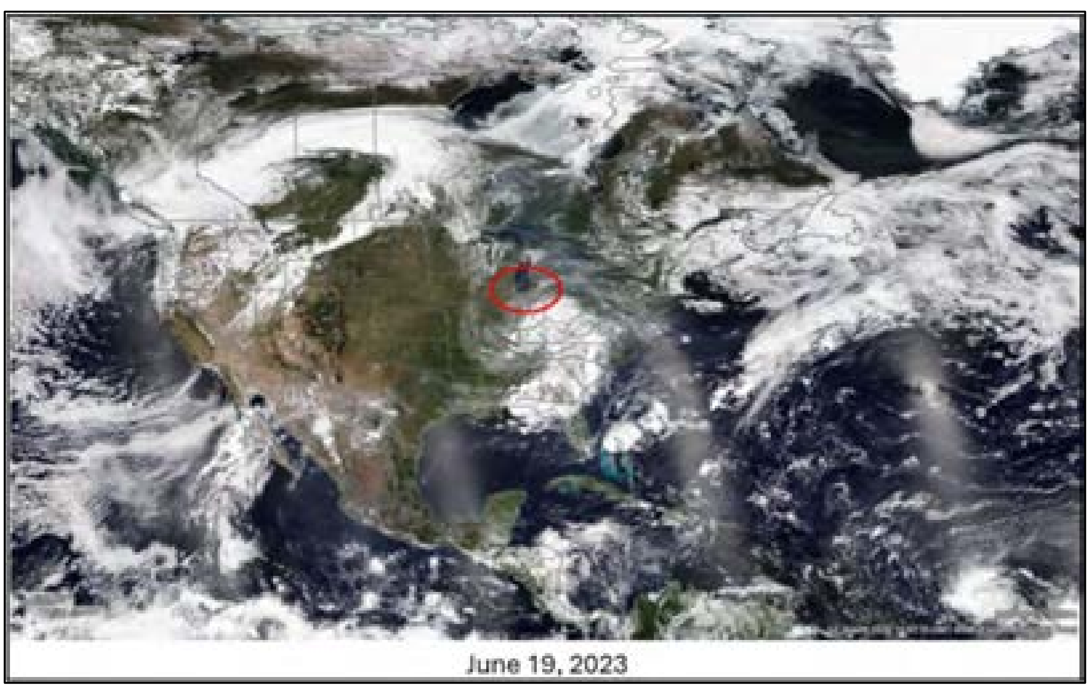


Figure 3.7.18 - Satellite Imagery of Northern Hemisphere on June 19, 2023



3.7.5 NOAA Smoke Narrative

Sunday, June 18, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 1645Z June 18, 2023

SMOKE:

Canada/United States/Atlantic Ocean…

Cloudiness has spread over some of the wildfires in various spots across Canada which has affected both fire and smoke detection in satellite imagery. This was especially true over western and central Canada. **The numerous large wildfires (some of which are still visible in satellite imagery), which have been scattered across portions of the southern half of Canada generally from northern British Columbia and the southwestern part of the Northwest Territories eastward over the southern tier of Canadian provinces to Quebec over the past number of weeks, continued to result in patches of moderate to thick density smoke which covered parts of Canada. Moderate to thick smoke also spread to the south and southeast from the Upper Mississippi Valley and Great Lakes regions to and off the Mid-Atlantic and southeastern U.S. coast.** Thinner density smoke from these fires covered a sizable part of the Atlantic reaching as far east as Europe. Embedded relatively smaller areas of moderate to thick density smoke were also seen over the northern Atlantic. In addition, it is likely that the southern portion of the smoke from Canada merged with smoke spreading northward from Mexico somewhere over the south central and southeastern U.S.

Monday, June 19, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY

SMOKE:

Canada/United States/Atlantic Ocean…

Wildfire activity was still noted across western Canada, although to a lesser extent than in previous weeks. This being said, smoke production was still observed across northeastern BC, northern Alberta, and southern NW Territory. The smoke was mainly light with some moderate density smoke. Smoke was moving south to southwestward around a low pressure over central Alberta. Cloud cover is likely obscuring smoke across central Alberta, southern BC, northern Saskatchewan and northern Manitoba. A couple fires were also seen producing smoke across central Saskatchewan, where the smoke was moving northeastward. The more significant wildfire activity is now located throughout Quebec and Ontario, from which thick smoke was being produced and moved south to southwestward. **Thick remnant smoke from both western and eastern Canada was seen across eastern Canada extending south across the Great Lakes and into the Ohio Valley, Mid-Atlantic, and out across the North Atlantic. Some was also merging with smoke/aerosol across the Great Plains, Gulf Coast and Florida**

3.7.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circles on Figures 3.7.19 and 3.7.20 indicate the location of the Lake and Porter County monitors. Estimated concentrations on the 18 are from 8-22 × 10^{15} molecules/cm^2 indicate strong to extreme wildfire smoke influence. On the 19 the concentrations are from 5-15 × 10^{15} molecules/cm^2 indicate moderate to extreme wildfire smoke influence.

Figure 3.7.19 - TROPOMI Satellite Daily Formaldehyde Monitoring

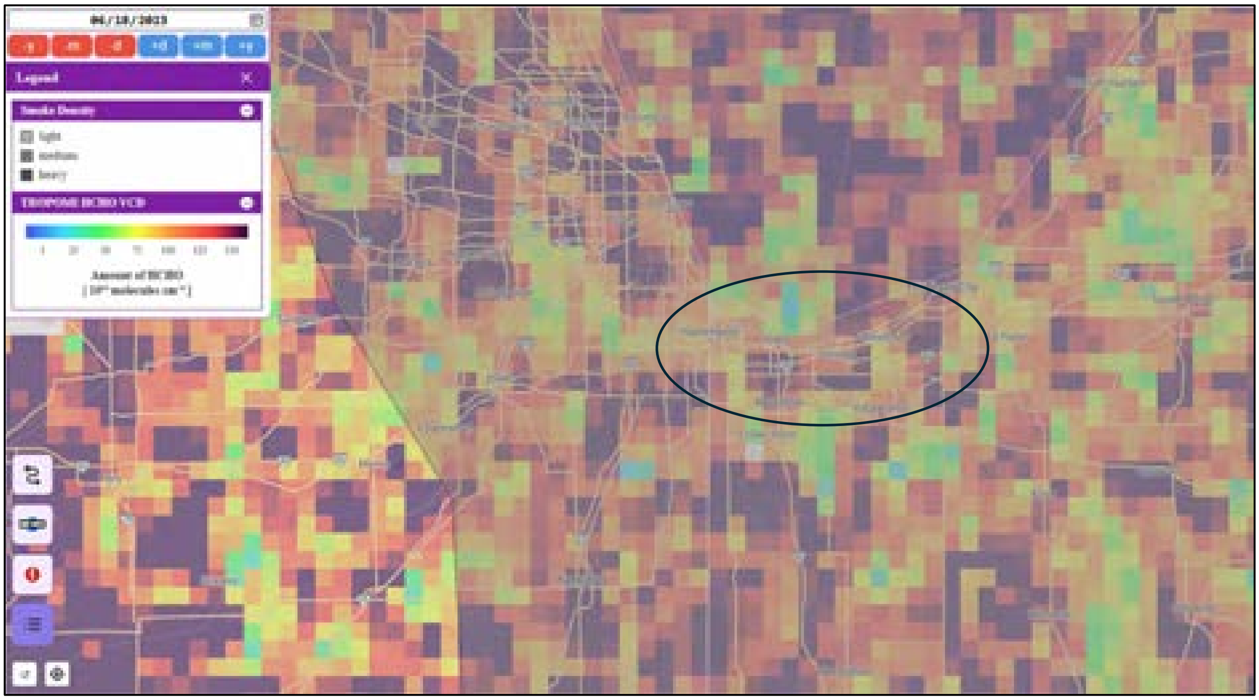
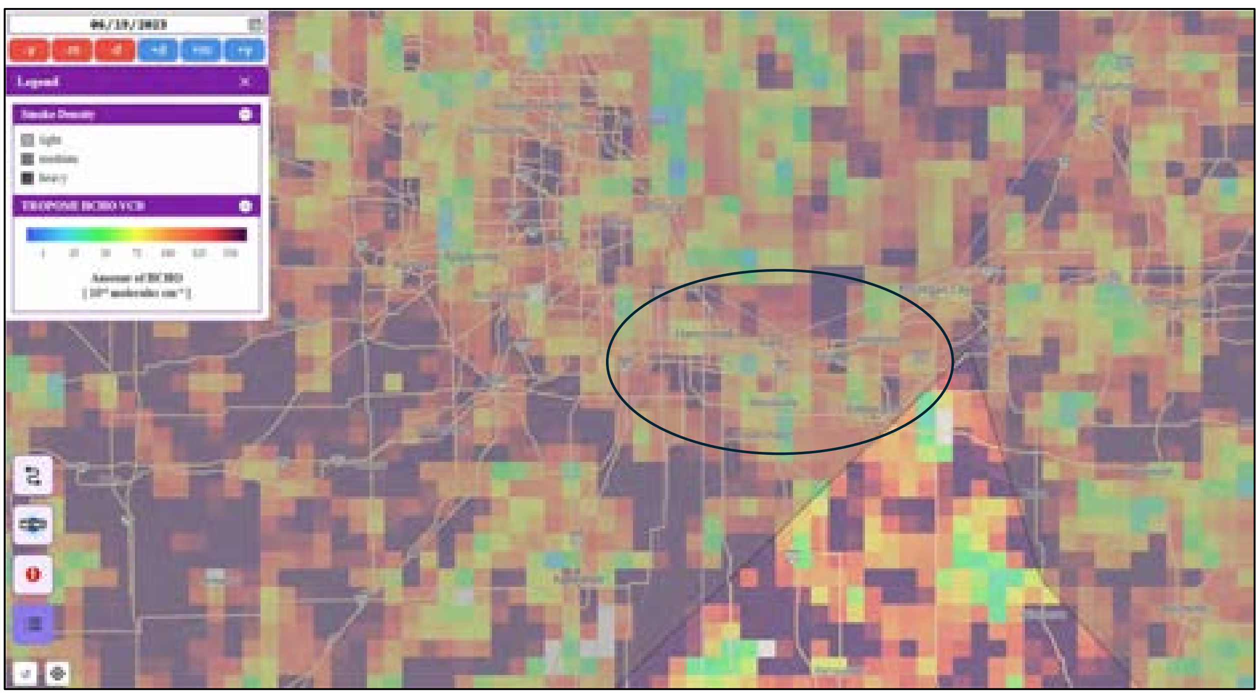


Figure 3.7.20 - TROPOMI Satellite Daily Formaldehyde Monitoring



3.7.7 AirNow Smoke Maps

AirNow shows in Figures 3.7.21 through 3.7.28 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.7.21 - AirNow Ozone Map

Figure 3.7.22 - AirNow Ozone Map

Figure 3.7.23 - AirNow $PM_{2.5}$ Map

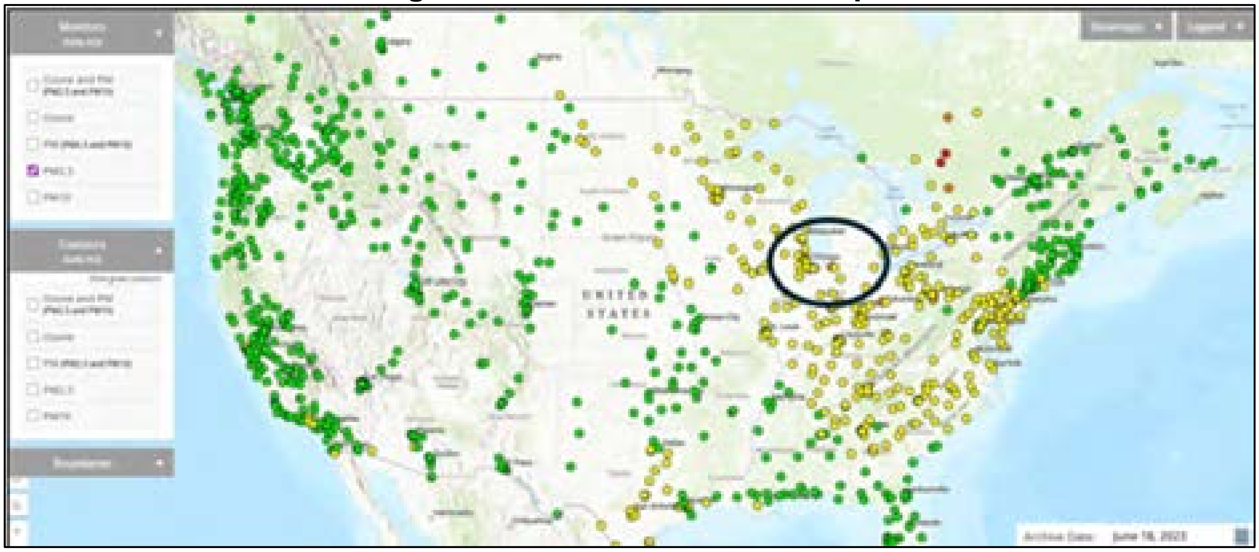


Figure 3.7.24 - AirNow Smoke and Ozone Map

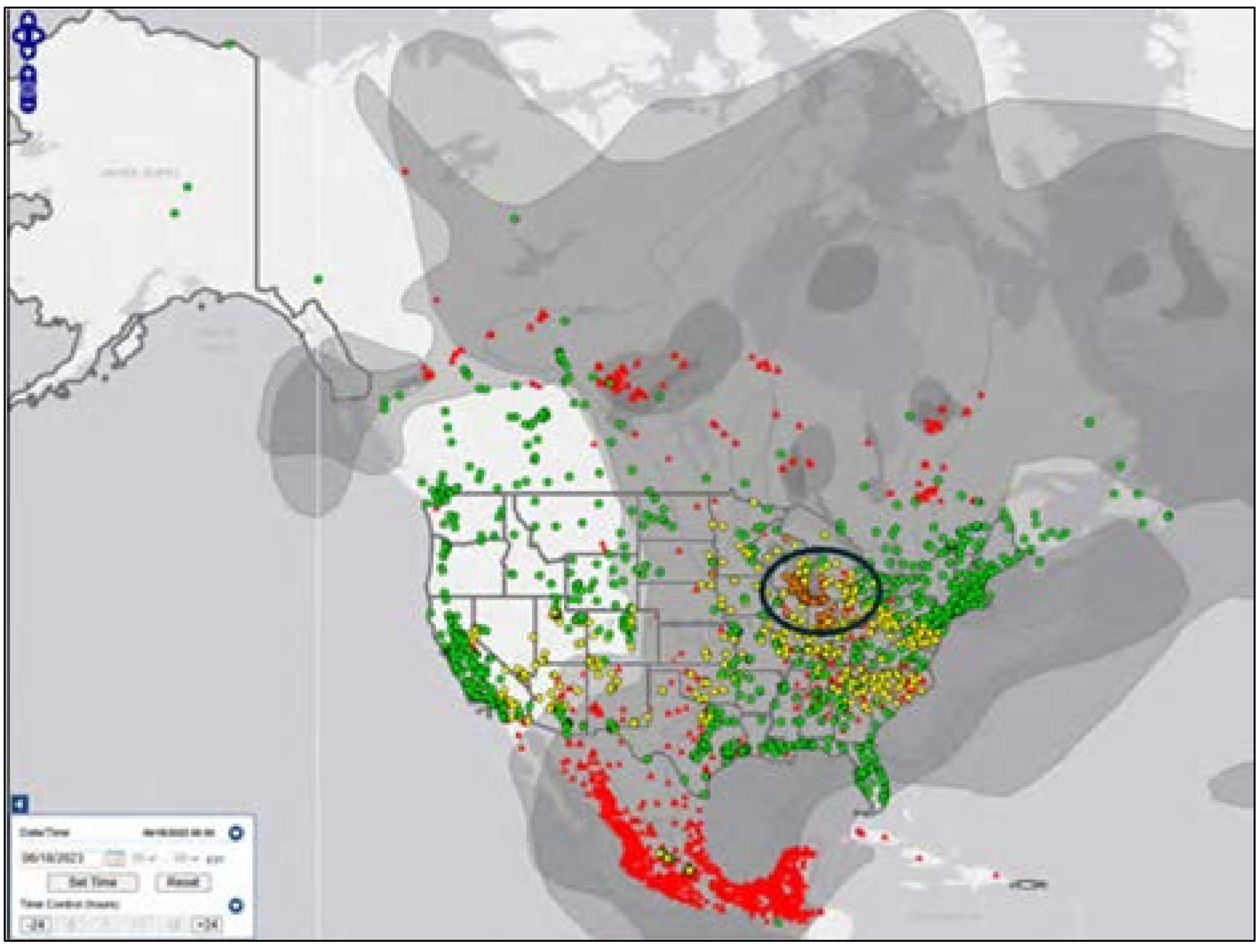


Figure 3.7.25 - AirNow Ozone Map

Figure 3.7.26 - AirNow Ozone Map

Figure 3.7.27 - AirNow $PM_{2.5}$ Map

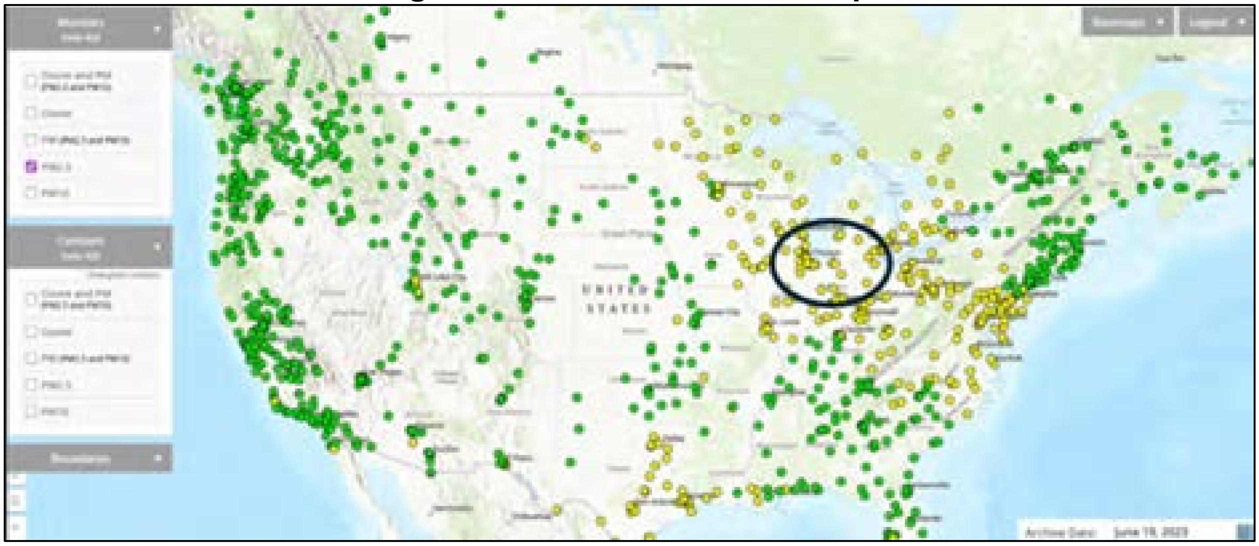
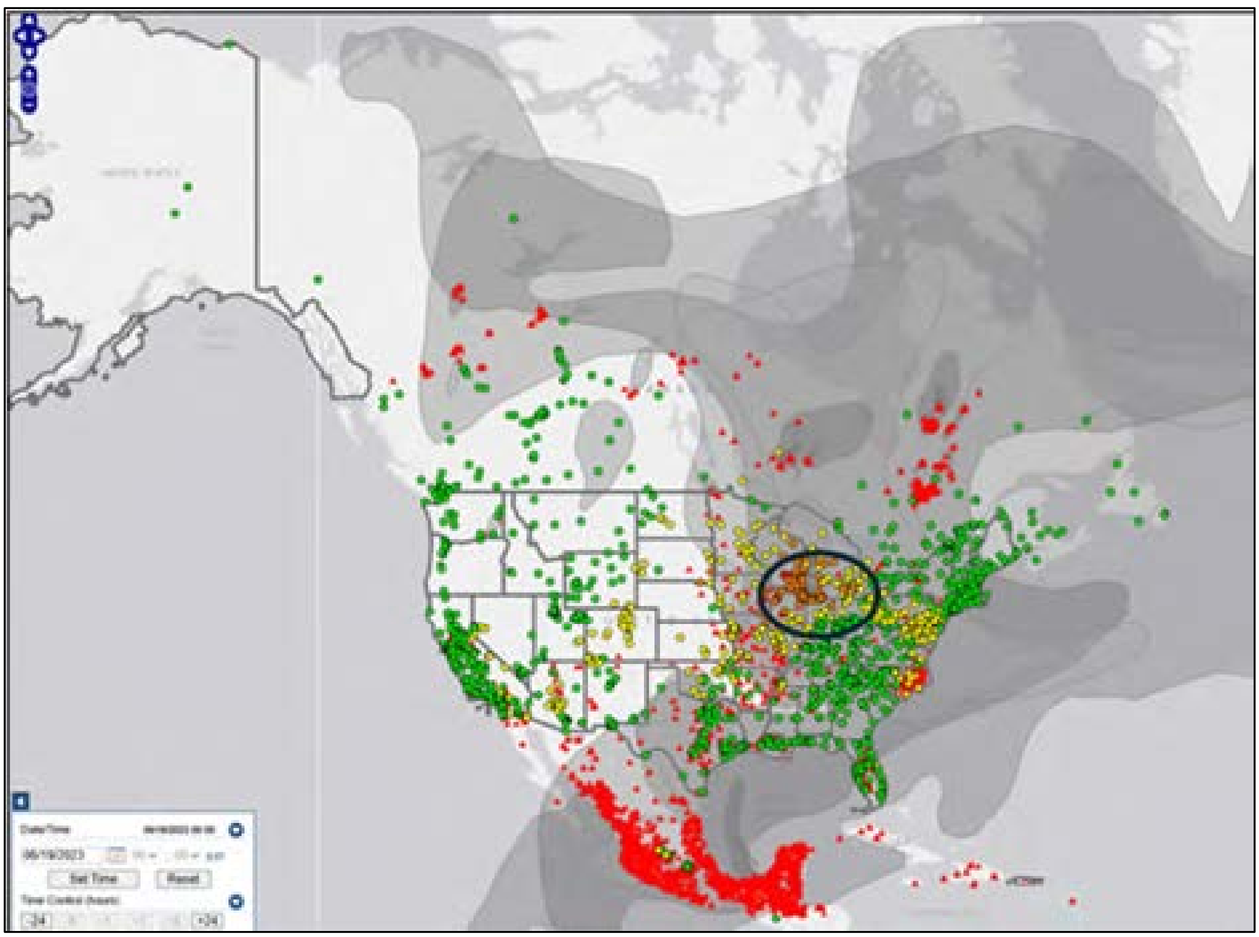


Figure 3.7.28 – AirNow Smoke and Ozone Map



3.7.8 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes.

Figures 3.7.29 through 3.7.36 show indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the white circles in each of the maps.

Figure 3.7.29 - GAM Smoke Maps Indicating Smoke Days June 18, 2023

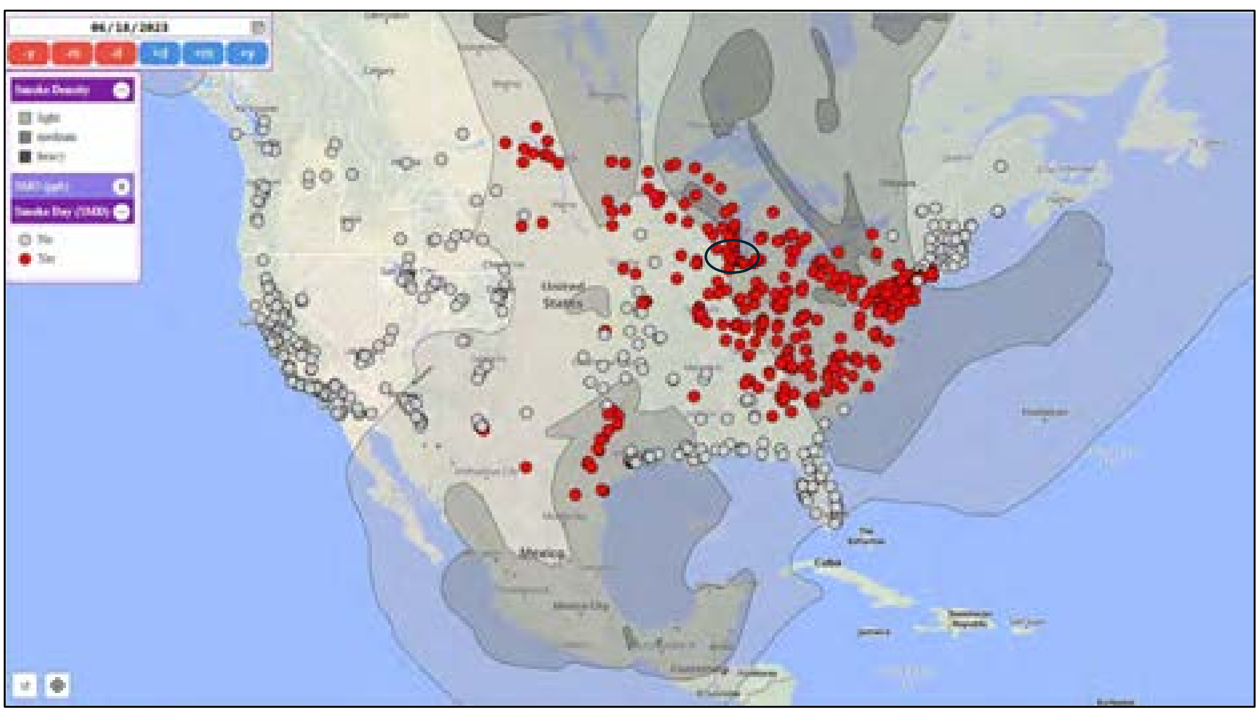


Figure 3.7.30 - GAM Smoke Maps Indicating Smoke Days June 19, 2023

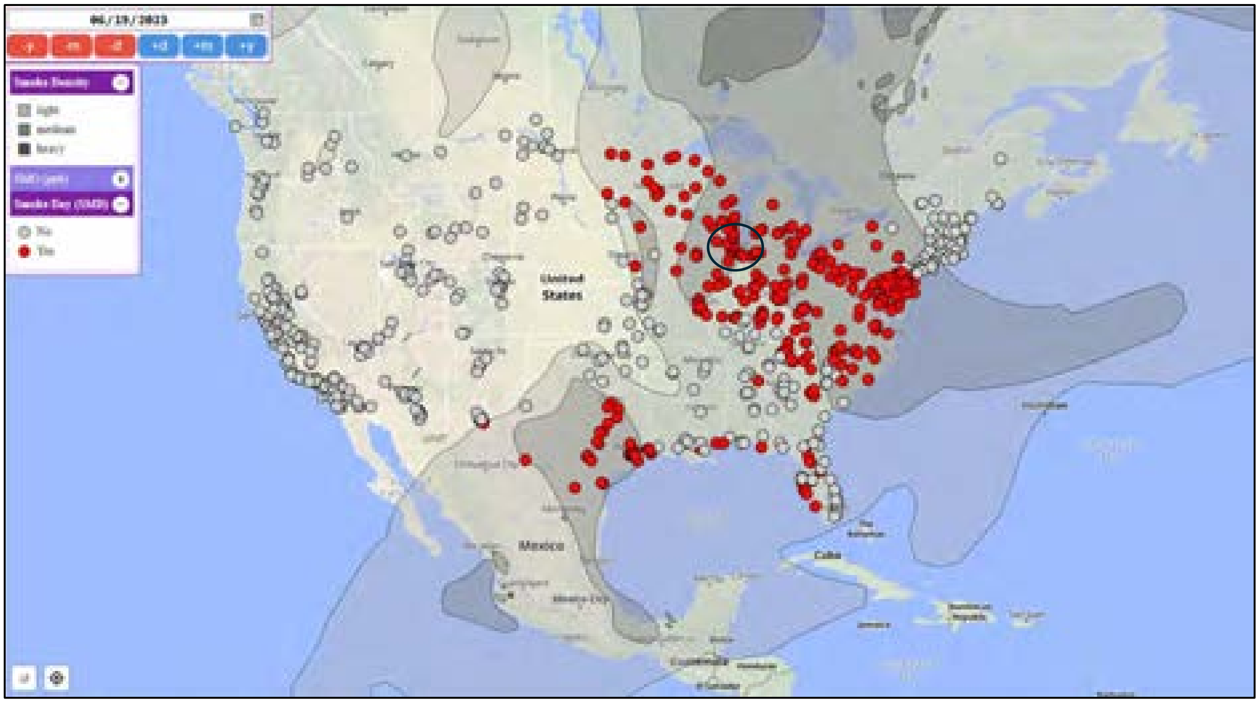


Figure 3.7.31 - GAM Observed Ozone with Smoke Days June 18, 2023

Figure 3.7.32 - GAM Observed ozone with Smoke days June 19, 2023

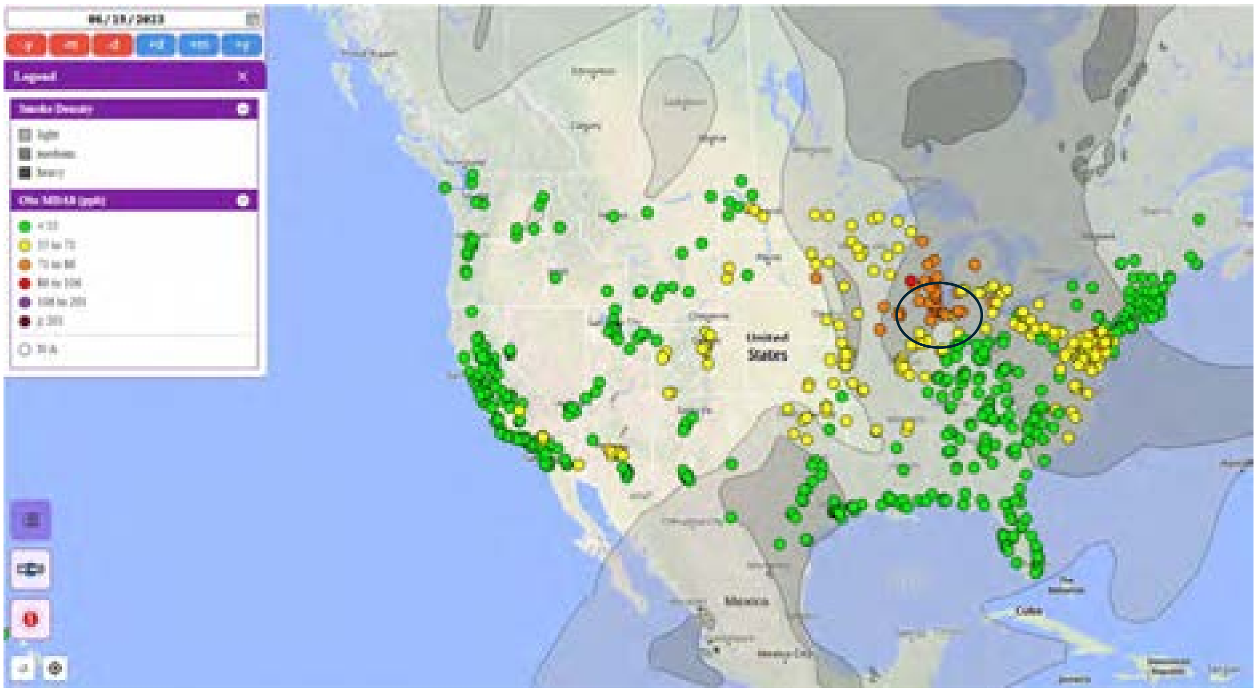


Figure 3.7.33 - GAM Smoke Estimates June 18 - 19, 2023

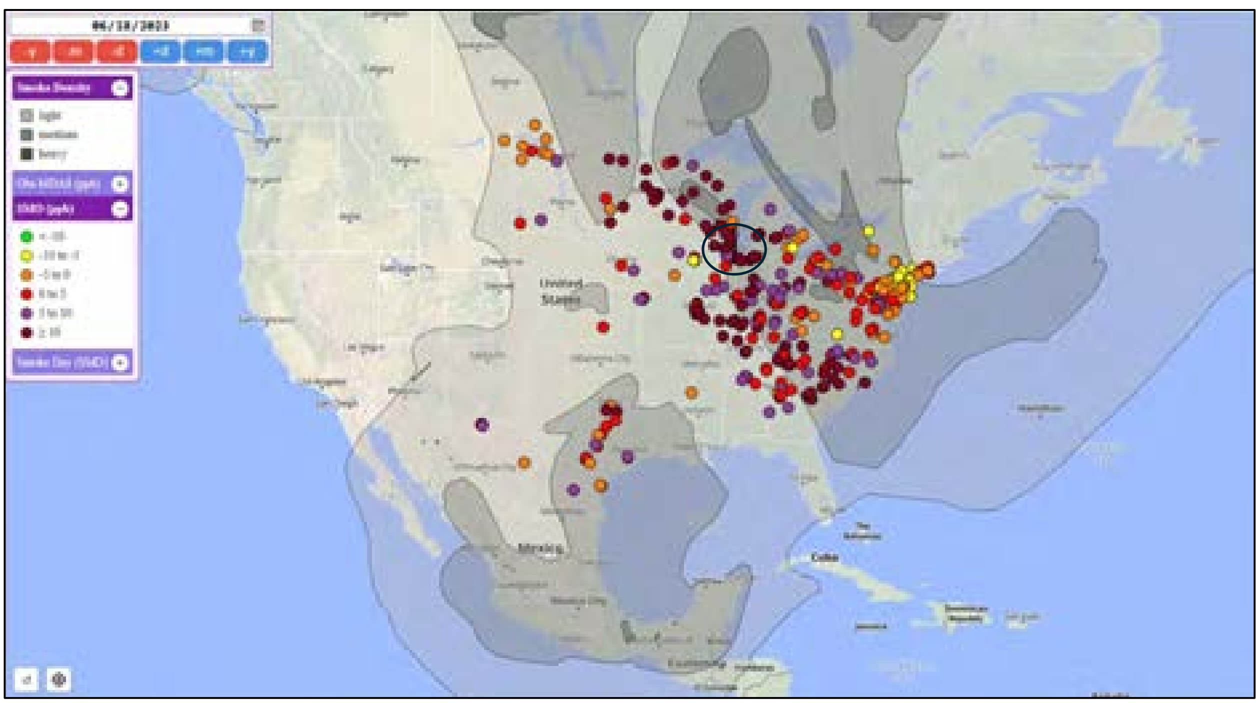


Figure 3.7.34 - GAM Smoke Estimates June 19, 2023

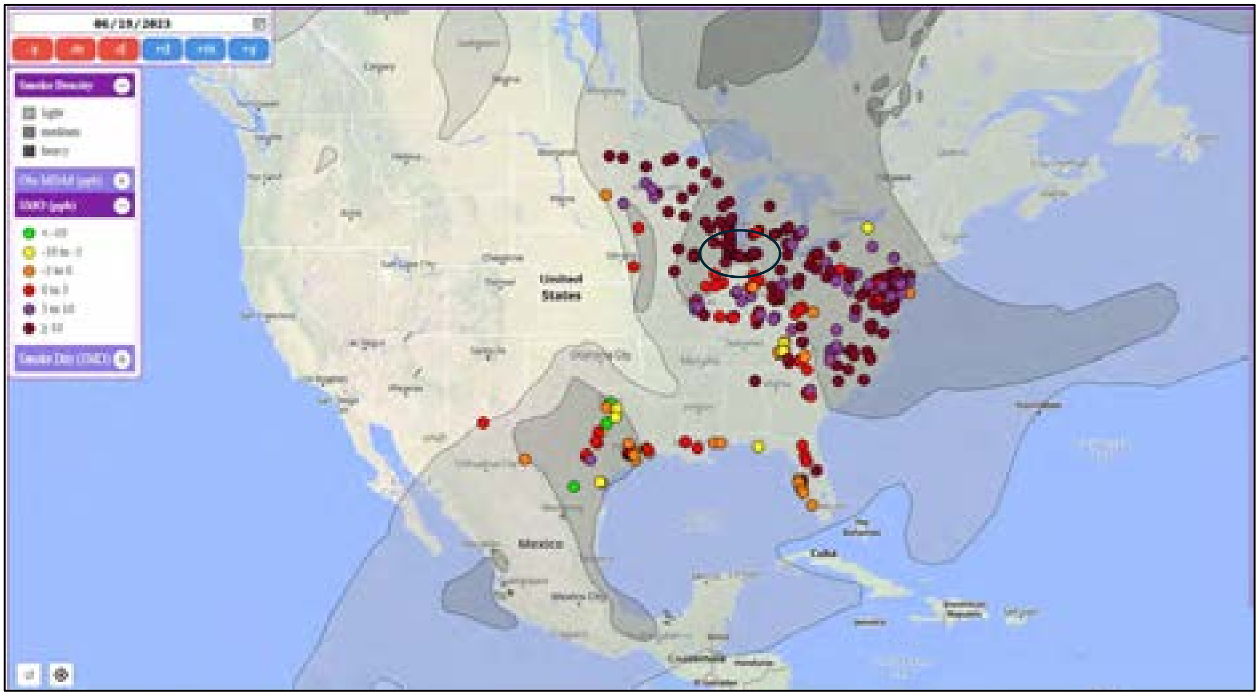


Figure 3.7.35 - EMBER Smoke Estimates June 18 - 19, 2023

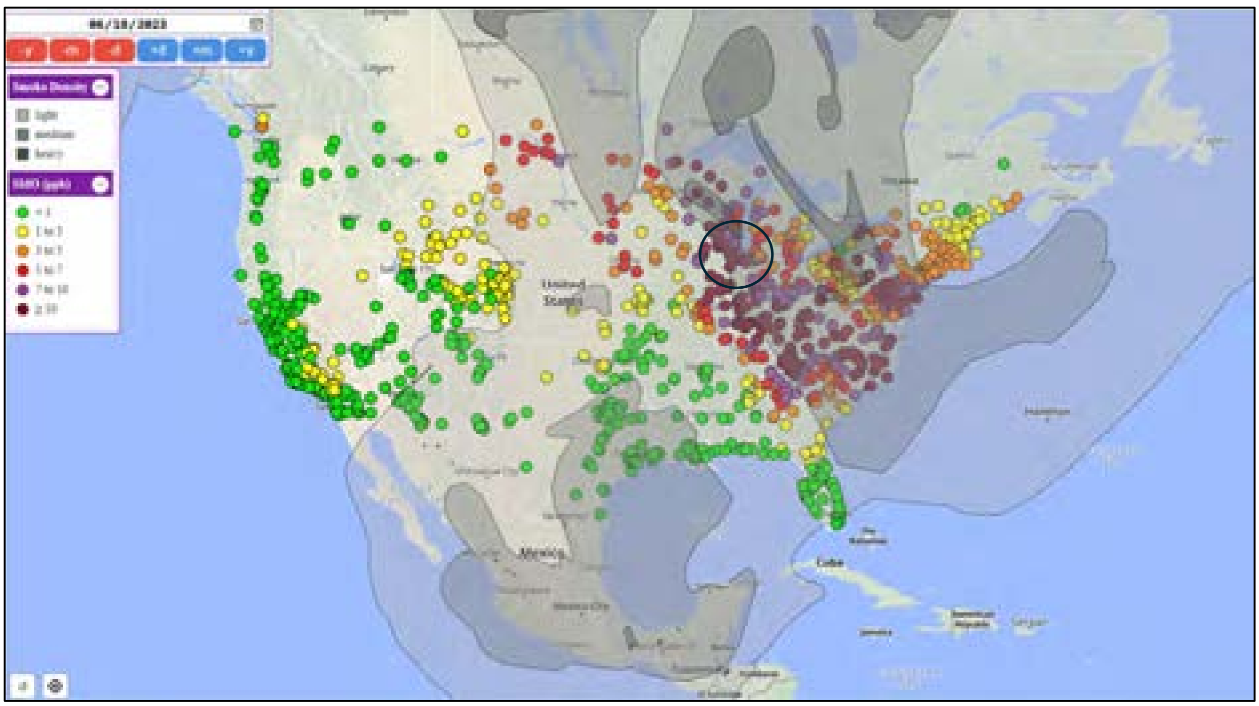
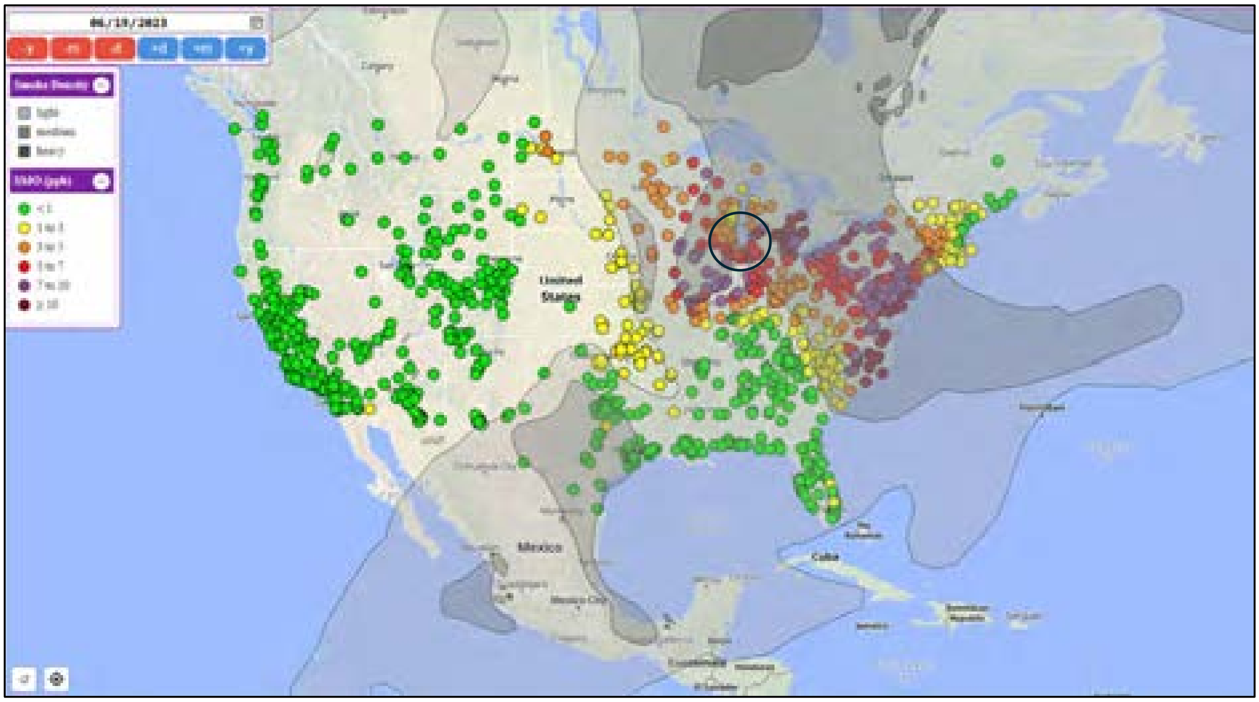


Figure 3.7.36 - EMBER Smoke Estimates June 19, 2023



Tables 3.7.3 and 3.7.4 summarize the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.7.3 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values June 18, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	77	57.0	20	72	5
180892008	Hammond	77	NA	NA	69	8
181270024	Ogden Dunes	75	59.3	15.7	72	3
181270026	Valparaiso	76	63.4	12.6	64	12

Table 3.7.4 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values June 19, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	74	55.8	18.2	70	4
180892008	Hammond	69	NA	NA	69	0
181270024	Ogden Dunes	76	56.2	19.8	70	6
181270026	Valparaiso	76	60.7	15.3	66	10

3.7.9 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on June 18 and 19, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.7.5 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 20-25 ppb lower than the MDA8 ozone concentrations observed those days with the maximum matching day MDA8 ozone concentration of a smoke influenced 79 ppb.

Table 3.7.5 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 18, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	75	77.7*	54.7

* Indicates Matching days were influenced by wildfire smoke

Table 3.7.6 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 19, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	76	79.3*	50.7

* Indicates Matching days were influenced by wildfire smoke

3.7.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. Figures 3.7.37 and 3.7.38 shows the trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red) for June 18 and 19 respectively while Figures 3.7.39 and 3.7.40 show the higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. June 18 three-day back trajectories indicate smoke from eastern Canada being drawn down to northwest Indiana. The trajectories in Figures 3.7.41 and 3.7.42 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over the wildfires in eastern Canada on June 18 and 19. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps

Figure 3.7.37 – Back Trajectories from June 18 (50, 100 and 500 meters - 72 hours)

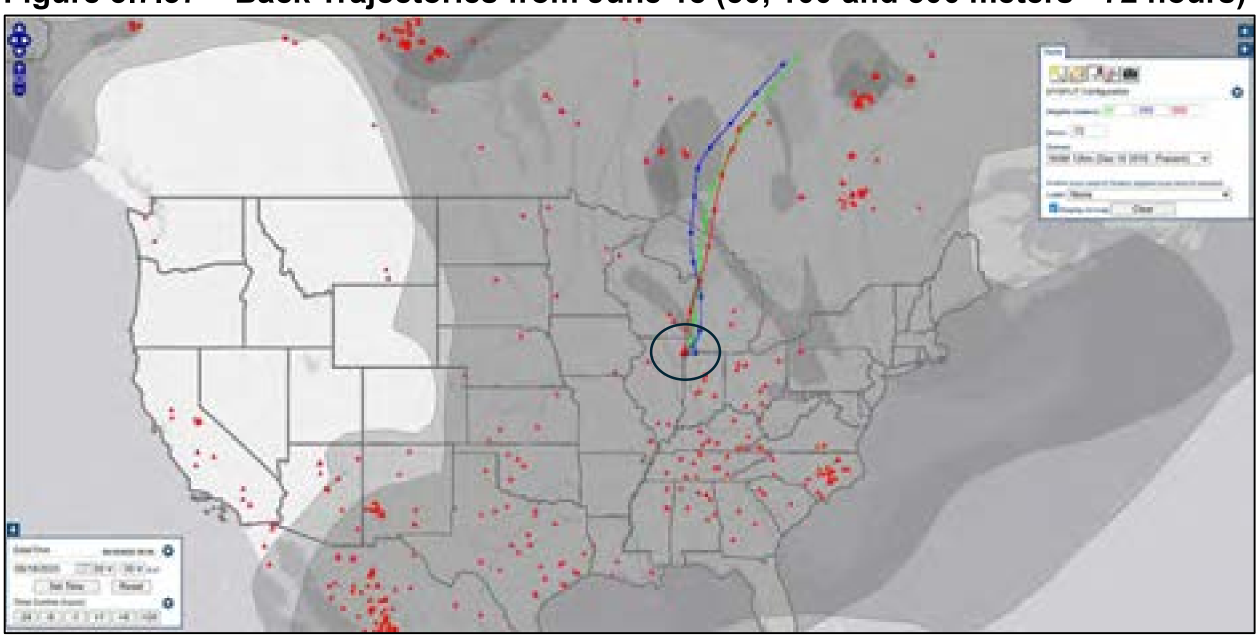


Figure 3.7.38 - Back Trajectories from June 18 (1000, 2000 and 3000 meters - 72 hours)

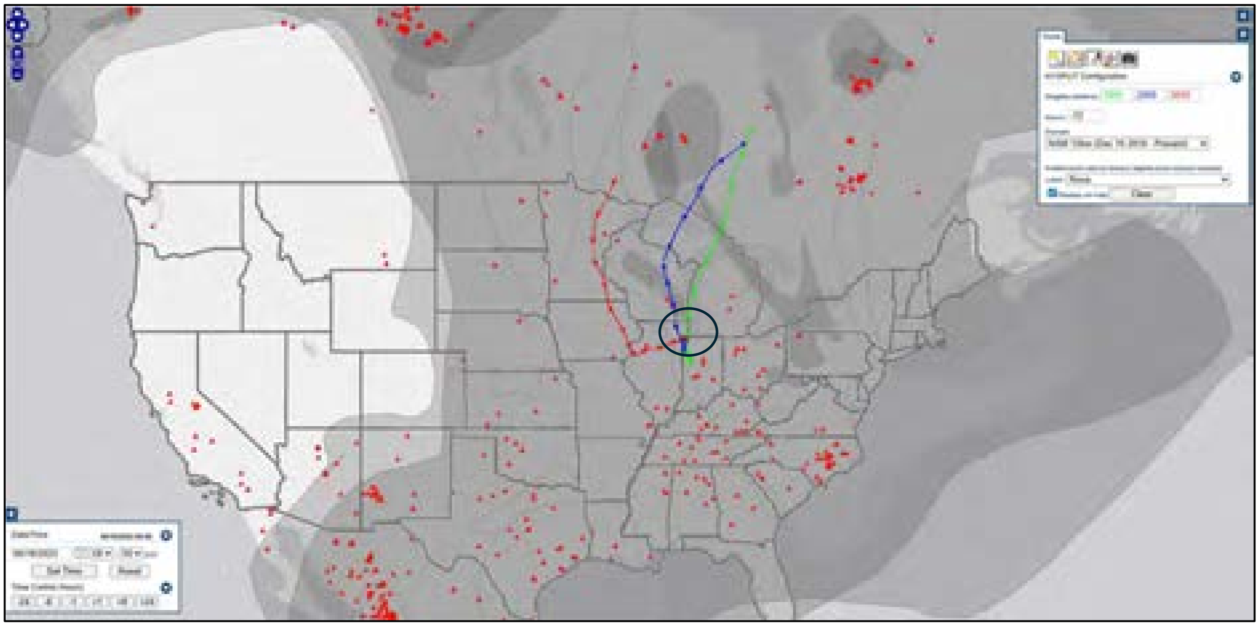


Figure 3.7.39 - Back Trajectories from June 19 (50, 100 and 500 meters - 72 hours)

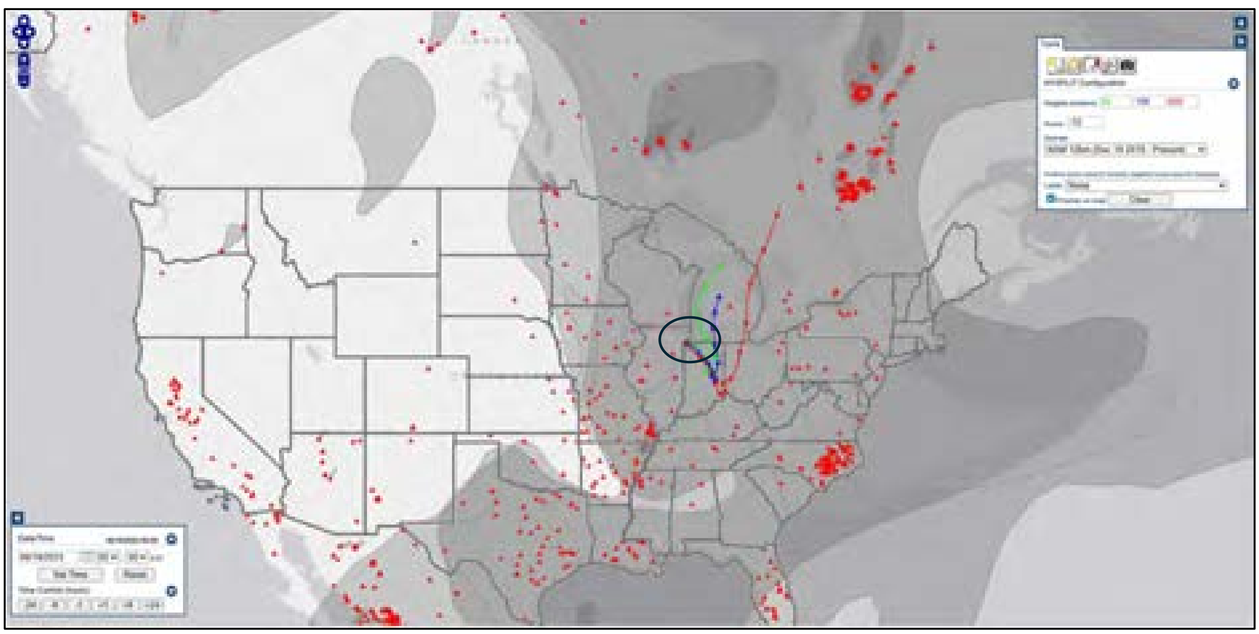


Figure 3.7.40 - Back Trajectories from June 19 (1000, 2000 and 3000 meters - 72 hours)

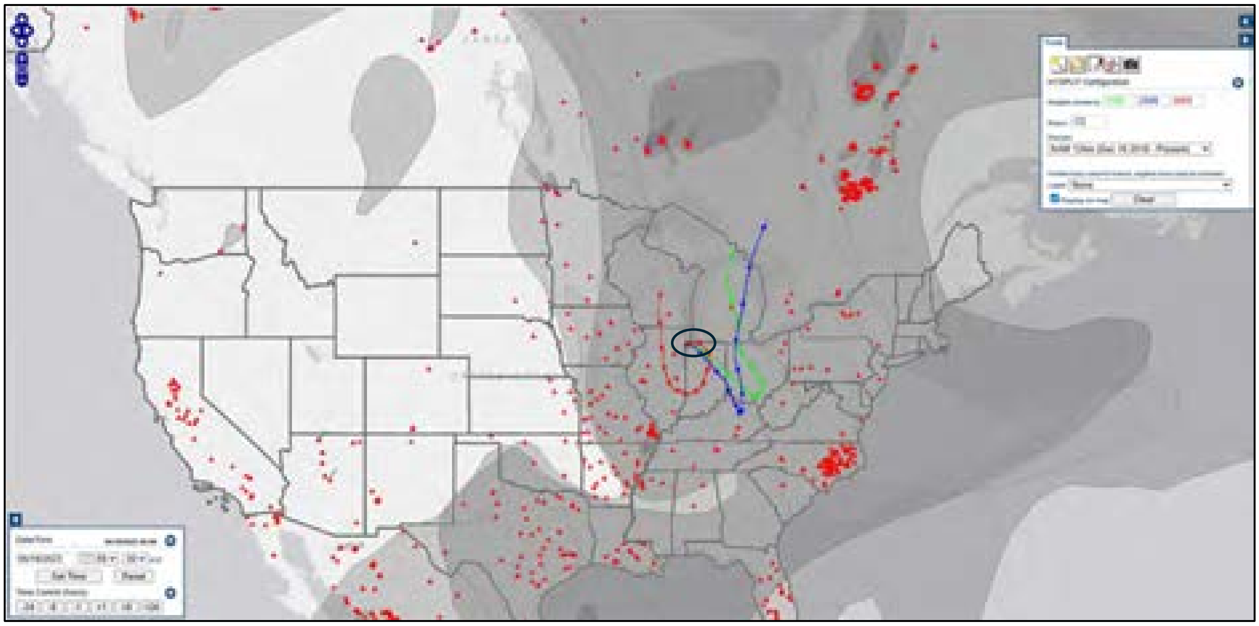


Figure 3.7.41 - Long-Range Back Trajectories from June 18 (100, 500 and 1000 meters - 168 hours)

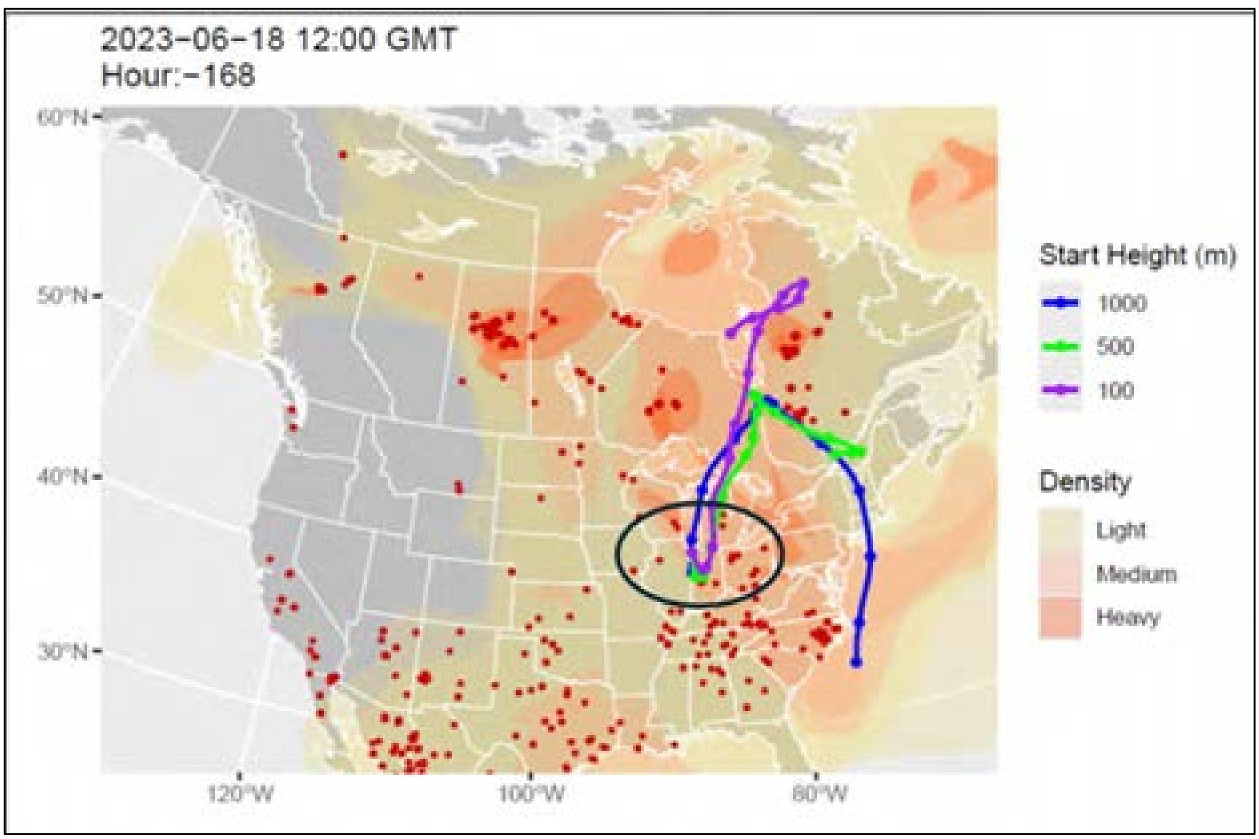
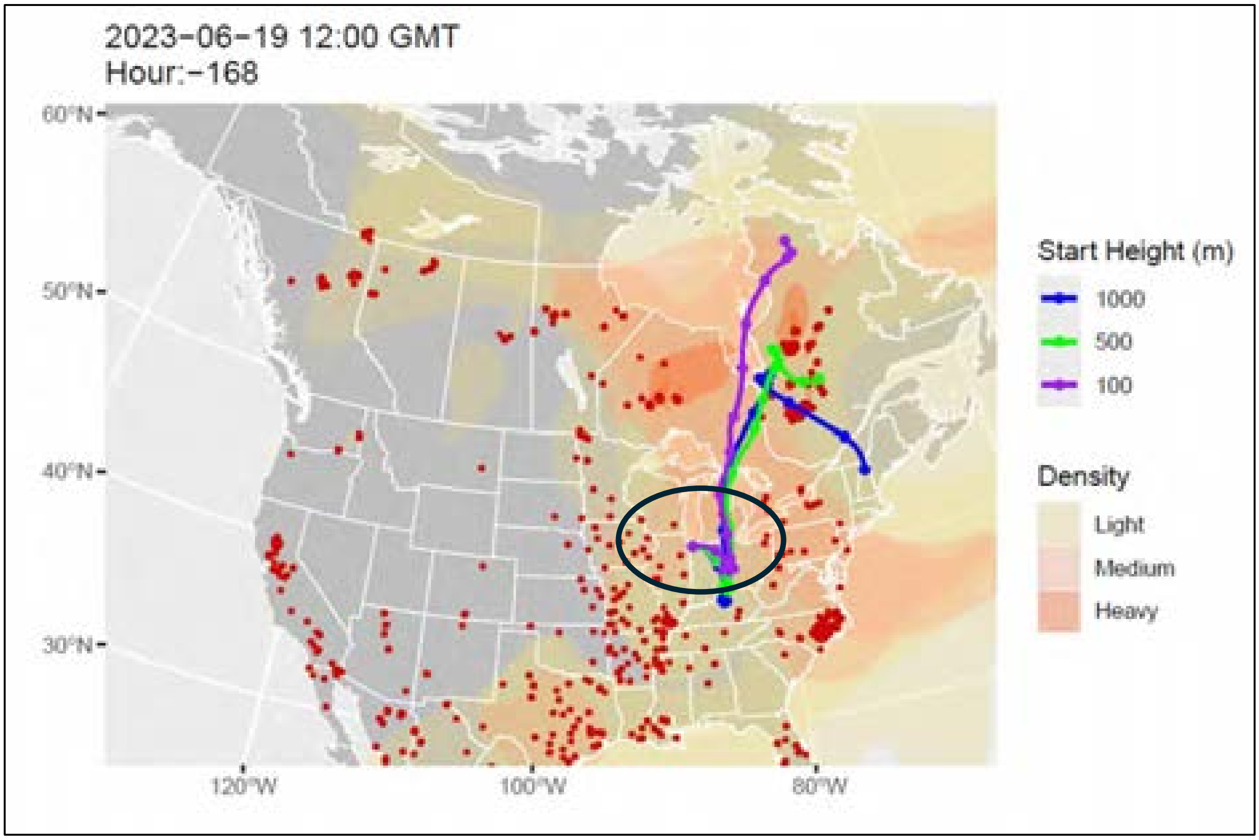


Figure 3.7.42 - Long-Range Back Trajectories from June 19 (100, 500 and 1000 meters - 168 hours)



3.7.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figures 3.7.43 and 3.7.44 indicate the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.7.43 HRRR Smoke Model for June 18, 2023

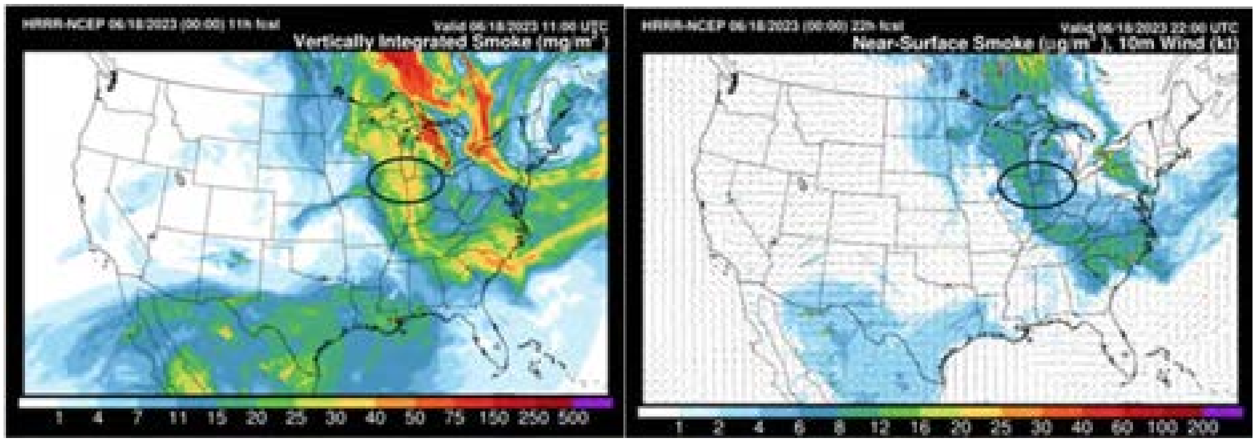
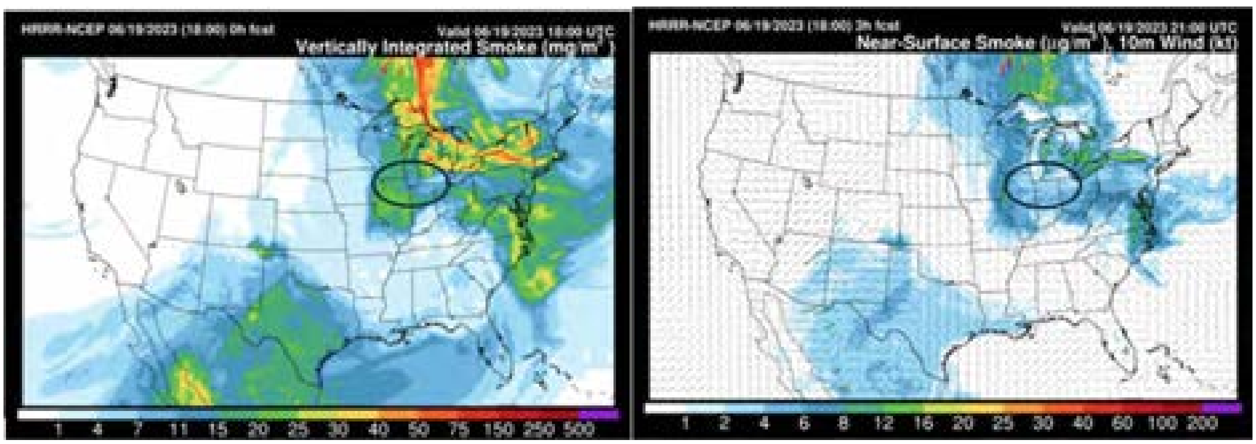


Figure 3.7.44 HRRR Smoke Model for June 19, 2023



3.7.12 Media Mentions

Northwest Fire Region Update: June 19, 2023 32 Active Fires 10 Out of Control

Nearly 300K hectares burned in Ontario wildfires, extremely poor air quality continues

Forest fire smoke affecting several parts of the region

IDEM issues Air Quality Action Day for TOMORROW Wednesday June 19

3.7.13 Summary of Requested Exclusion of June 18 - 19, 2023

Table 3.7.7 - Summary Table - Gary IITRI

Event Date	**June 18, 2023**	**June 19, 2023**
MDA8 Ozone Concentration (PPB)	77	74
Does Ozone Concentration exceed the 95th Percentile?	Yes	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes	Yes
GAM predicted MDA8 ozone (PPB)	57	55.8
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	5	4
Matching day MDA8 ozone (max., avg.) (PPB)	77.7*, 54.7	79.3*, 50.7
HYSPLIT indicated wildfire regions	James Bay Priority Fires, Quebec, Western-edge Wabakimi Fire,	
Do HRRR Models indicate smoke?	Yes	Yes
Media Mentions	Yes	Yes
Clear causal relationship established?	Yes	Yes

3.8 June 21, 2023 Ozone Event

3.8.1 Executive Summary

On June 21, 2023, Northwest Indiana experienced ozone exceedances across Lake and Porter County monitors, with values ranging from 69-78 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 7-18 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to James Bay Priority Fires, Quebec.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of June 21, 2023, as an exceptional event under U.S. EPA guidelines.

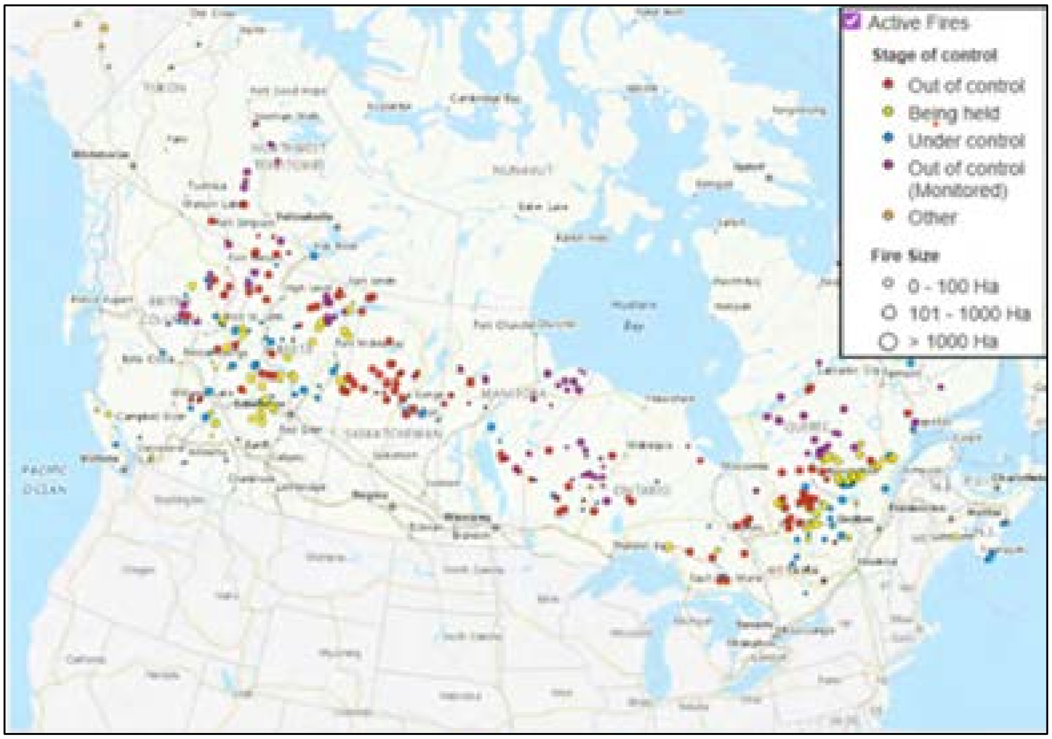
Table 3.8.1 June 21, 2023 Lake and Porter County MDA 8-Hour Ozone Values (PPB)

Date	**Gary -IITRI**	**Hammond**	**Ogden Dunes**	**Valparaiso**
Monitor ID	180890022	180892008	181270024	181270026
June 21, 2023	76	69	78	72

On June 21, 2023, multiple Canadian wildfires, show in Figure 3.8.1, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in June 2023 included the:

- James Bay Priority Fires, which began on June 1, 2023, when a historic lightning outbreak ignited 182 separate fires across northern Quebec, many near the Cree communities of Eastmain, Wemindji, and Waskaganish. Extreme drought, high winds, and low humidity allowed several fires to expand rapidly, with many reaching 20,000–100,000+ hectares.

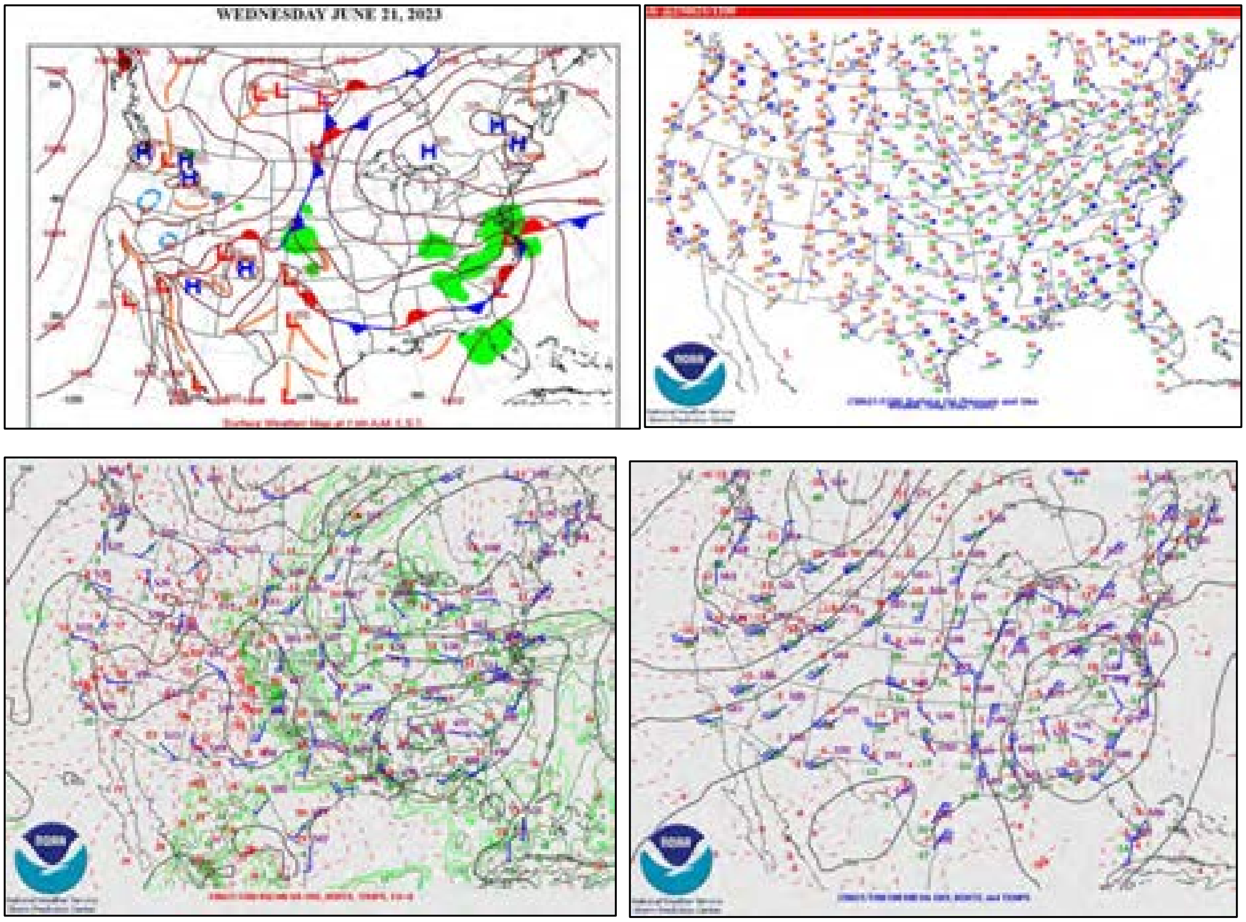
Figure 3.8.1 - Canadian Wildfires June 21, 2023



3.8.2 Meteorological Episode Overview

Strong surface high pressure set up over Ottawa and Ontario provinces as a sharp upper air trough was present over southeastern Canada for June 21. This surface high pressure remained entrenched over the area as an upper air low and associated surface low moved over the southern tier of U.S. states. This combination of upper air and surface features provided consistent north-northeast winds, tapping into the wildfire smoke from Quebec and Ontario and transporting it into the northwest Indiana area. Surface temperatures approached 90° F and lower humidity levels helped to make conducive ozone conditions which produced elevated levels of ozone throughout the area. Figure 3.8.2 shows the surface, 850 mb and 500 mb maps of the weather conditions on June 21.

Figure 3.8.2 - Surface, 850 and 500 mb Plots from 12Z on June 21, 2023



Wind rose (Figure 3.8.3) and pollution rose (Figure 3.8.4) analyses were taken from the Gary IITRI meteorological station. Wind directions on June 21 were primarily from the northeast. The pollution rose, using Ogden Dunes ozone, indicates that the highest ozone readings were from the northeast, the direction where Quebec province wildfires were still burning. This is consistent with the back trajectories, which show transport from the north, moving over areas covered in smoke and over points of wildfire activity. There was persistent high surface pressure and Rex Block conditions during this time, contributing to stagnant conditions and a buildup of pollutants. Temperatures were high and skies were sunny, contributing to ozone production.

Figure 3.8.3 - Gary IITRI Windrose

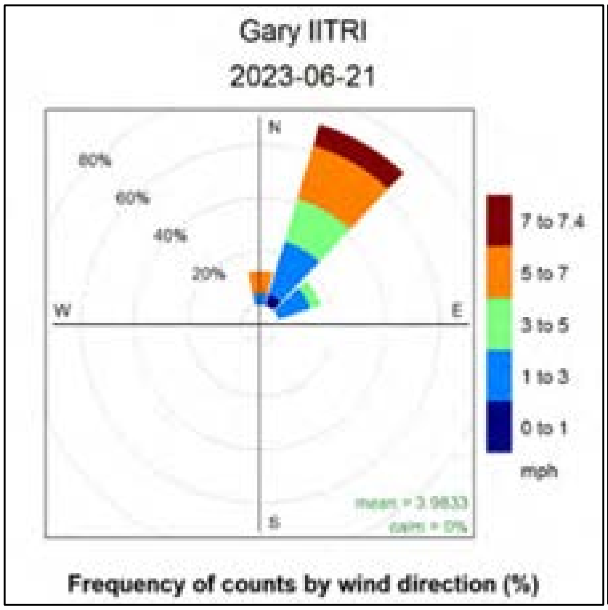


Figure 3.8.4 Gary ITRII Pollution Rose

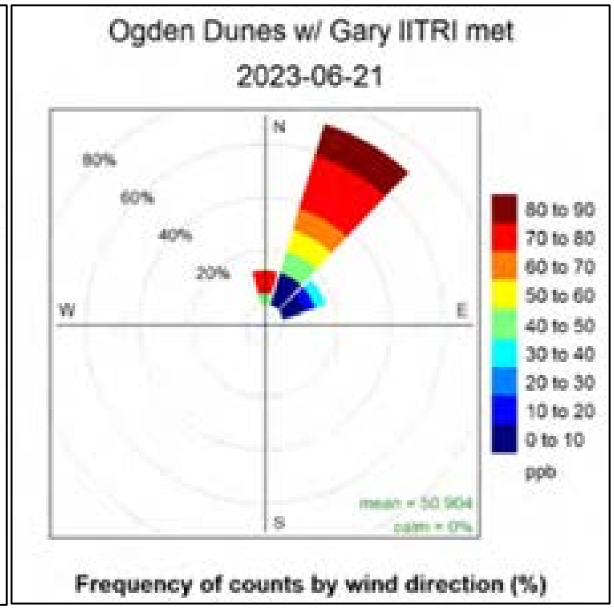
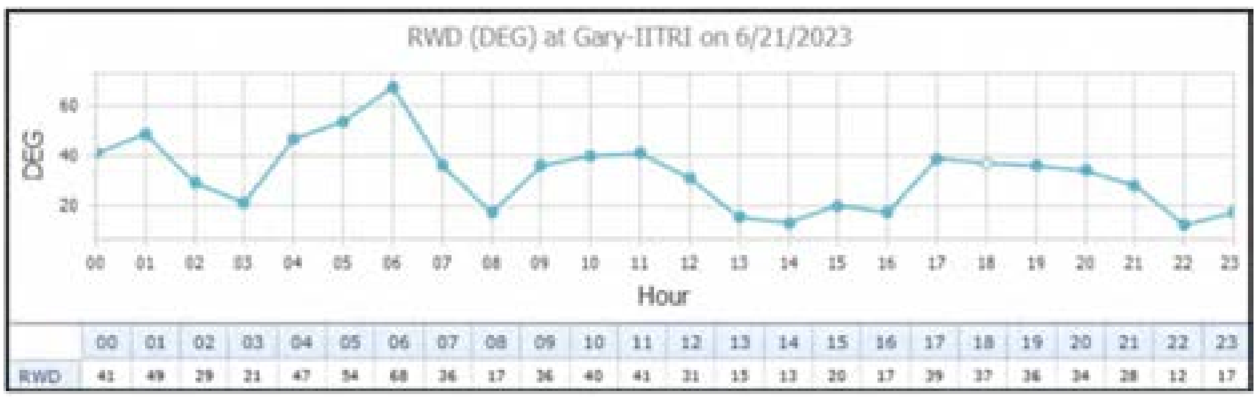


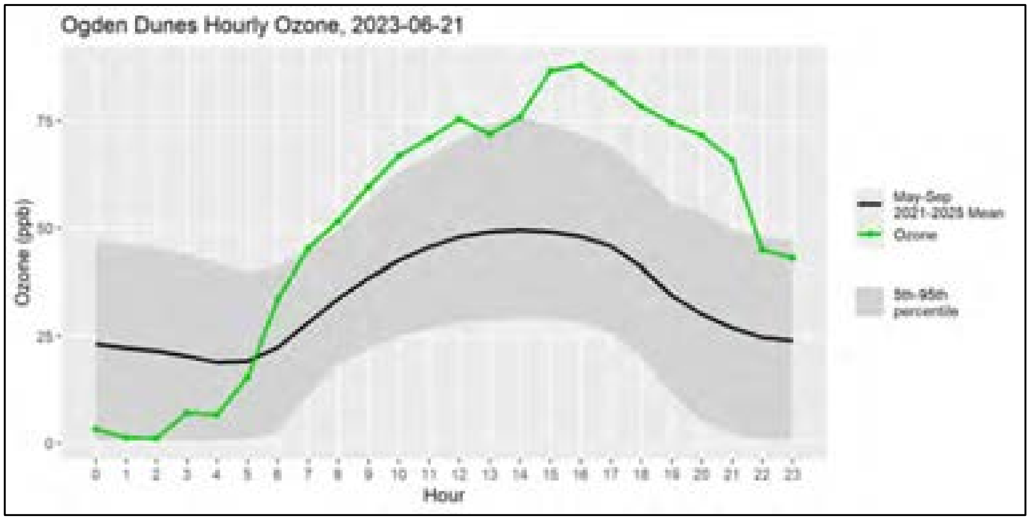
Figure 3.8.5 - Hourly Wind Directions at Gary IITRI for June 21, 2023

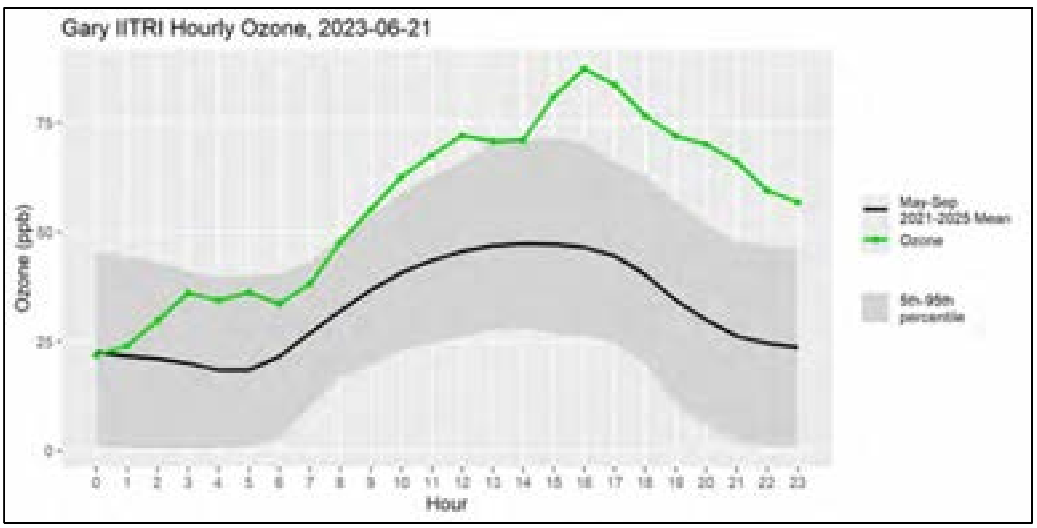


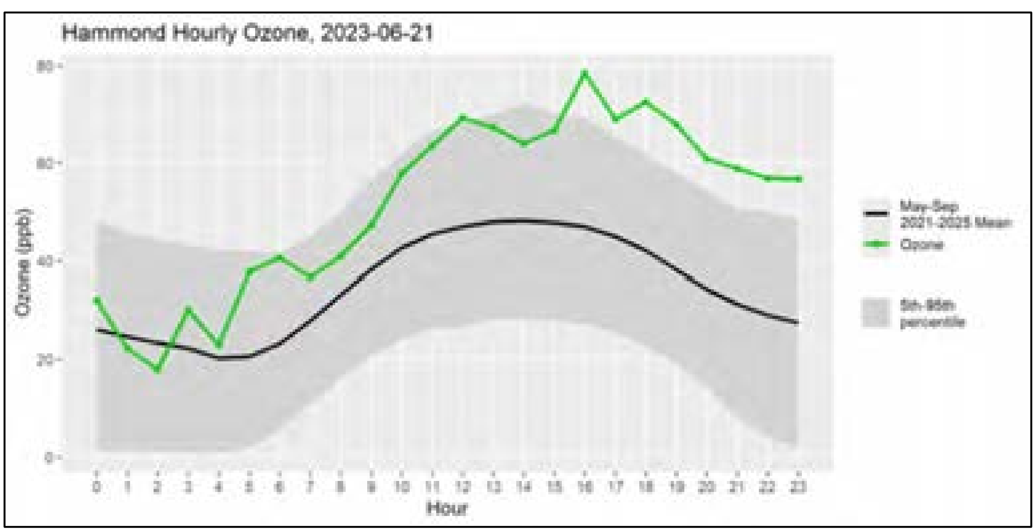
3.8.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for June 21 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.8.6. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.8.6 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes June 21, 2023

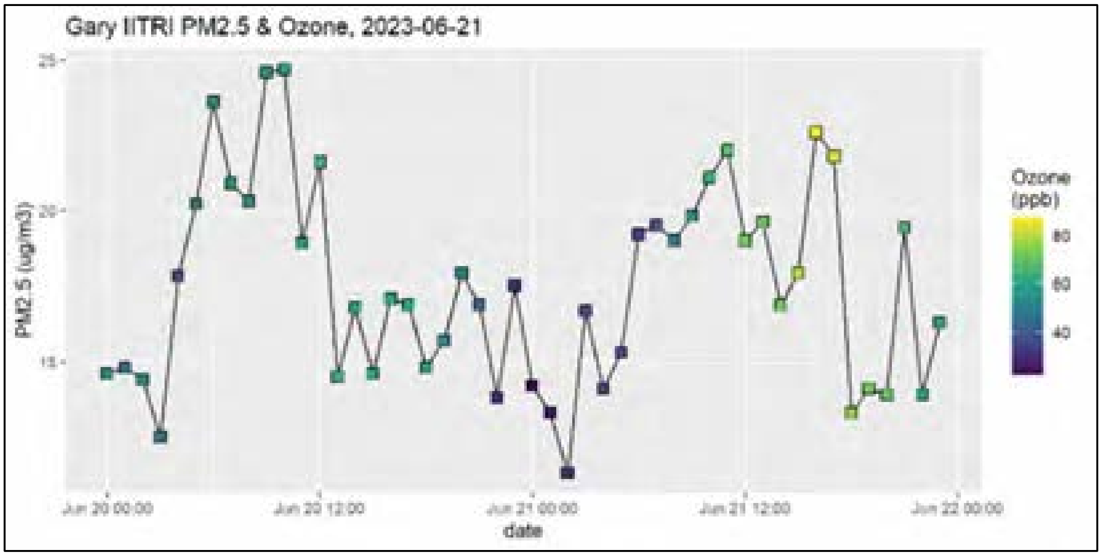






Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for June 20 - 21 as shown in Figure 3.8.7. $PM_{2.5}$ concentrations ranged from 11 - 27 µg/m^3 on May 23.

Figure 3.8.7 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data June 21, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.8.2 shows the percentage above the five-year average. Black Carbon was well above the average, CO and NO_2 were near or below average.

Table 3.8.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
6/21/2023	109%	26%	154%

3.8.4 AOD and Satellite Analyses

Figure 3.8.8 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in Northwest Indiana indicates the presence of smoke.

Figure 3.8.8 - Aerosol Optical Depth (AOD) June 21, 2023

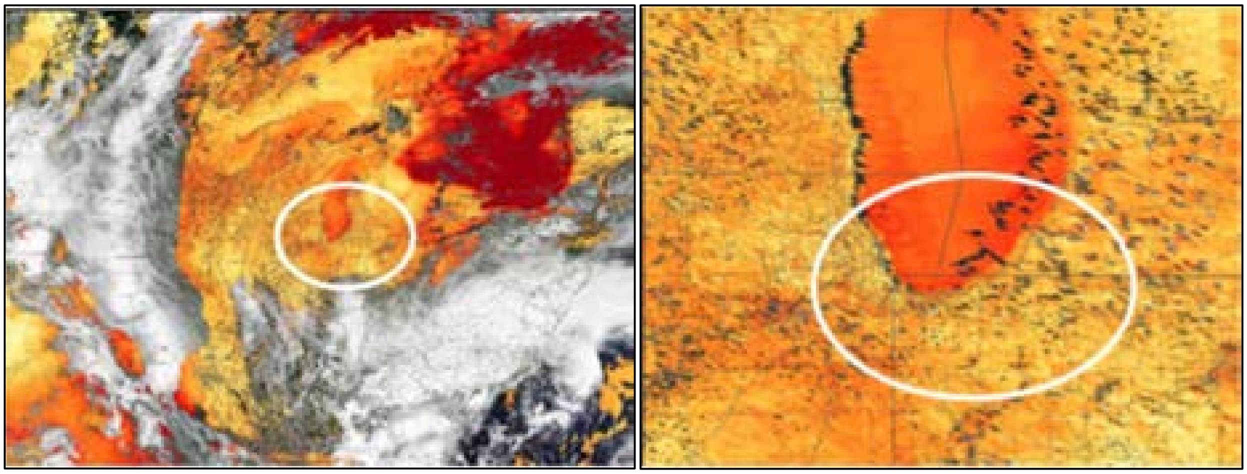
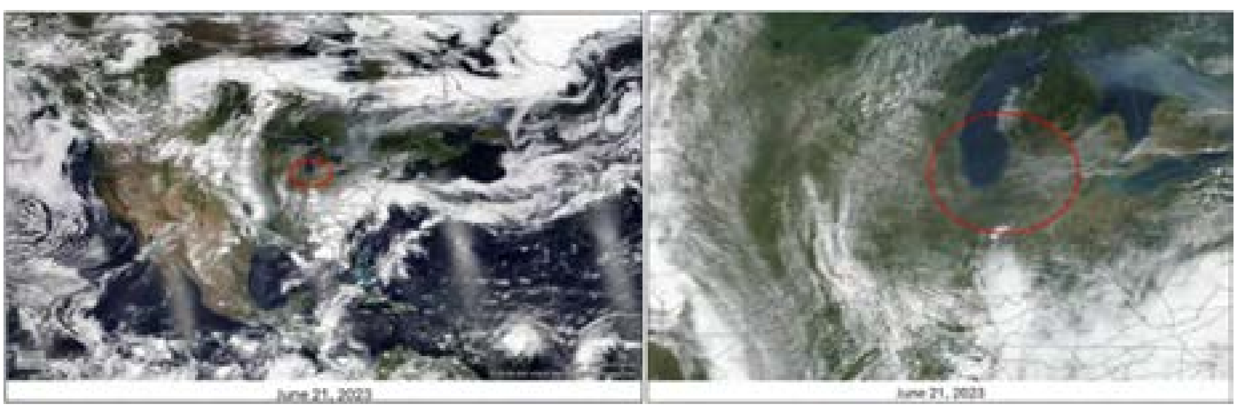


Figure 3.8.9 shows the satellite images below captured by NOAA's GOES 18 satellite for North America (left) taken on June 21 show clouds and a plume of gray smoke extending from Canada to the upper Midwest states, including Indiana. The close up view of the upper Midwest (right) shows the wildfire smoke clearly over Lake and Porter counties. The northwest Indiana area is indicated by the red circle on the satellite image Credit: NOAA NESDIS

Figure 3.8.9 - Satellite Imagery June 21, 2023



3.8.5 NOAA Smoke Narrative

Wednesday, June 21, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1645Z June 21, 2023

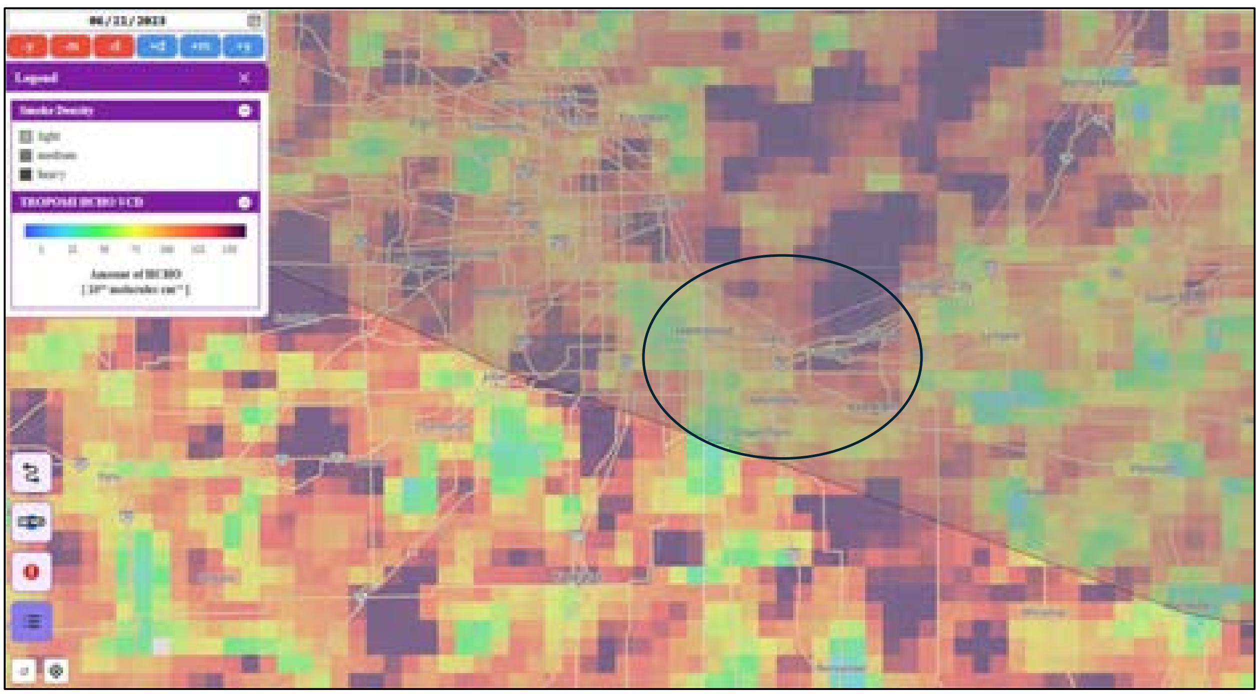
SMOKE:

Canada/United States/Atlantic Ocean/Pacific Ocean off the West Coast of Southwestern Canada and the Western U.S… Significant wildfire activity continued especially over western Canada including northern and northeastern British Columbia, northern Alberta, and the southwest part of the northwest Territories as well as central and eastern Canada including west central Ontario and central and southern Quebec. Smoke from these fires covered virtually all of Canada and extended southward into some of the northwestern and western U.S. and the Pacific off the southwest coast of Canada and the U.S. west coast as well as most of the U.S. from the front range of the Rockies eastward to the east coast. The smoke also spread across much of the northern and central Atlantic, likely reaching Europe. The thickest smoke linked to the fires in Ontario and Quebec was seen over central and eastern Ontario and the central and southwestern part of Quebec with the edge of the thick smoke appearing to brush some of Lake Huron and the northern portion of New York state. **A much larger surrounding area of moderate smoke mainly from the Ontario and Quebec fires affected a larger part of south central and southeastern Canada and the north central U.S. including the Great Lakes region**. Farther to the west, patches of thicker density smoke were noted over central and eastern British Columbia, northern Alberta, and the southwest part of the Northwest Territories. Also, a very narrow curving band of possible moderate density smoke, attributed to the western Canada fires, was spreading from the far eastern Pacific inland over central California and extending to the northeast from there to central Montana. It is likely that the smoke from the Canadian fire merged with smoke from the fires in Mexico somewhere over the south central and southeastern U.S.

3.8.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.8.10 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 7-16 × 10^{15} molecules/cm² indicate strong to extreme wildfire smoke influence.

Figure 3.8.10- TROPOMI Satellite Daily Formaldehyde Monitoring



3.8.7 AirNow Smoke Maps

AirNow shows in Figures 3.8.11 through 3.8.14 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.8.11 - AirNow Smoke Ozone and $PM_{2.5}$ June 21, 2023

Figure 3.8.12 - AirNow Smoke Ozone - June 21, 2023

Figure 3.8.13 - AirNow $PM_{2.5}$ Map - June 21, 2023

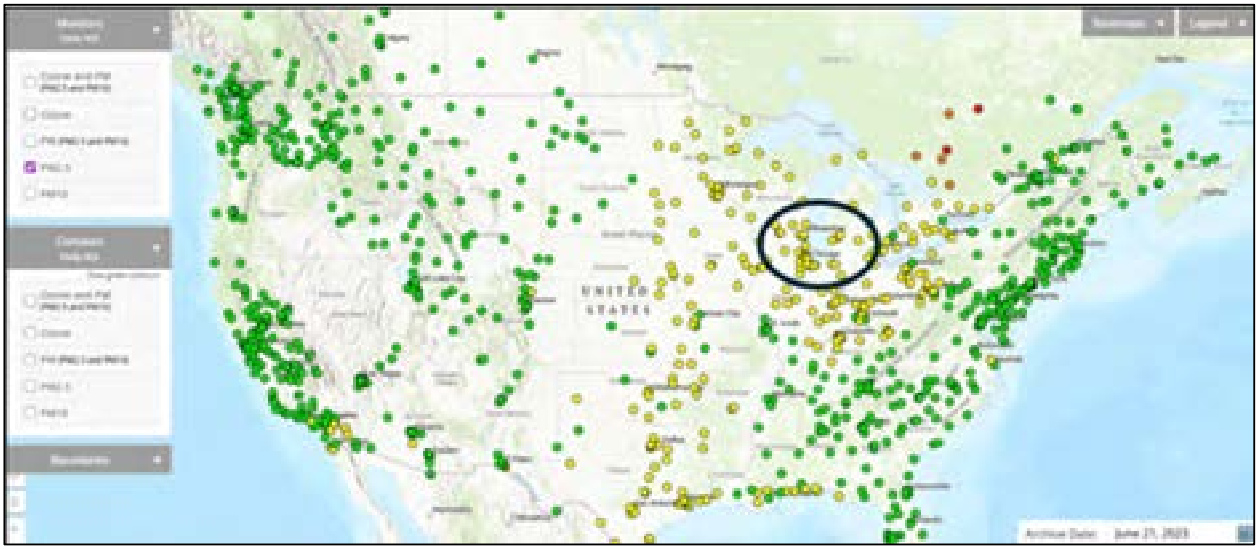
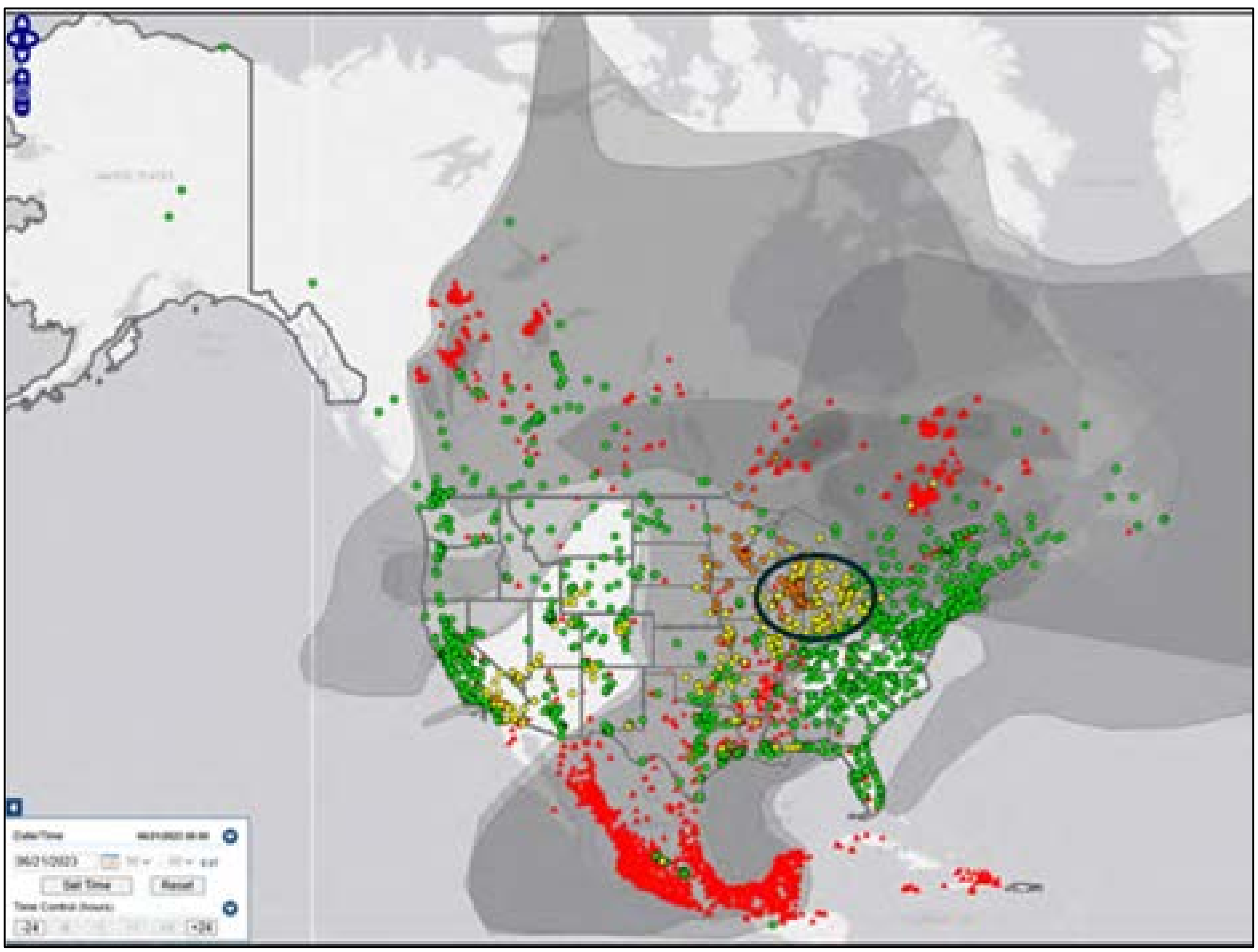


Figure 3.8.14 - AirNow Smoke and Ozone Map - June 21, 2023



3.8.8 Statistical Modeling Analyses

Figures 3.8.15 through 3.8.18 show indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the black circles on each of the maps.

Figure 3.8.15 - GAM Smoke Maps Indicating Smoke Days June 21, 2023

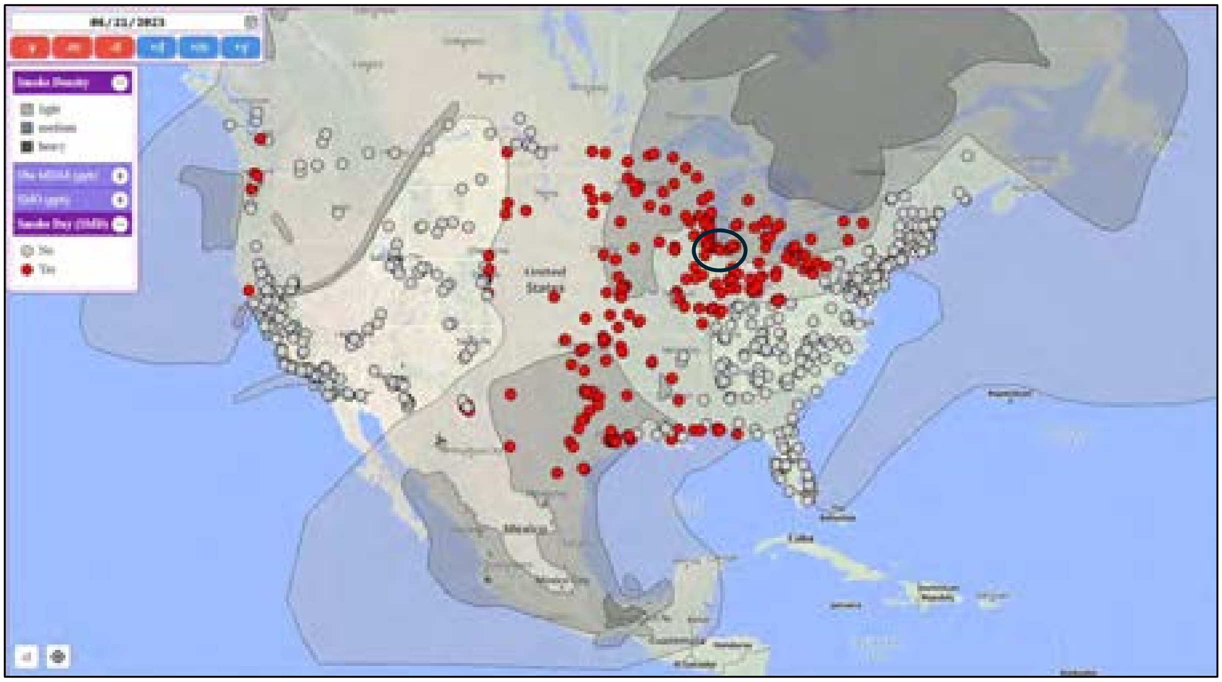


Figure 3.8.16 - GAM Observed Ozone with Smoke Days June 21, 2023

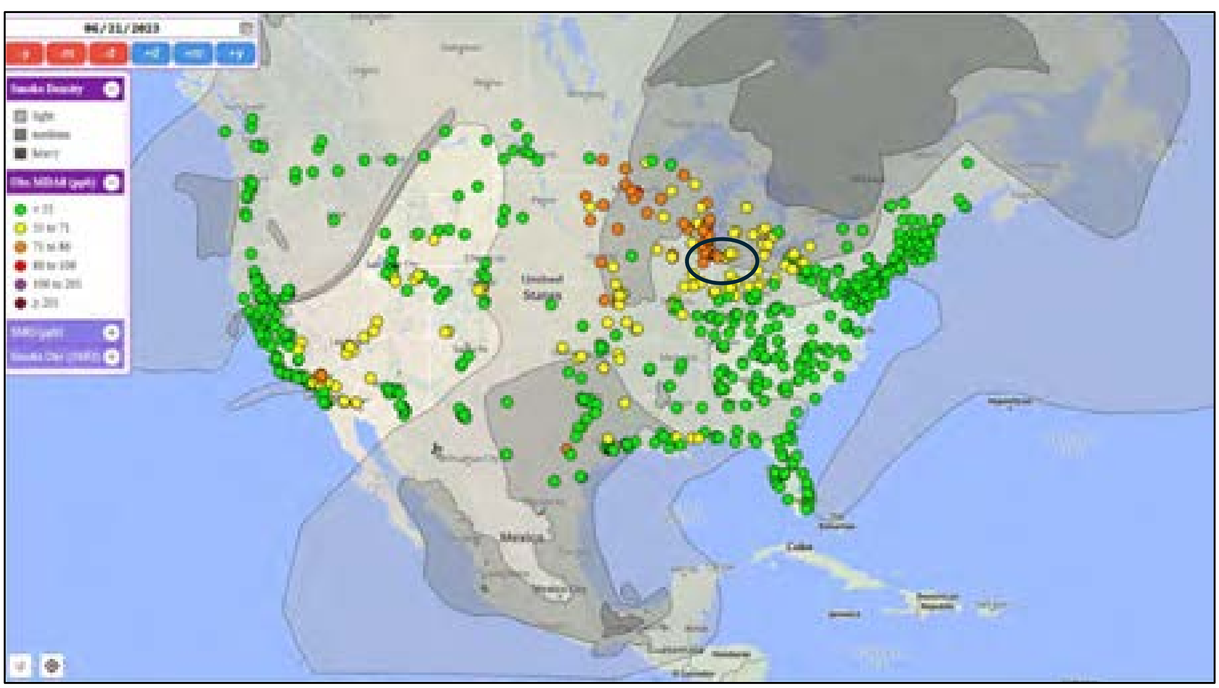


Figure 3.8.17 - GAM Smoke Estimates June 21, 2023

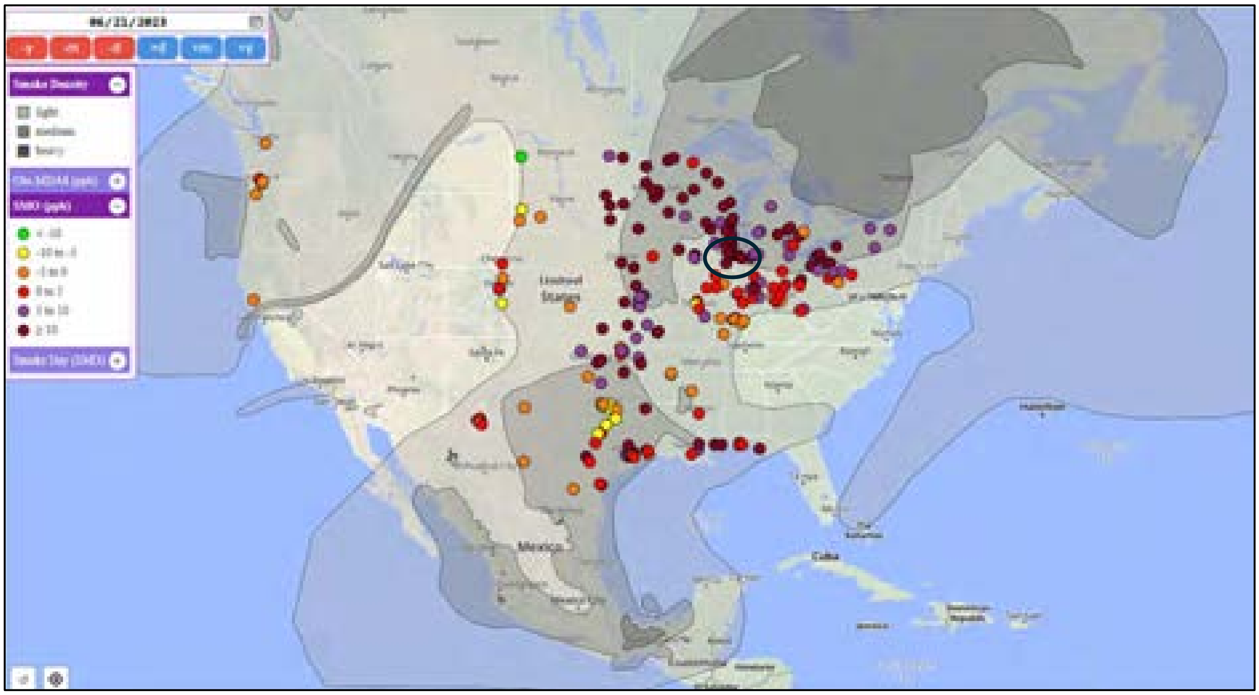


Figure 3.8.18 - EMBER Smoke Estimates June 21, 2023

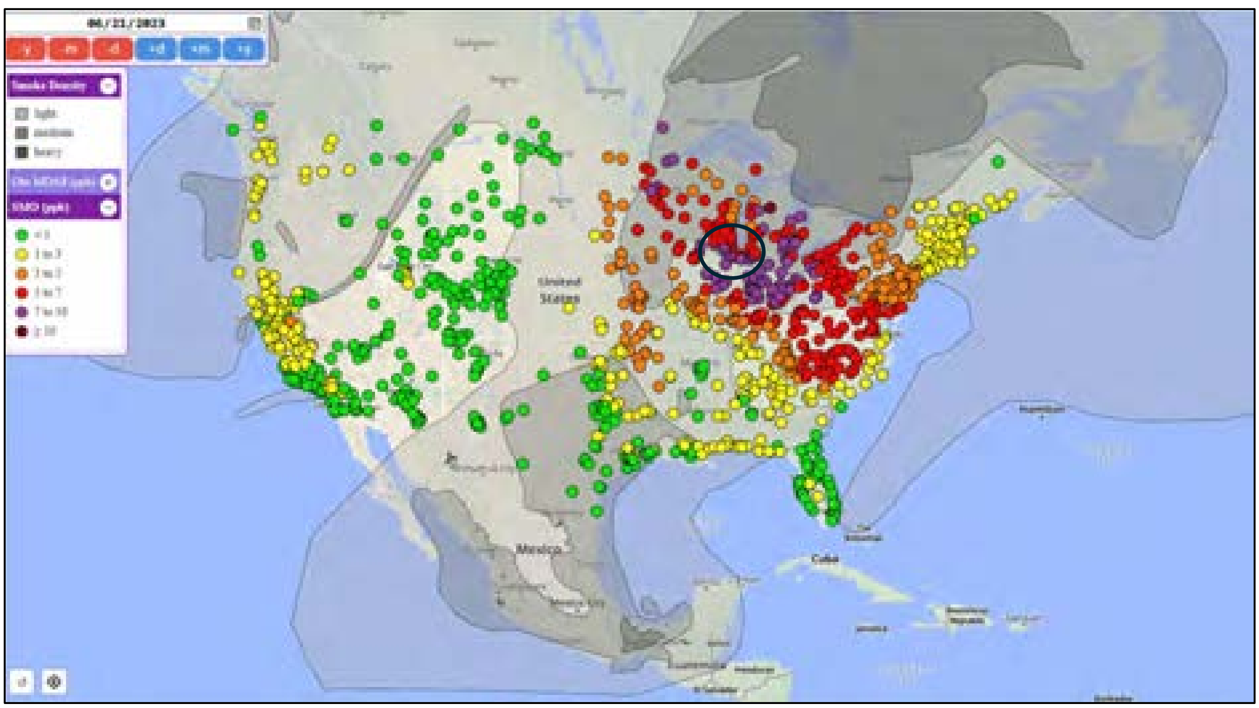


Table 3.8.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.8.3 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values June 21, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	76	58.0	18	69	7
180892008	Hammond	69	NA	NA	71	-2
181270024	Ogden Dunes	78	60.8	17.2	69	9
181270026	Valparaiso	72	62.0	10.0	65	7

3.8.9 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on June 21, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.8.4 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 29.5 ppb lower than the MDA8 ozone concentrations observed on June 21 with the maximum matching day MDA8 ozone concentration of a smoke influenced 77.1 ppb.

Table 3.8.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 21, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	78	77.1*	48.5

* Indicates Matching days were influenced by wildfire smoke

3.8.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. Figures 3.8.19 and 3.8.20 show the trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red), and higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. June 21 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure 3.8.21 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over the wildfires in Quebec. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps

Figure 3.8.19 – Back Trajectories June 21, 2023: 50, 100 and 500 meters (-72 hours)

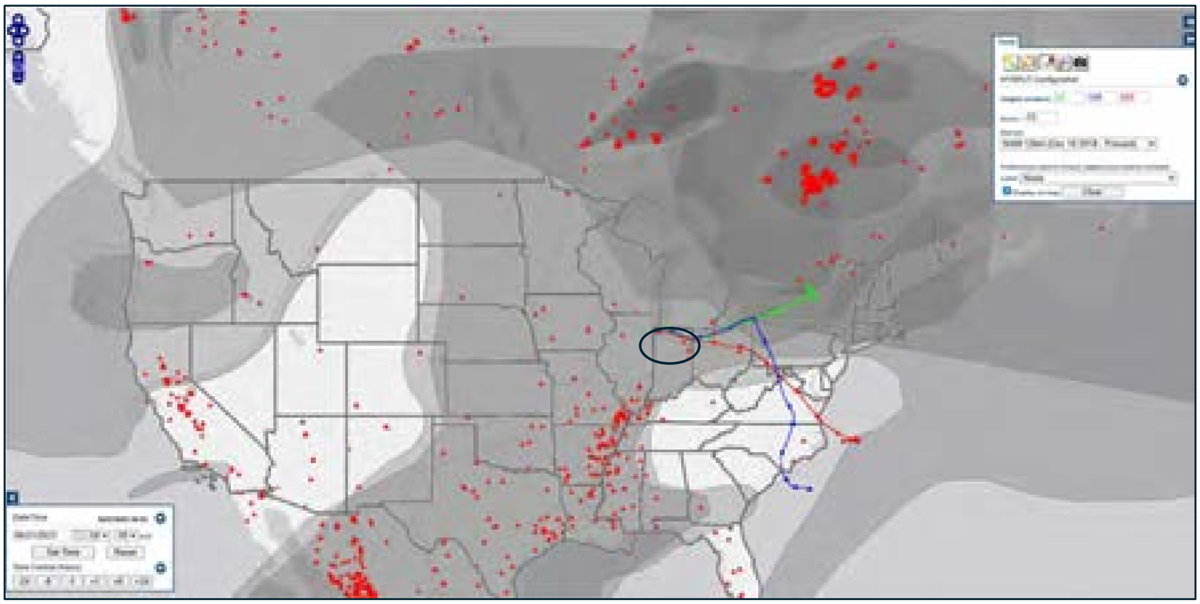


Figure 3.8.20 – Back Trajectories June 21, 2023: 1000, 2000 and 3000 meters (-72 hours)

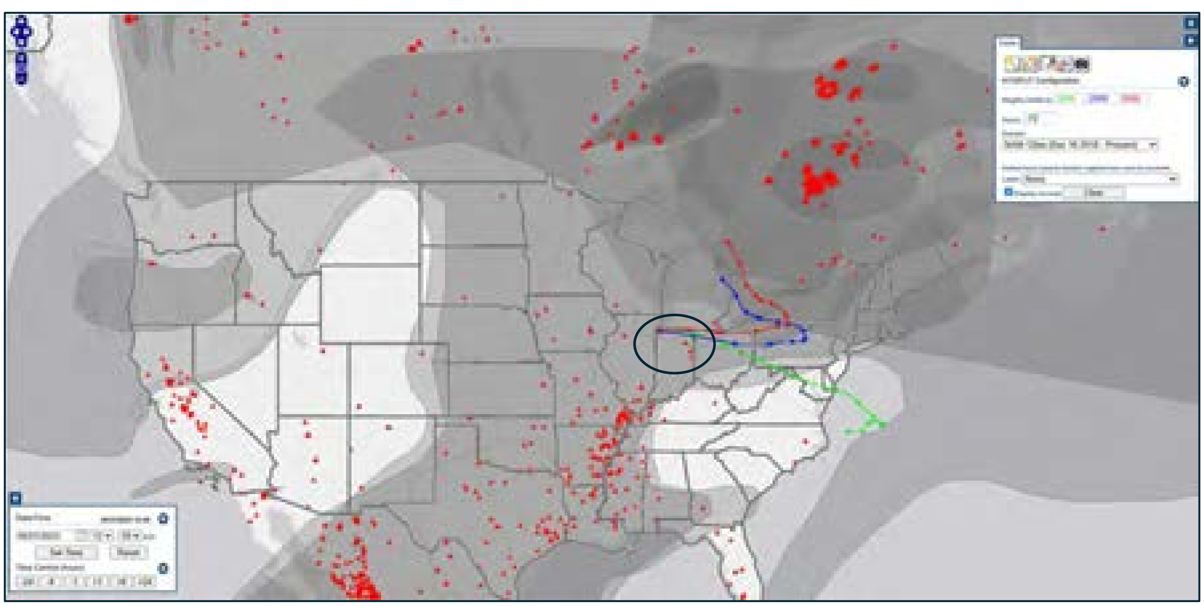
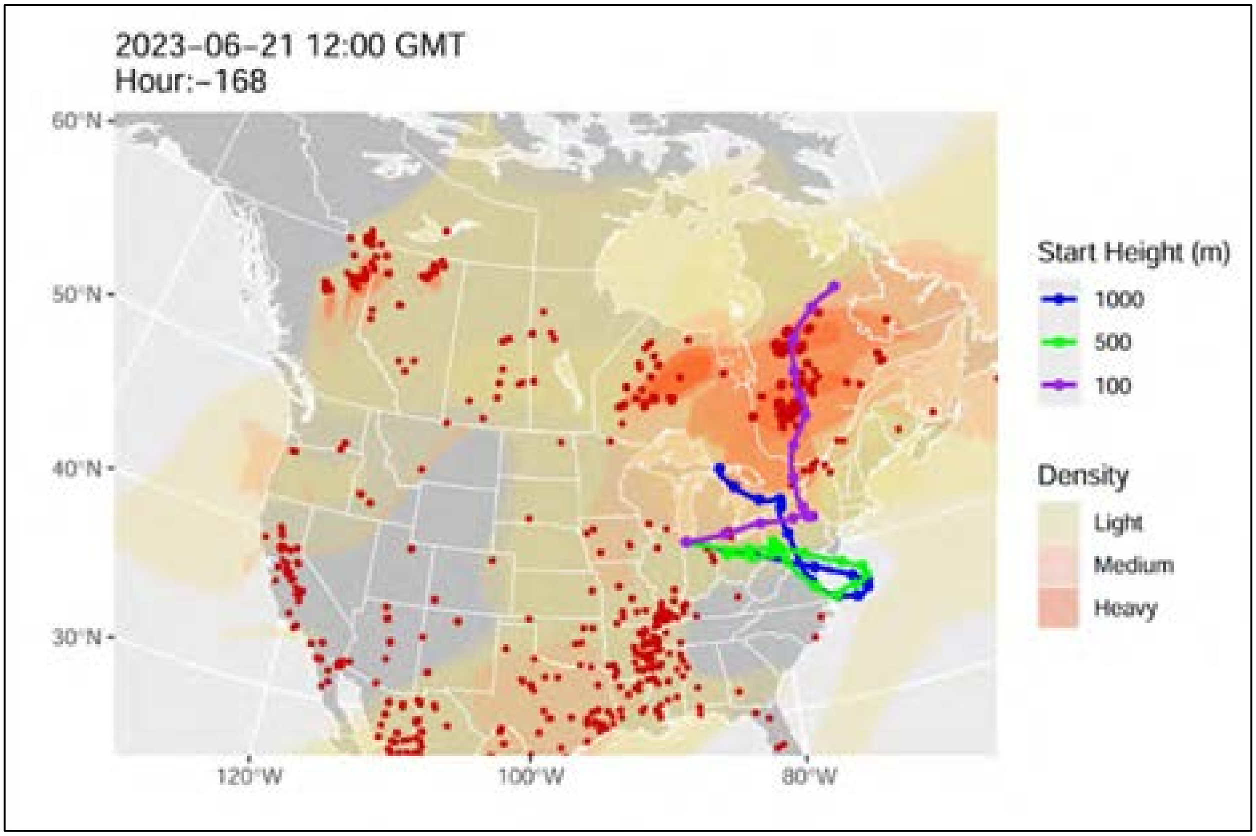


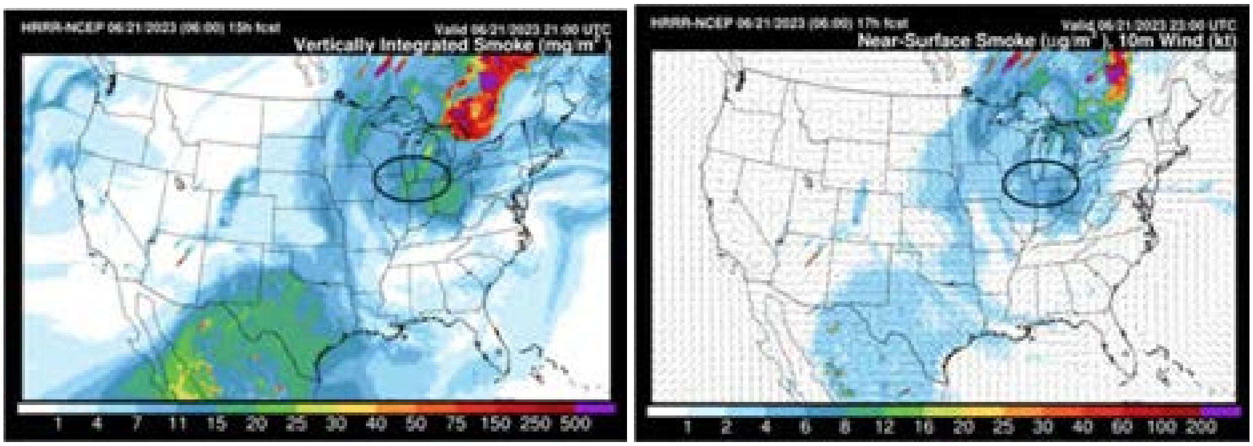
Figure 3.8.21 - Long-Range Back Trajectories from June 21, 2023 (100, 500 and 1000 meters - 168 hours)



3.8.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.8.22 indicates the vertically integrated smoke column on the left and the near surface smoke on the right shows wildfire smoke all throughout the column to the surface.

Figure 3.8.22 HRRR Smoke Model



3.8.12 Media Mentions

[The 2023 wildfire season in Québec: an overview of extreme conditions, impacts, lessons learned, and considerations for the future]

[Wildfire Smoke and Air Quality]

[Wednesday forecast: Air quality alert issued on first day of summer]

[IDEM issues Air Quality Action Day for Thursday, June 22, 2023 for two northern Indiana regions including Logansport]

3.8.13 Summary of Requested Exclusion of June 21, 2023

Table 3.8.5 - Summary Table - Gary IITRI

Event Date	June 21, 2023
MDA8 Ozone Concentration (PPB)	76
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone (PPB)	58
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	7
Matching day MDA8 ozone (max., avg.) (PPB)	48.5, 48.5
HYSPLIT indicated wildfire regions	James Bay Priority Fires, Quebec
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

3.9 July 4, 2023

3.9.1 Executive Summary

On July 4, 2023, Northwest Indiana experienced ozone exceedances across three of the four Lake and Porter County monitors, with values ranging from 73-81 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Ontario were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 1-20 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to Western-edge Wabakimi Fire, Sioux Lookout 33 Fire Ontario and Nipigon 13 and 19 Fires, Ontario.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of July 4, 2023, as an exceptional event under U.S. EPA guidelines.

Table 3.9.1 July 4, 2023 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

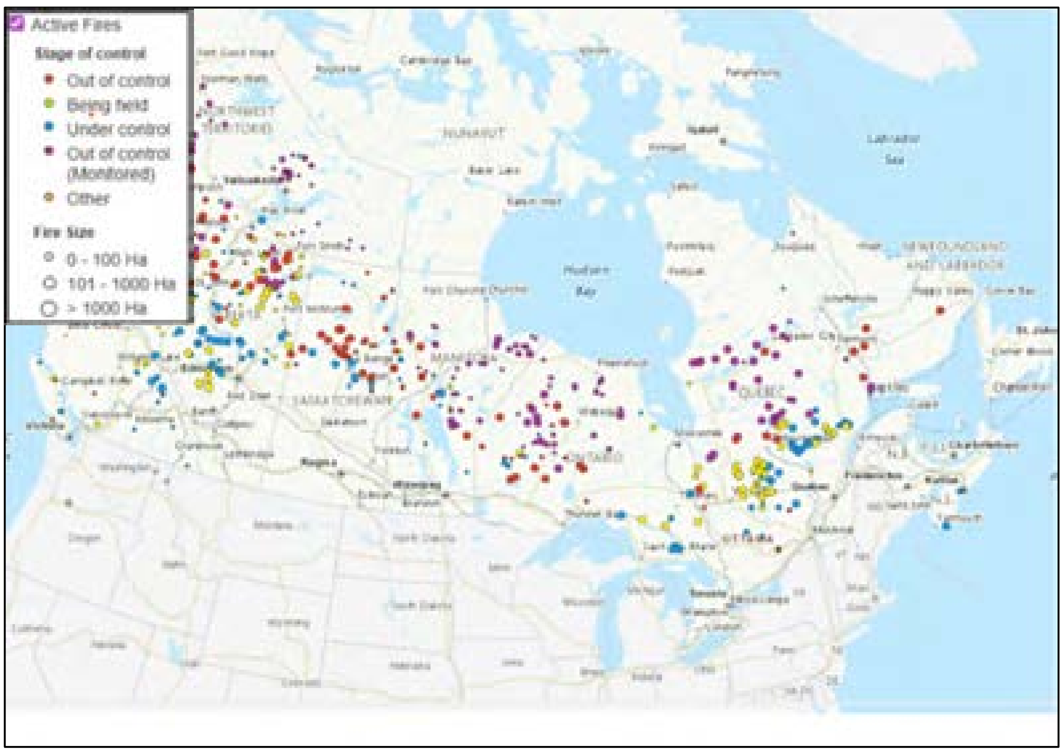
Date	Gary -IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
July 4, 2023	73	73	81	60

On July 4, 2023, multiple Canadian wildfires, as shown in Figure 3.9.1, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in July 2023 included the:

- Western-edge Wabakimi Fire, which began in early June 2023 along the western boundary of Wabakimi Provincial Park in northwestern Ontario. Although the exact ignition source was not publicly confirmed, reports do not identify whether lightning or human activity caused the blaze. The fire grew rapidly through late June, reaching approximately 41,000 hectares by June 24, and was listed as “not under control” due to aggressive fire behavior and continuous hot, dry conditions.

- Sioux Lookout 33 Wildfire, which was discovered on June 11, 2023, near the western edge of Wabakimi Provincial Park and quickly became one of northwestern Ontario’s major “Fires of Note.” Although the ignition cause was never formally identified, the region was experiencing significant lightning-driven ignition events during this period. The fire displayed rapid expansion through June and early July, growing from an early estimate of 41,548 hectares to 60,394 hectares by July 6, remaining “not under control.”
- Nipigon 13 and 19 Fires, which started in mid-June 2023 west of Ogoki Lake. The fires were suspected to be lightning related and burned 48,000 hectares between the two fires.

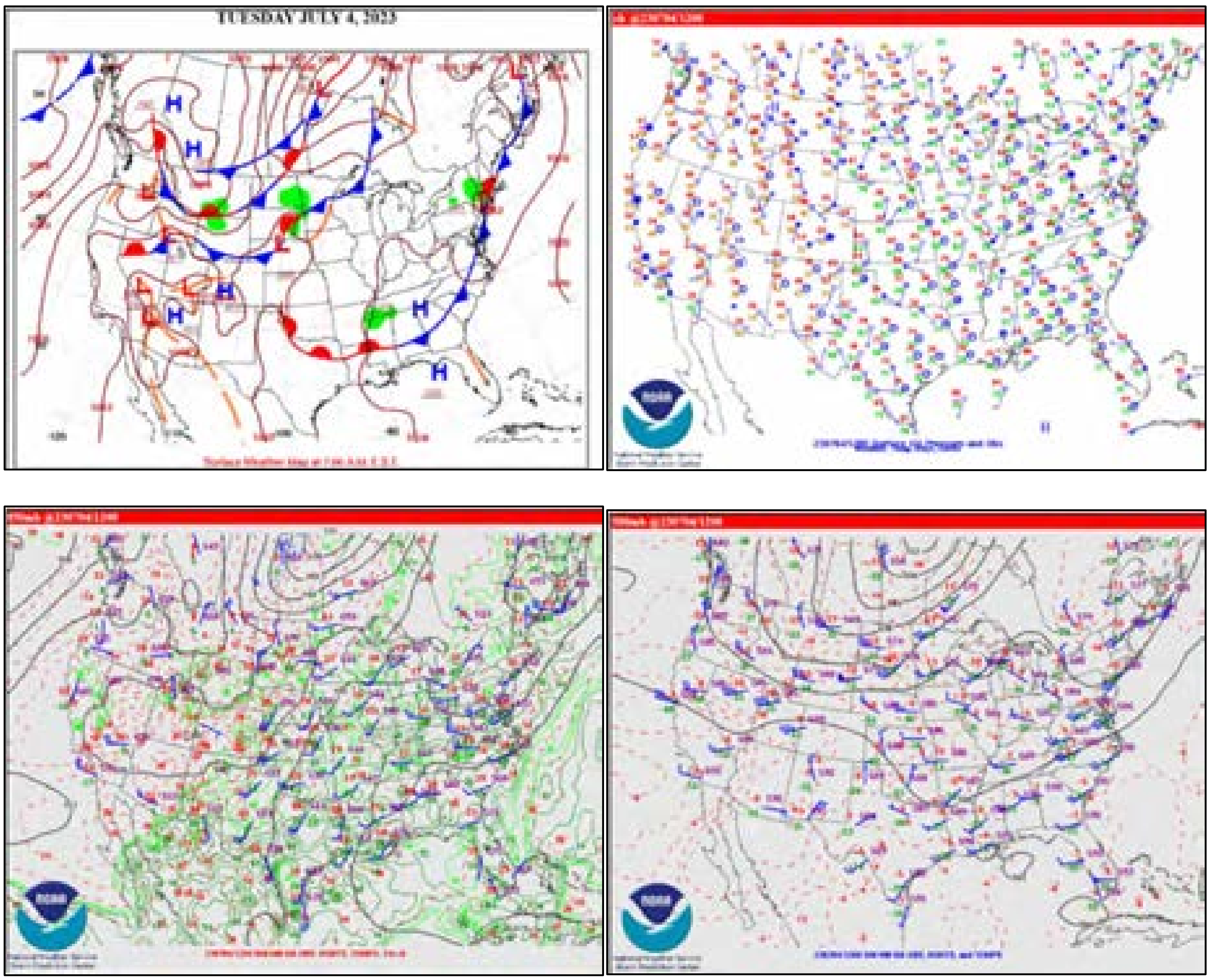
Figure 3.9.1 - Canadian Wildfires July 4, 2023



3.9.2 Meteorological Episode Overview

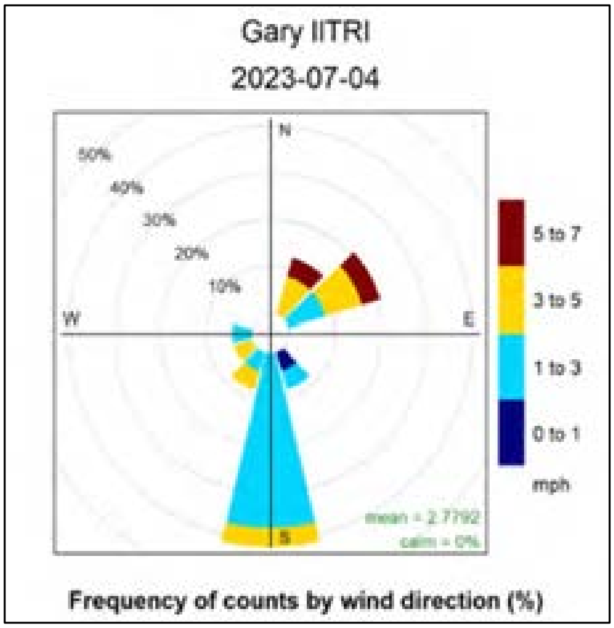
Broad upper air riding was evident on July 4 as surface high pressure was set up south of Indiana. As wildfires continued in the Ontario and Quebec provinces, smoke was transported into northwest Indiana as a sharp upper air trough was present over southeastern Canada. The surface features provided turning winds from the south to the northeast winds. Surface temperatures were in the upper 80’s ^{o}F, lowering humidity levels and clear skies helped to promote ozone development. Light winds turned from the southwest to the northeast, helping to transport the Ontario wildfire smoke and remnant smoke to the upper Midwest. Figure 3.9.2 shows the surface, 850 mb and 500 mb maps of the weather conditions on July 4.

Figure 3.9.2 - Surface, 850 and 500 mb Plots from 12Z on July 4, 2023



Wind rose (Figure 3.9.3) and pollution rose (figure 3.9.4) analyses were taken from the Gary IITRI meteorological station. Wind directions on July 4 were primarily from the northeast and south. The pollution rose, using Ogden Dunes ozone, indicates that the highest ozone readings were from the northeast. This is consistent with the back trajectories, which show transport from the north, moving over areas covered in smoke and over points of wildfire activity. The surface and upper air features during this time contributed to stagnant conditions and a buildup of pollutants.

Figure 3.9.3- Gary IITRI Windrose **Figure 3.9.4 Gary ITRII Pollution Rose**



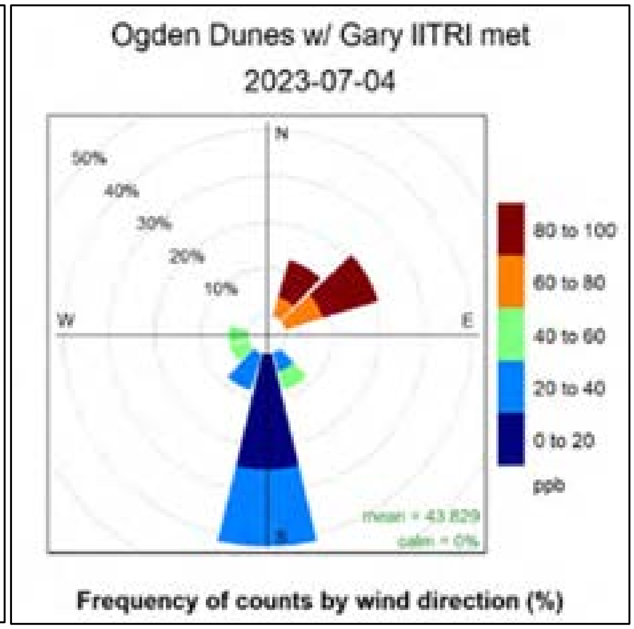


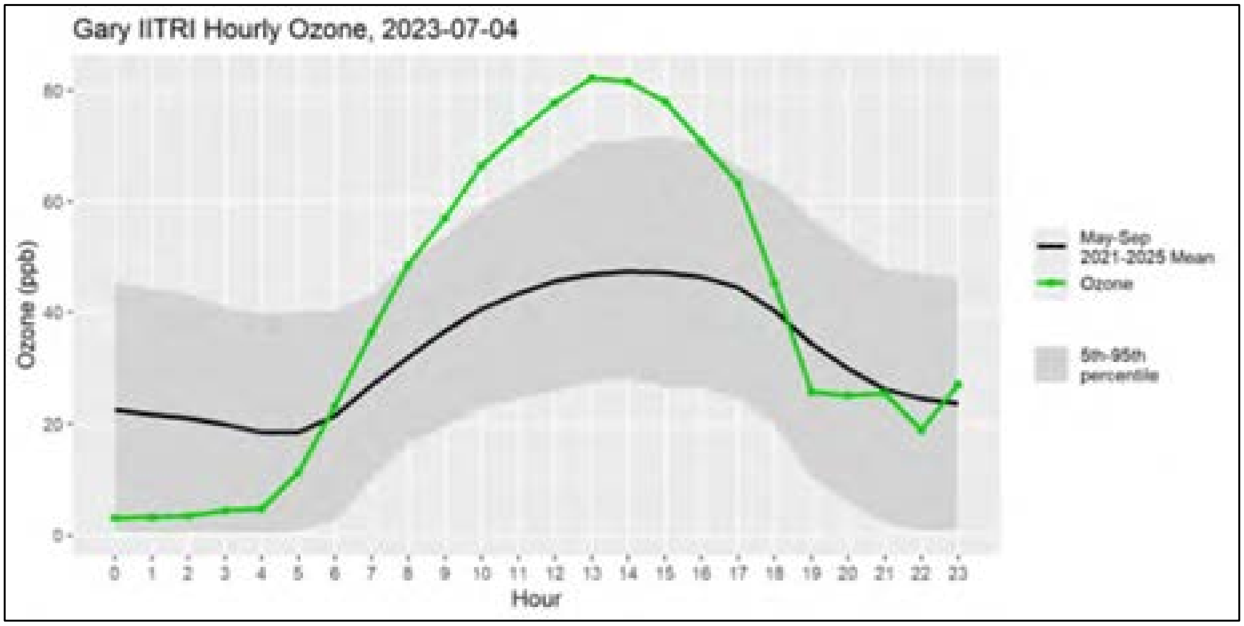
Figure 3.9.5 shows the hourly wind directions with the northeast winds bringing smoke and higher ozone concentrations into the area.

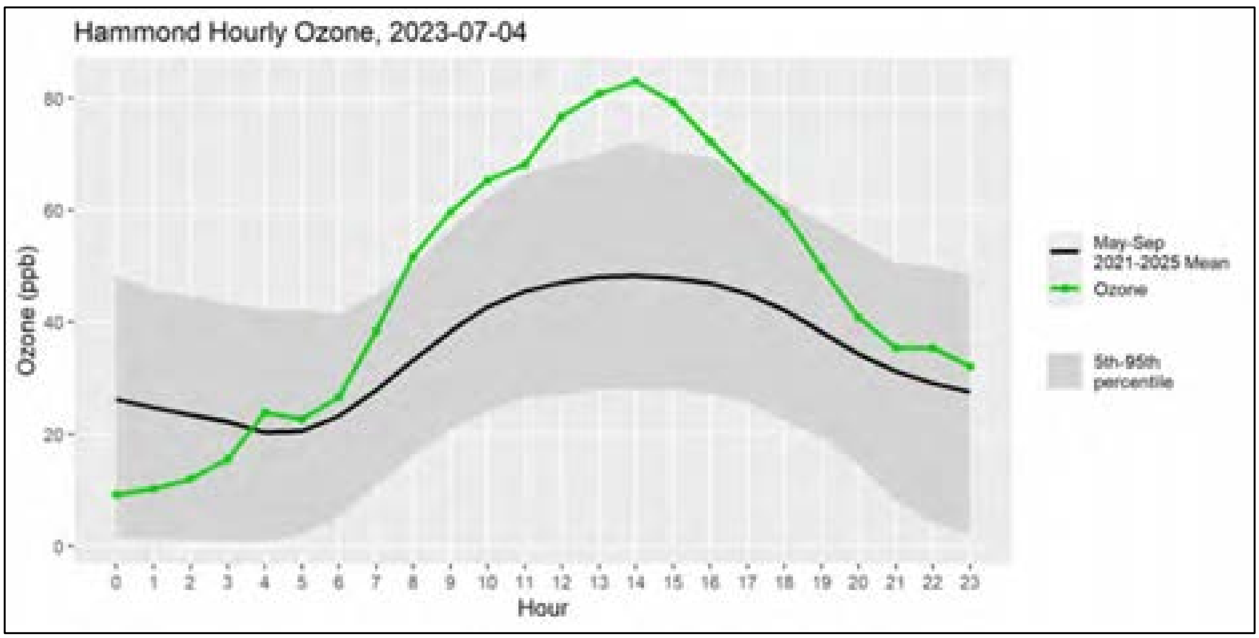
Figure 3.9.5 - Hourly Wind Directions at Gary IITRI for July 4, 2023

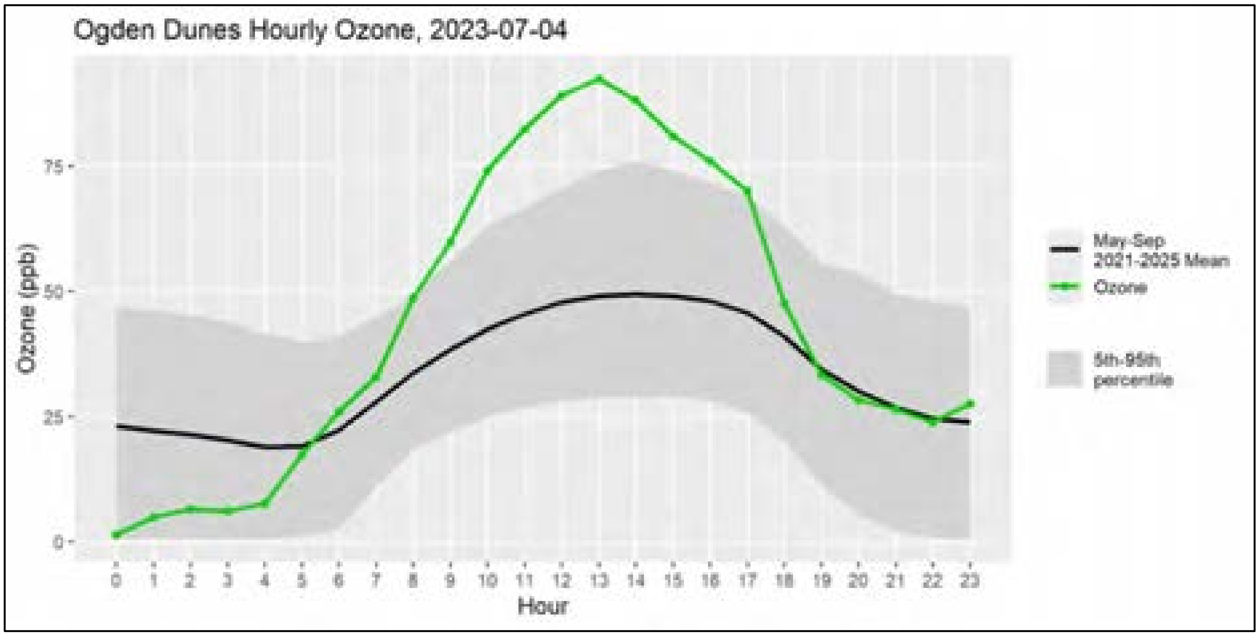
3.9.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for July 4, 2023 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.9.6. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.9.6- Ozone diurnal pattern for Gary IITRI, Hammond and Ogden Dunes July 4, 2023

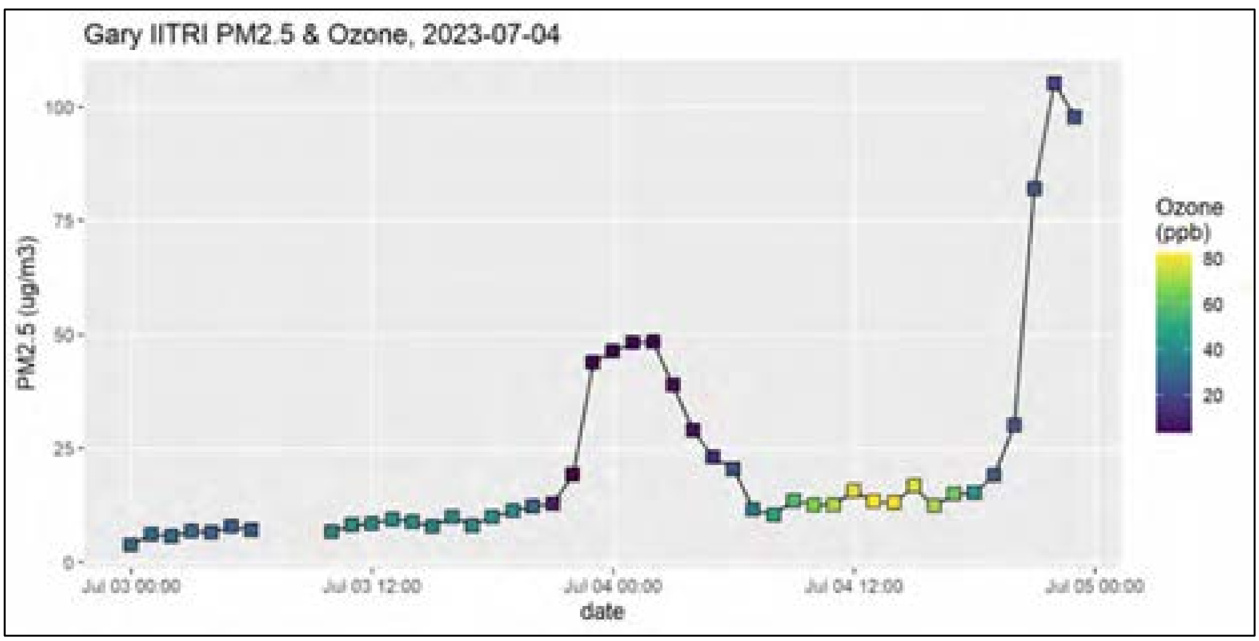






Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for July 3 and 4 as shown in Figure 3.9.7. $PM_{2.5}$ concentrations ranged from 15 - 50 µg/m^3.

Figure 3.9.7- Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data July 4, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon Monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.9.2 shows the percentage above the five-year average. All three pollutants were well above the average.

Table 3.9.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
7/4/2023	130%	109%	233%

3.9.4 AOD and Satellite Analyses

Figure 3.9.8 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of light to moderate smoke from the Midwest satellite view (left) and Lake and Porter counties (right).

Figure 3.9.8- Aerosol Optical Depth (AOD) - July 4, 2023

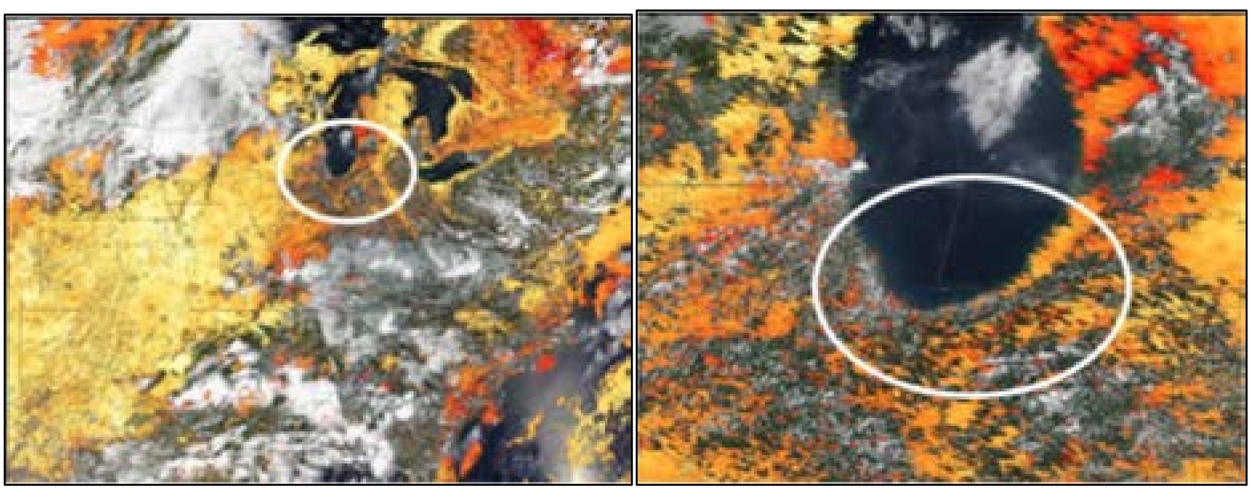
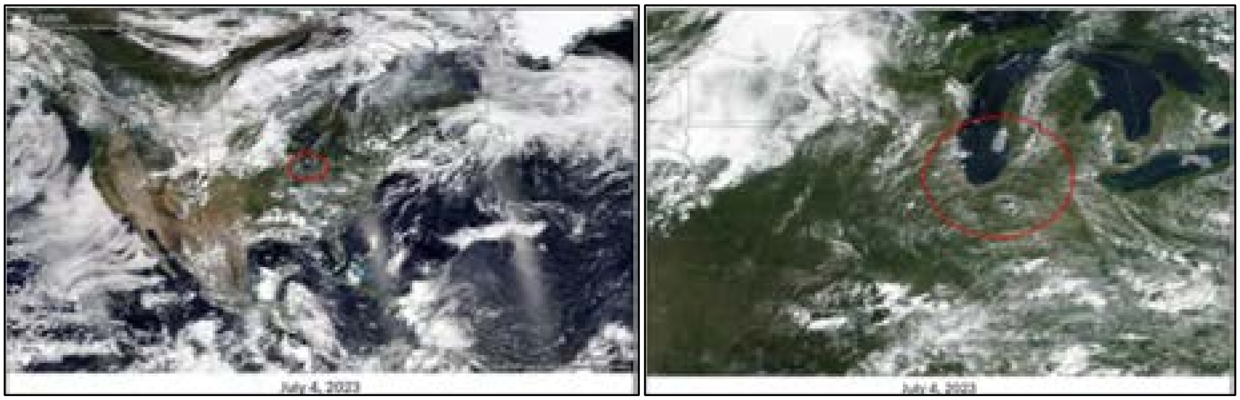


Figure 3.9.9 - Satellite Imagery July 4, 2023



The right and left images captured by NOAA's GOES 18 satellite images of North America taken July 4, 2023 shows clouds and a plume of gray smoke extending from western Canada to the upper Midwest states. Credit: NOAA NESDIS

3.9.5 NOAA Smoke Narrative

Tuesday, July 4, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1545Z July 4, 2023

SMOKE:

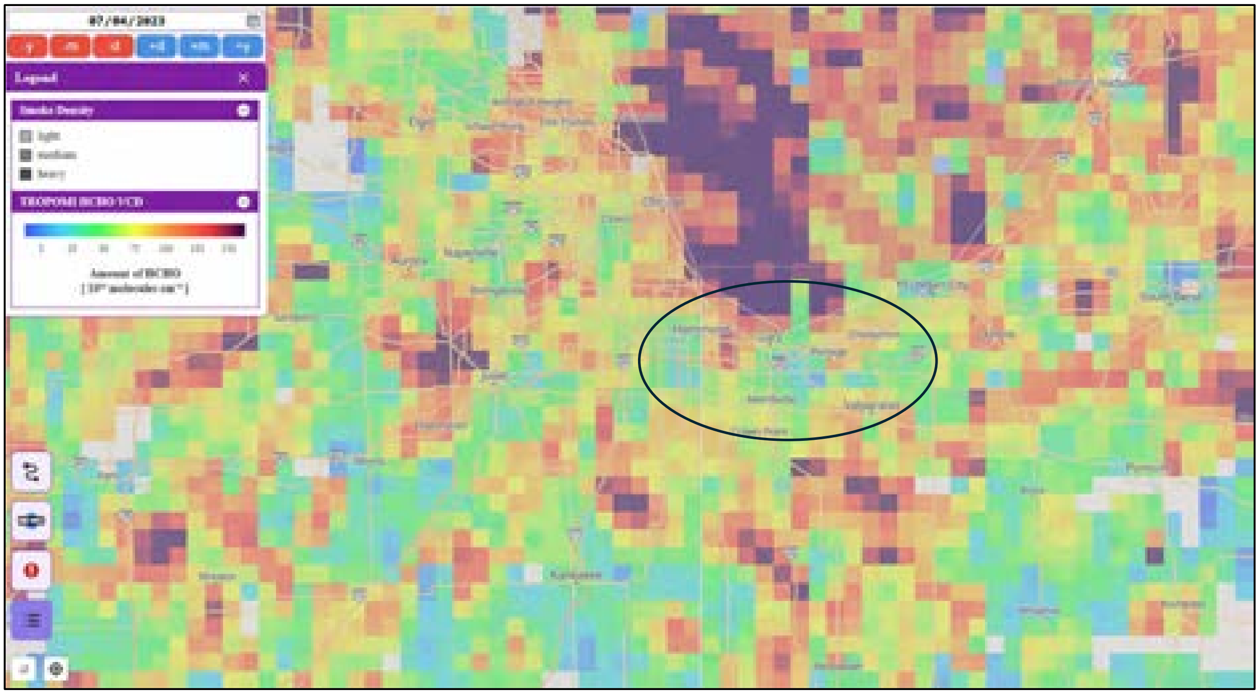
Canada/U.S./Atlantic...

Wildfire activity persists across Canada, especially in central-northern British Columbia, northwestern-northern Alberta, northwestern Ontario, and central Quebec. Wildfire activity persists across Canada, especially in central-northern British Columbia, northwestern-northern Alberta, northwestern Ontario, and central Quebec. Emissions from those wildfires continued to feed a large plume of predominantly light density smoke covering nearly all of Canada, the northern and eastern 2/3 of the CONUS, and parts of the northwestern Atlantic. Pockets of heavy-density smoke could be seen over central-northern Quebec, while medium-density smoke stretched over central-northern Quebec and northern Newfoundland, in addition to central-northern British Columbia and northwestern Alberta and dipping into northwestern Washington state. The bulk of the smoke is dispersing eastward across Canada thereby extending over the northern Atlantic and eventually making its way over parts of western Europe.

3.9.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.9.10 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 5-13 × 10^{15} molecules/cm^2 indicate strong to extreme wildfire smoke influence.

Figure 3.9.10- TROPOMI Satellite Daily Formaldehyde Monitoring



3.9.7 AirNow Smoke Maps

AirNow shows in Figures 3.9.11 through 3.9.14 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.9.11 - AirNow Ozone Map - July 4, 2023

Figure 3.9.12 - AirNow Ozone Map - July 4, 2023

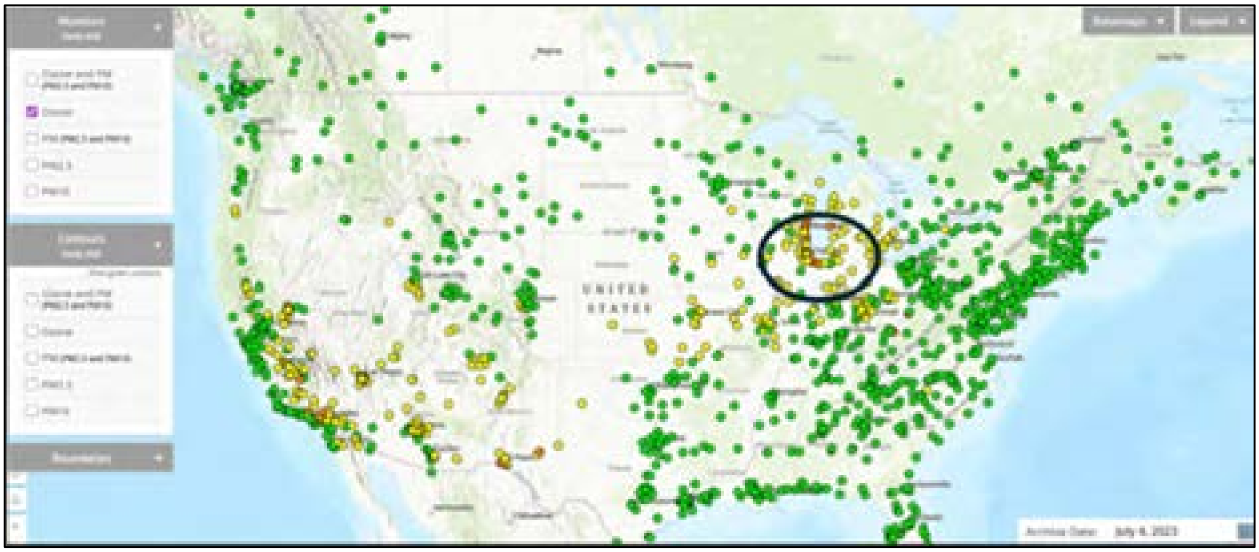


Figure 3.9.13 - AirNow $PM_{2.5}$ Map - July 4, 2023

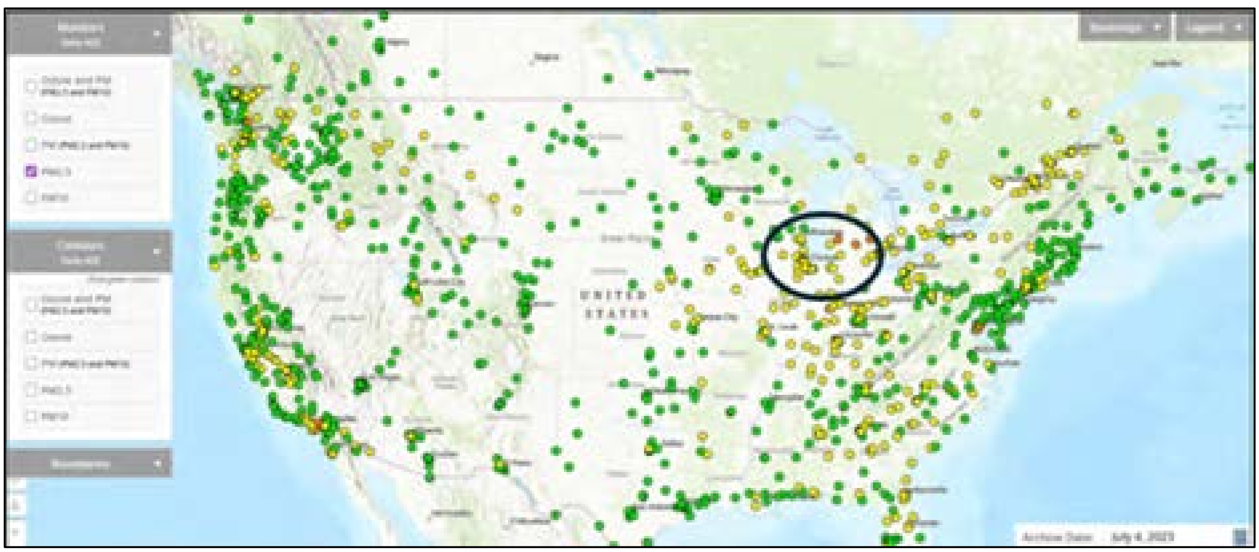
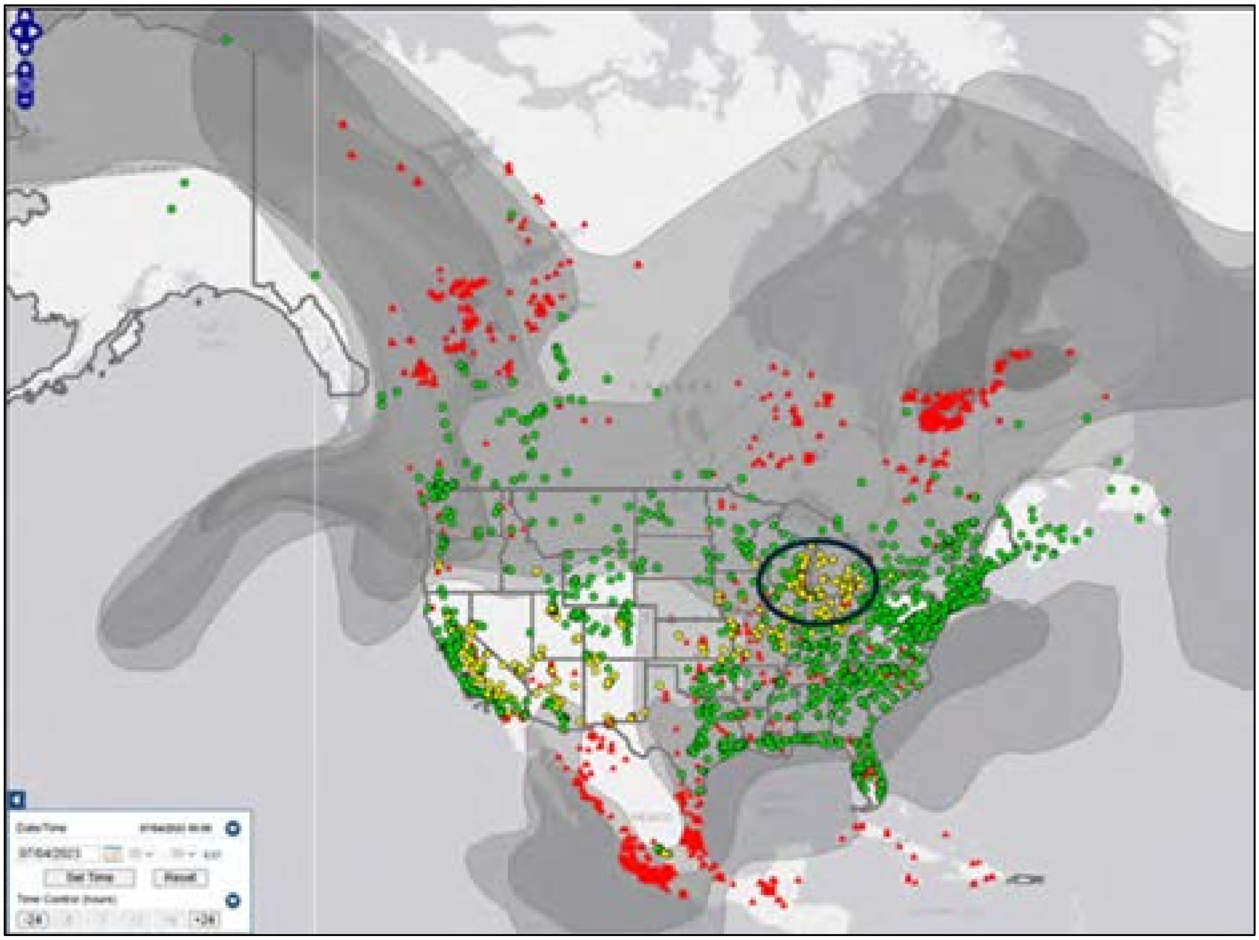


Figure 3.9.14 - AirNow Smoke and Ozone Map - July 4, 2023



3.9.8 Statistical Modeling Analyses

Figures 3.9.15 through 3.9.18 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the black circles on each of the maps.

Figure 3.9.15 - GAM Smoke Maps Indicating Smoke Days July 4, 2023

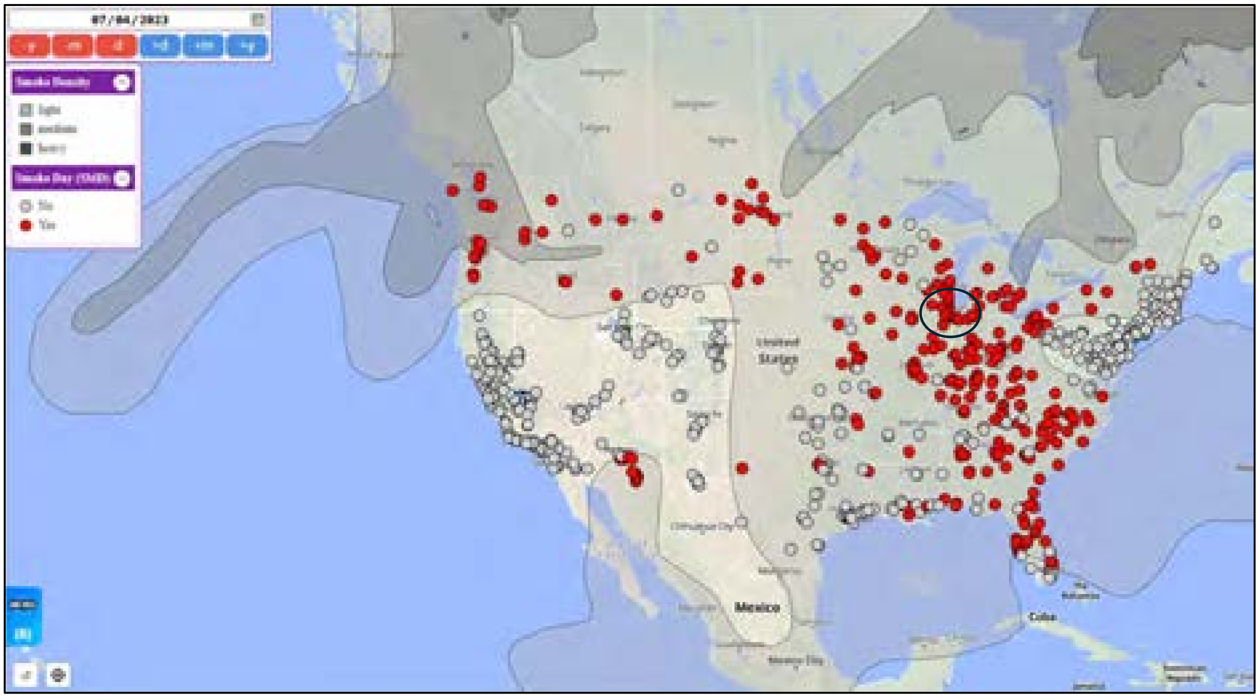


Figure 3.9.16 - GAM Observed Ozone with Smoke Days July 4, 2023

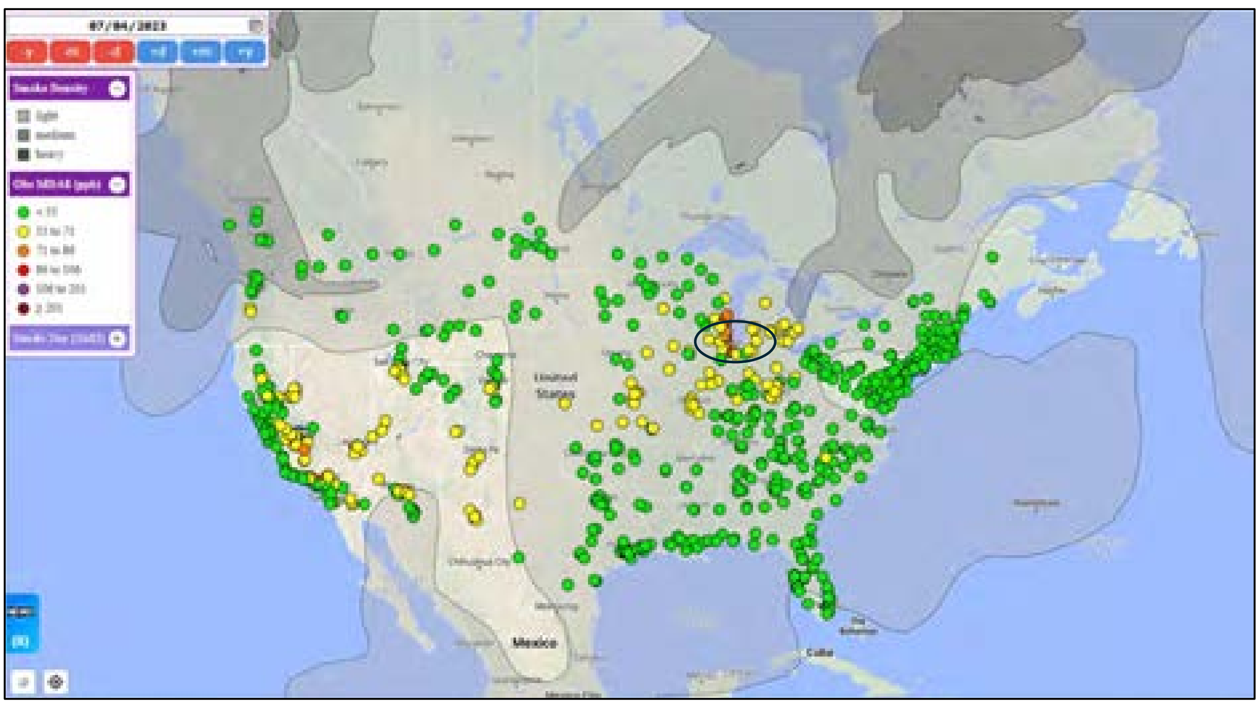


Figure 3.9.17 - GAM Smoke Estimates July 4, 2023

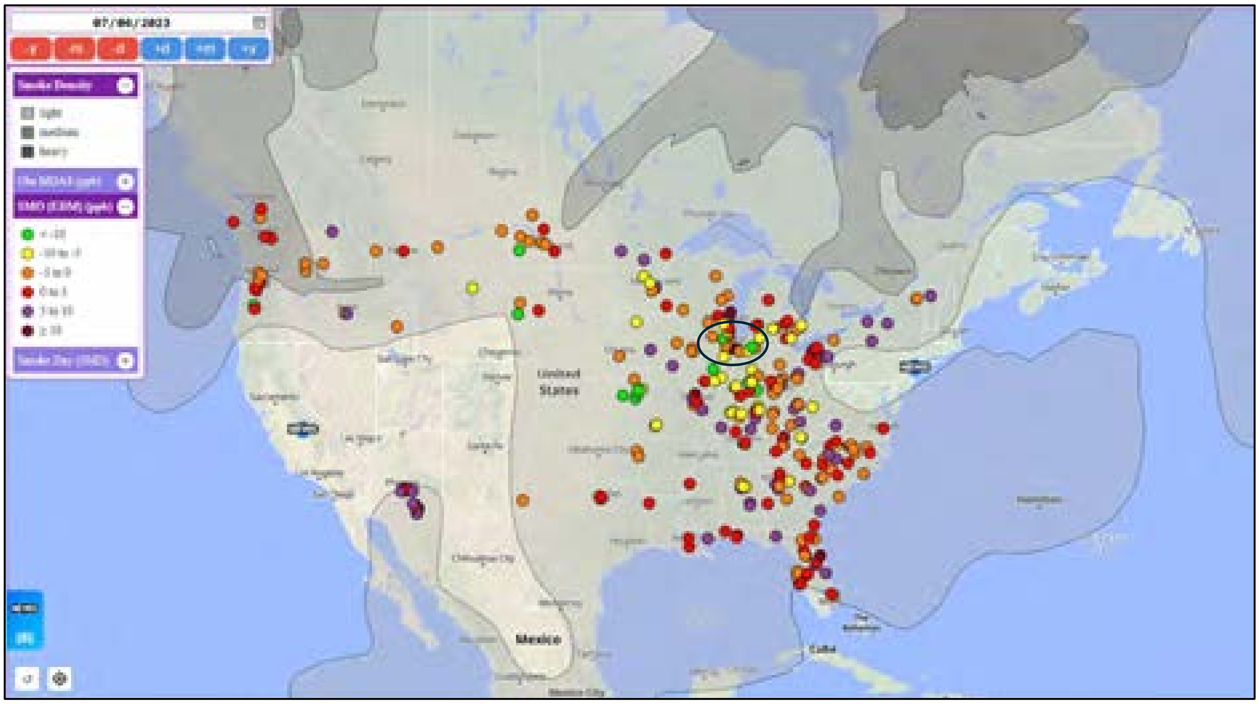


Figure 3.9.18 - EMBER Smoke Estimates July 4, 2023

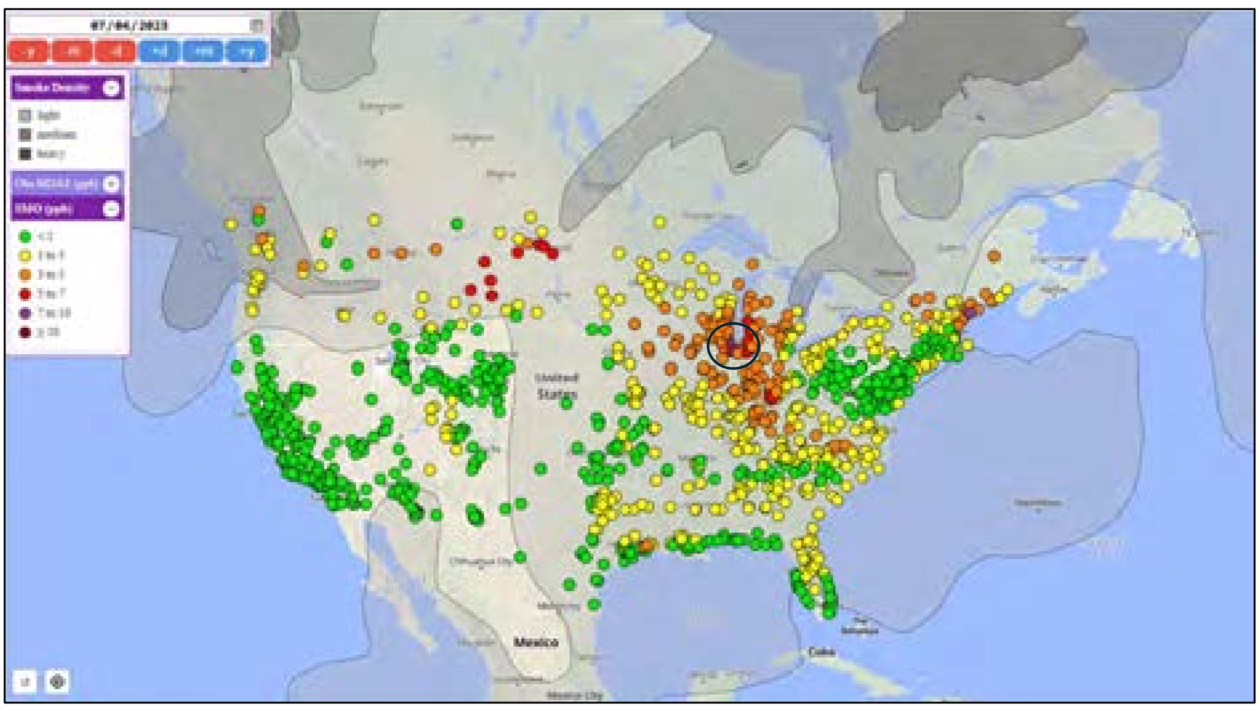


Table 3.9.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.9.3 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values July 4, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	73	58.5	14.5	72	1
180892008	Hammond	73	NA	NA	59	14
181270024	Ogden Dunes	81	60.8	20.2	72	9
181270026	Valparaiso	60	60.2	-0.2	49	11

3.9.9 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on July 4, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.9.4 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 26 ppb lower than the MDA8 ozone concentrations observed on July 4 with the maximum matching day MDA8 ozone concentration of 77 ppb.

Table 3.9.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values July 4, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	78	77.0*	52.3

3.9.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red). And higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. July 4 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure 3.9.21 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over the wildfires in Ontario. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.9.19 Back Trajectories July 4, 2023: 50, 100 and 500 meters (-72 hours)

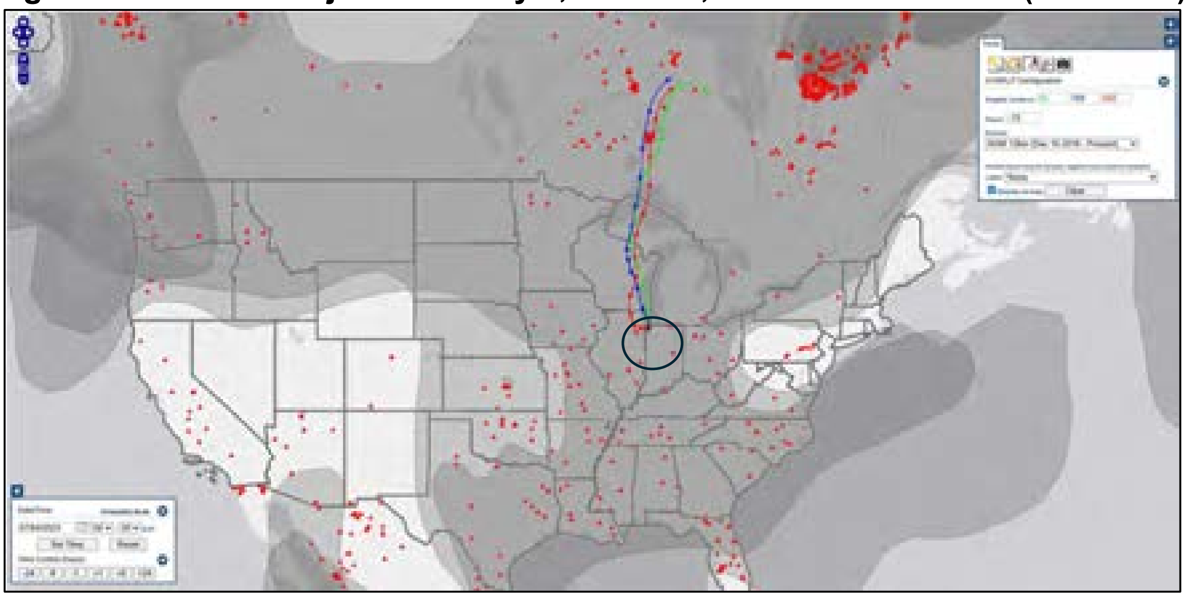


Figure 3.9.20 – Back Trajectories July 4, 2023: 1000, 2000 and 3000 meters (-72 hours)

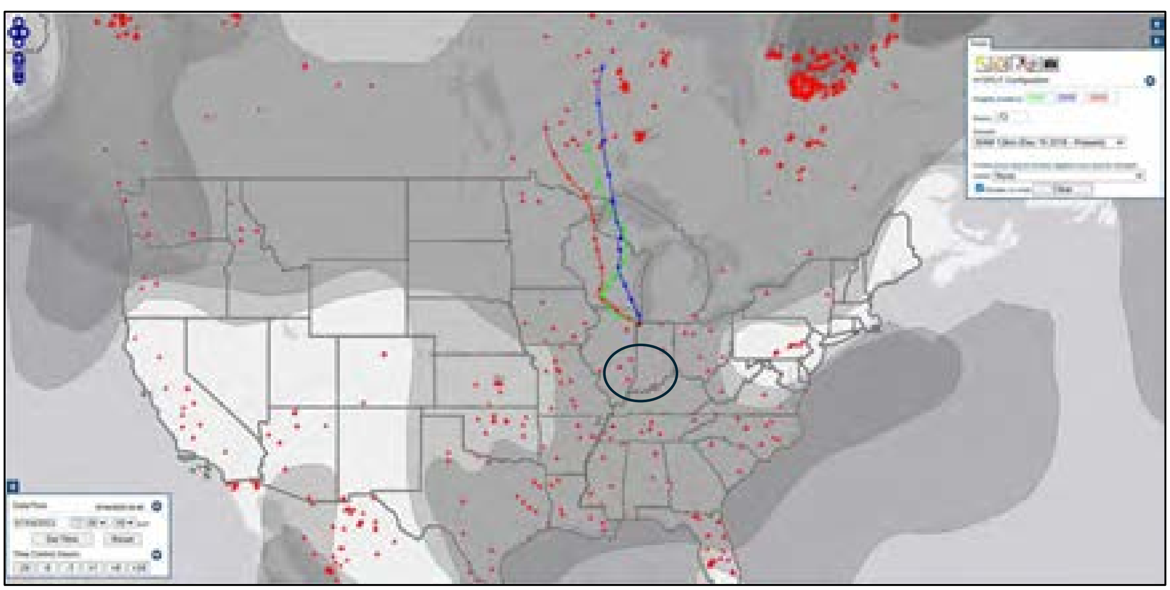
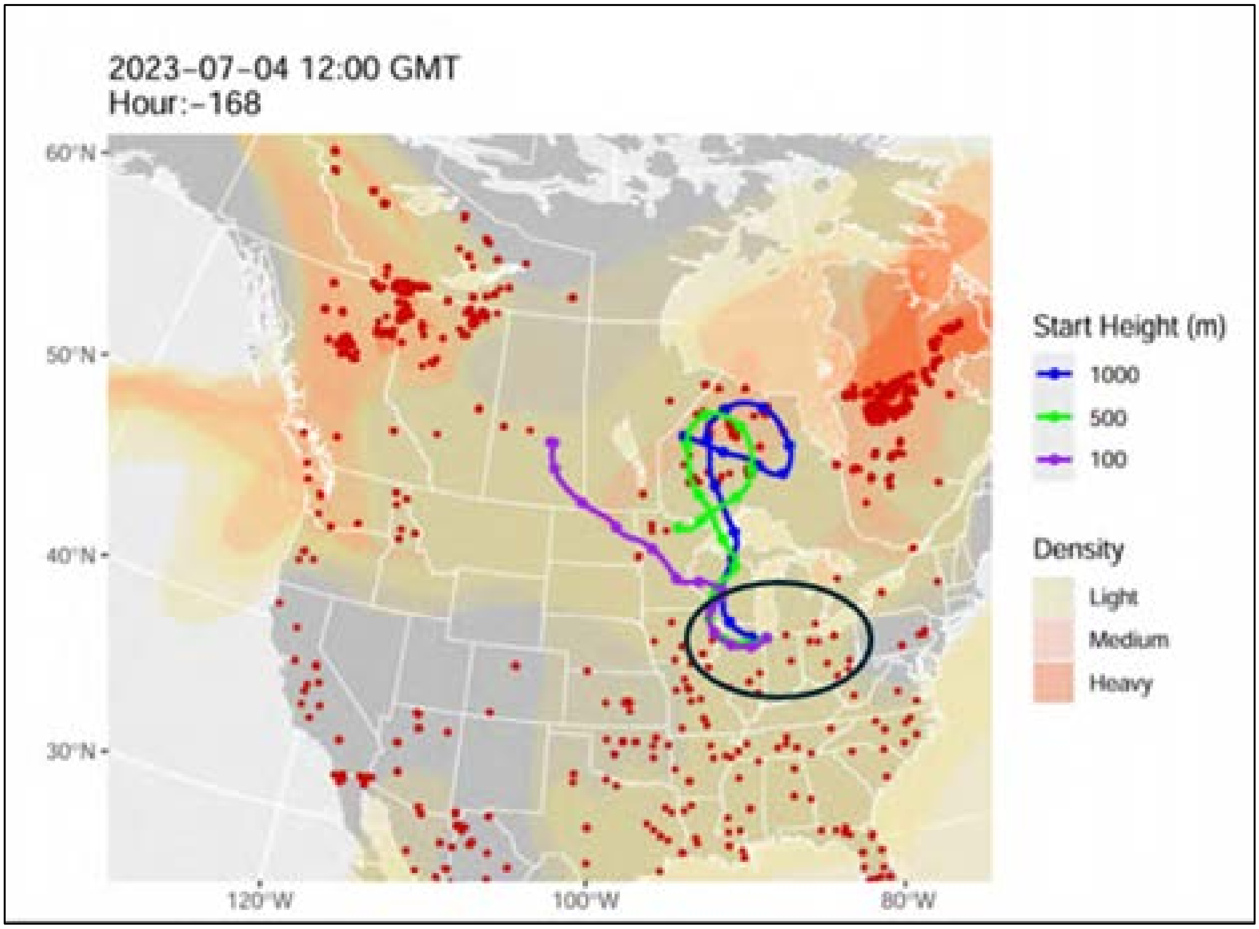


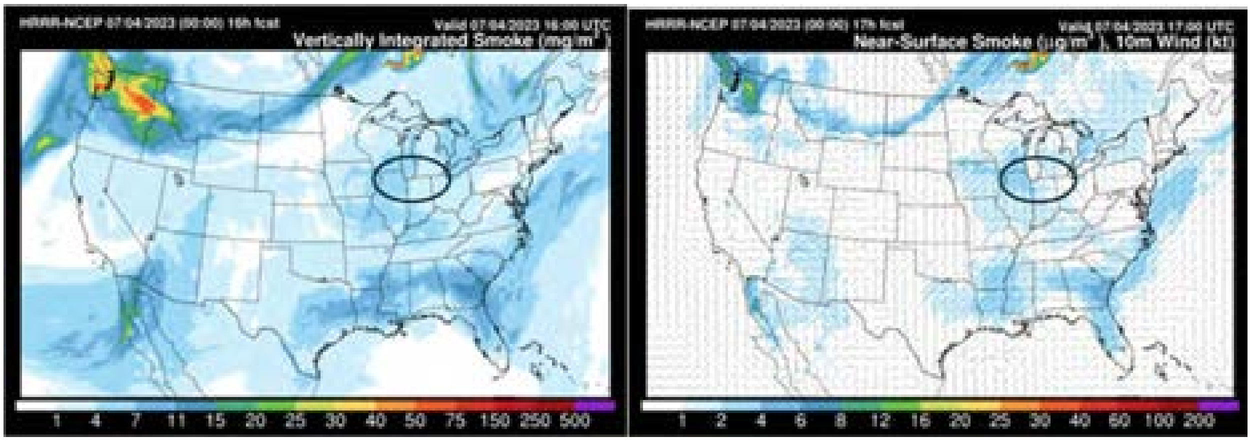
Figure 3.9.21 - Long-Range Back Trajectories from July 4, 2023 (100, 500 and 1000 meters - 168 hours)



3.9.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.9.22 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.9.22 HRRR Smoke Model



3.9.12 Media Mentions

[July 5, 2023 – Four New Wildfires in Northwest District Bring Total to 55 Active Fires]

[Experts issue reminder to check home air filters after Canadian wildfire smoke moves through area]

[Air quality unhealthy overnight due to firework smoke]

3.9.13 Summary of Requested Exclusion of Jul 4, 2023

Table 3.9.5 - Summary Table - Gary IITRI

Event Date	**July 4, 2023**
MDA8 Ozone Concentration (PPB)	73
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone (PPB)	58.5
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	1
Matching day MDA8 ozone (max., avg.) (PPB)	77*, 52.3
HYSPLIT indicated wildfire regions	Western-edge Wabakimi Fire, Sioux Lookout 33 Fire
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

3.10 July 23 and 25, 2023 Ozone Event

3.10.1 Executive Summary

On July 23 and 25, 2023, Northwest Indiana experienced ozone exceedances across all Lake and Porter County monitors, with values ranging from 71–78 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Alberta, Saskatchewan, and Manitoba were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 5–23 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to the Shaw Fire, Smith Fire and Vermette Fire, Saskatchewan.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of July 23 and 25, 2023, as an exceptional event under U.S. EPA guidelines.

Table 3.10.1 July 23 and 25, 2023 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

Date	Gary - IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
July 23, 2023	71	69	75	63
July 25, 2023	78	78	76	71

On July 23 and 25, 2023, multiple Canadian wildfires, as shown in Figures 3.10.1 and 3.10.2, contributed ground level smoke that caused all four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in late July 2023 included the:

- Shaw Fire, which began on May 4, 2023, between Buffalo Narrows and Île-à-la-Crosse in northwestern Saskatchewan. Its ignition source was not confirmed, though the 2023 season featured widespread lightning and drought conditions. It quickly grew into the province's largest wildfire of the year, covering 186,420 hectares.

- Vermette Fire (designated "23BN-VERMETTE"), which ignited on April 29, 2023, southwest of Dillon, Saskatchewan—near Dillon, St. George's Hill, and Michel Village. Classified as a human-caused wildfire, it rapidly expanded to cover 88,446 hectares as of June 11, 2023. Firefighting efforts included Type 1, 2, and 3 crews, heavy equipment, helicopters, and airtanker operations, with a focus on protecting communities and key transport routes such as Highway 925.
- Smith Fire, located north of Pinehouse and was noted in mid-May 2023. By May 18, it had grown to 103,624 hectares. While the exact start date and ignition source were not publicly detailed in available sources, its rapid growth during dry spring conditions suggests a combination of weather and forest fuel factors.

Figure 3.10.1- Canadian Wildfires - July 23, 2023

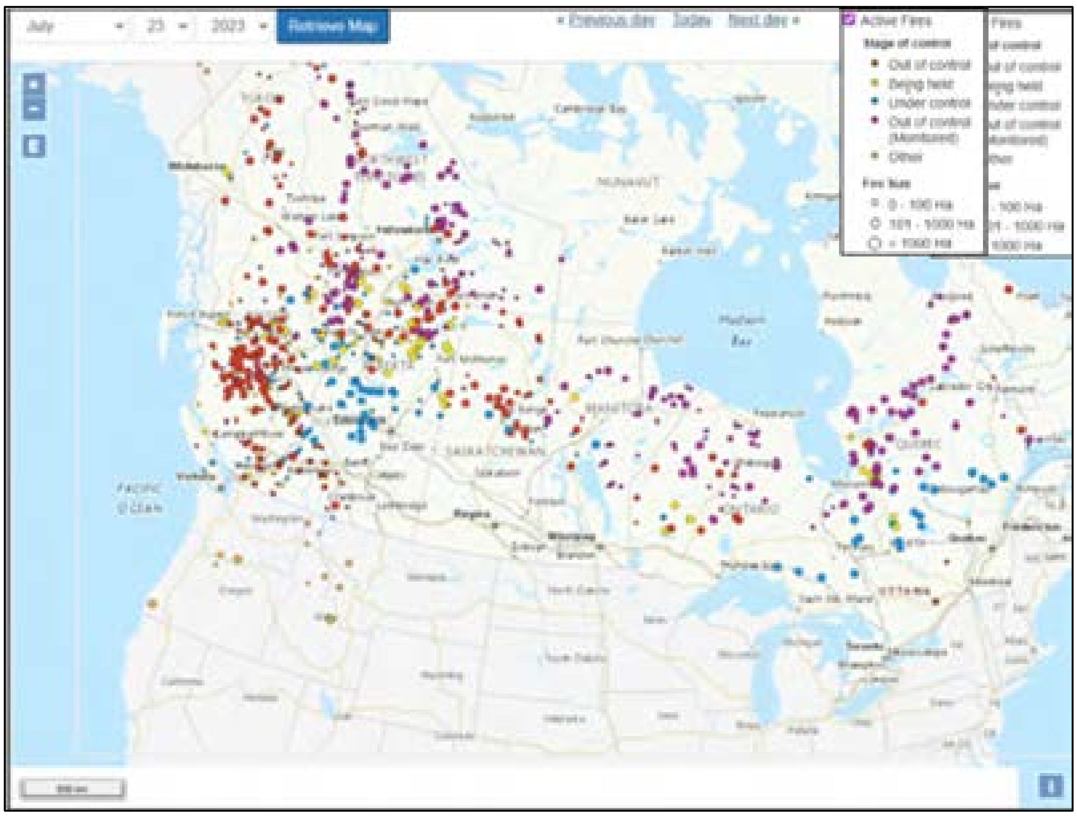
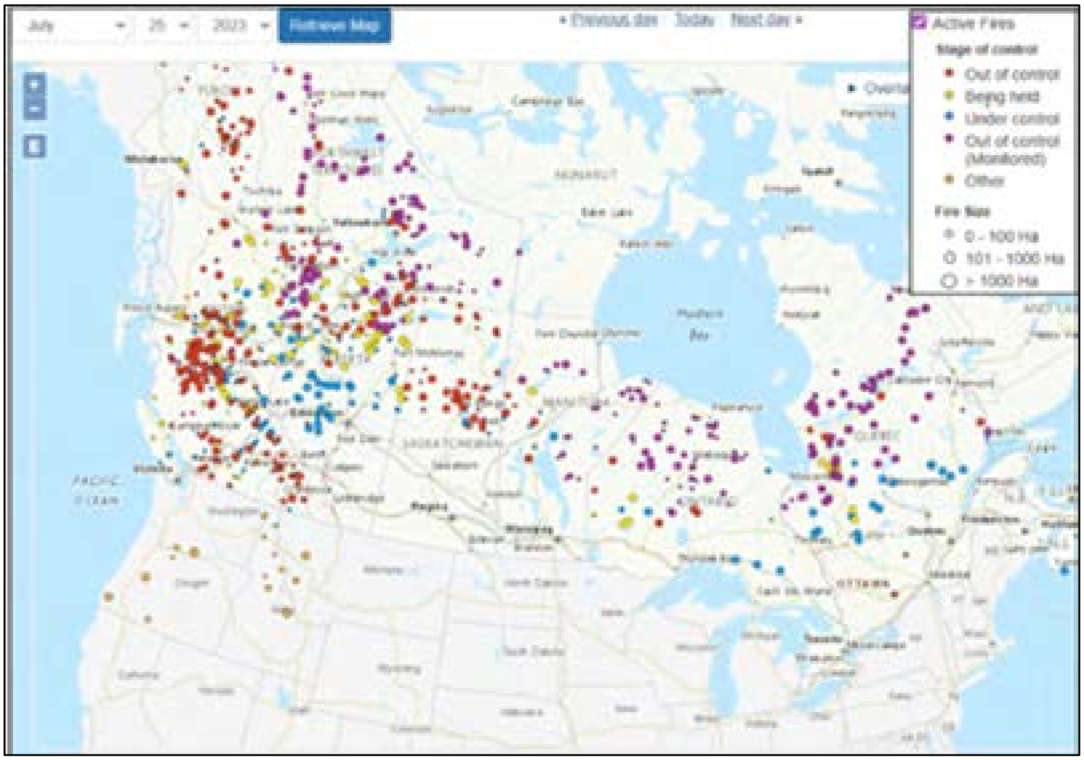


Figure 3.10.2 - Canadian Wildfires July 25, 2023



3.10.2 Meteorological Episode Overview

Broad upper air ridge was evident of the southwest U.S. on July 23 with a deep upper air trough over the Midwest. This upper air set up was key in transporting wildfire smoke from the southwest and western Canadian provinces of British Columbia, Alberta, Saskatchewan and Northwest Territories into the northwest Indiana area. A series of cold fronts, moving from the west-northwest to the east-southeast helped to transport and reinforce the wildfire smoke into the area. As surface fronts passed through the area, drier, smoke-filled air filtered into Lake and Porter counties under sunny skies. Air temperatures remained in the mid and upper 80's ^{o}F and lower humidity levels helped to make conducive ozone conditions. The smoke invaded the area by later July 23 through July 25 which produced elevated levels of ozone throughout the area. This weather pattern remained in place for several days as fronts brought more smoke into northwest Indiana. Figure 3.10.3 shows the surface, 850 mb and 500 mb maps of the conditions on July 23 and Figure 3.10.4 shows surface, 850 mb and 500 mb maps of the weather conditions on July 25.

Figure 3.10.3 - Surface, 850 and 500 mb Plots from 12Z on July 23, 2023

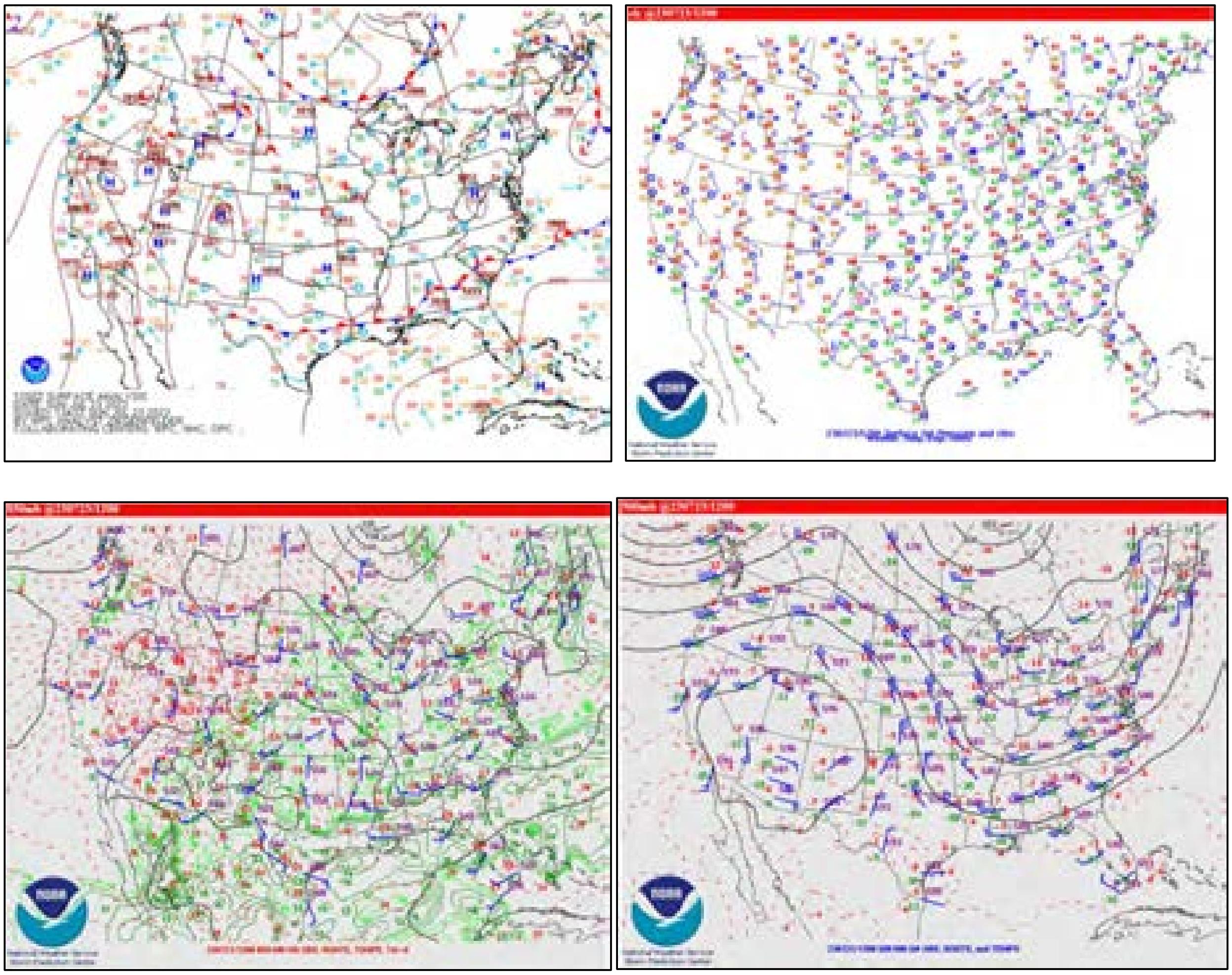
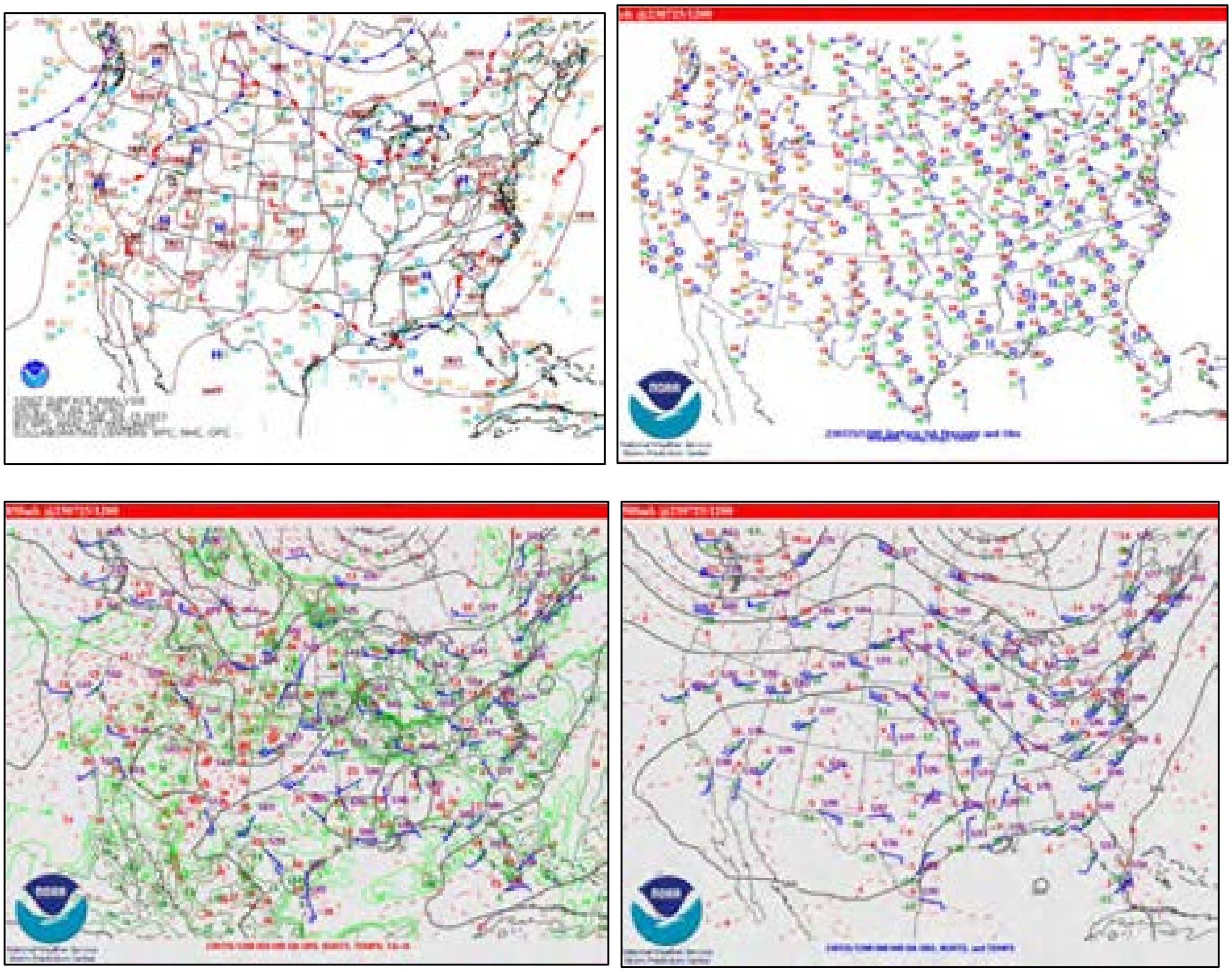


Figure 3.10.4 - Surface, 850 and 500 mb Plots from 12Z on July 25, 2023



Wind rose and pollution rose analyses were taken from the Gary IITRI meteorological station. Wind directions on the 23 and 25 were primarily from the south and northeast. The pollution rose, using Ogden Dunes ozone, indicates that the highest ozone readings were from the northeast on July 23 and from the south as frontal passages were followed by surface high pressure that move south and east and anticyclonic flow recirculated remnant smoke with surface winds from the south. Temperatures were high and skies were sunny, contributing to ozone production.

Figure 3.10.5- Gary IITRI Windrose

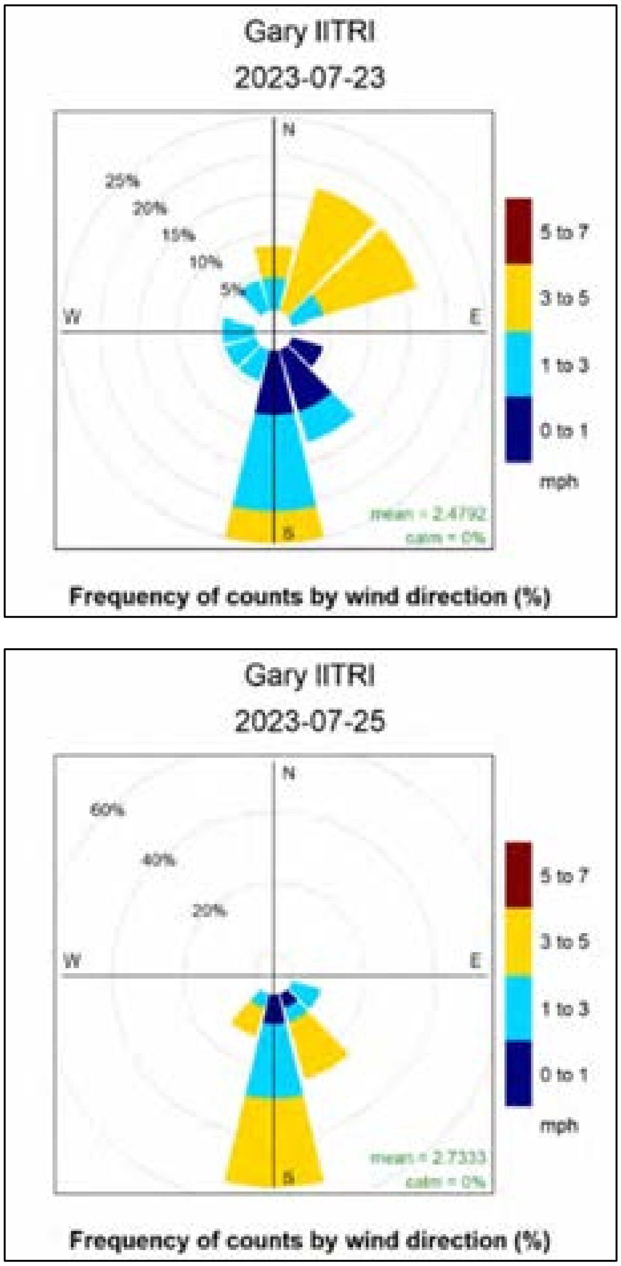


Figure 3.10.6 Gary ITRII Pollution Rose

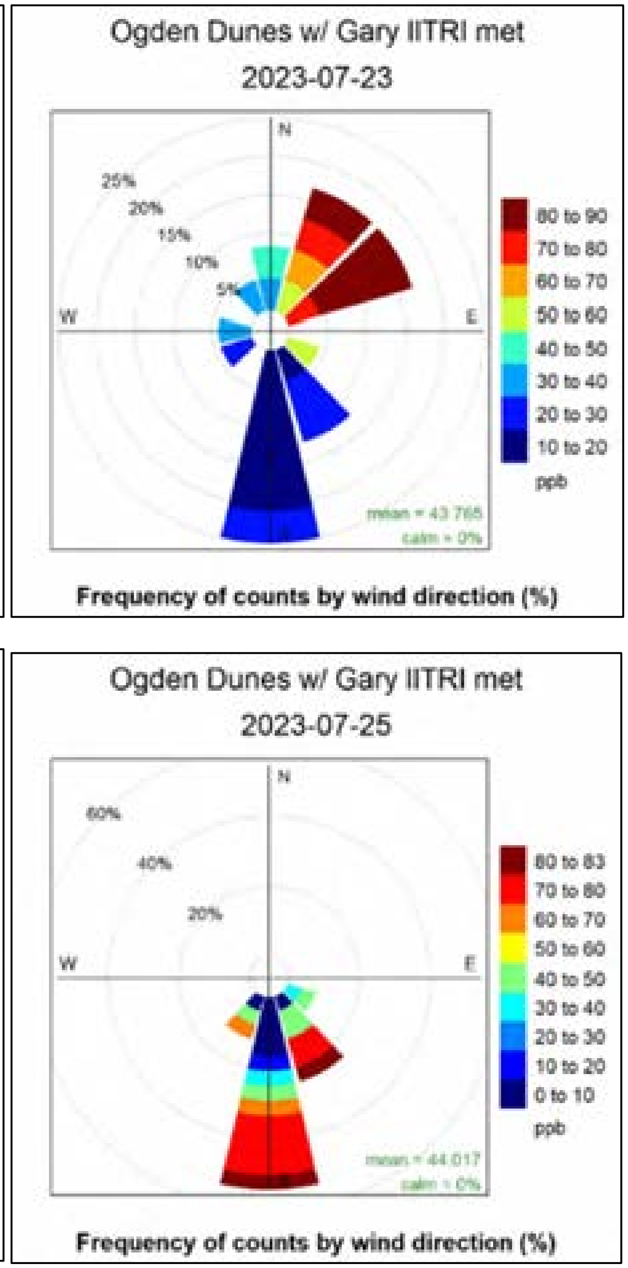
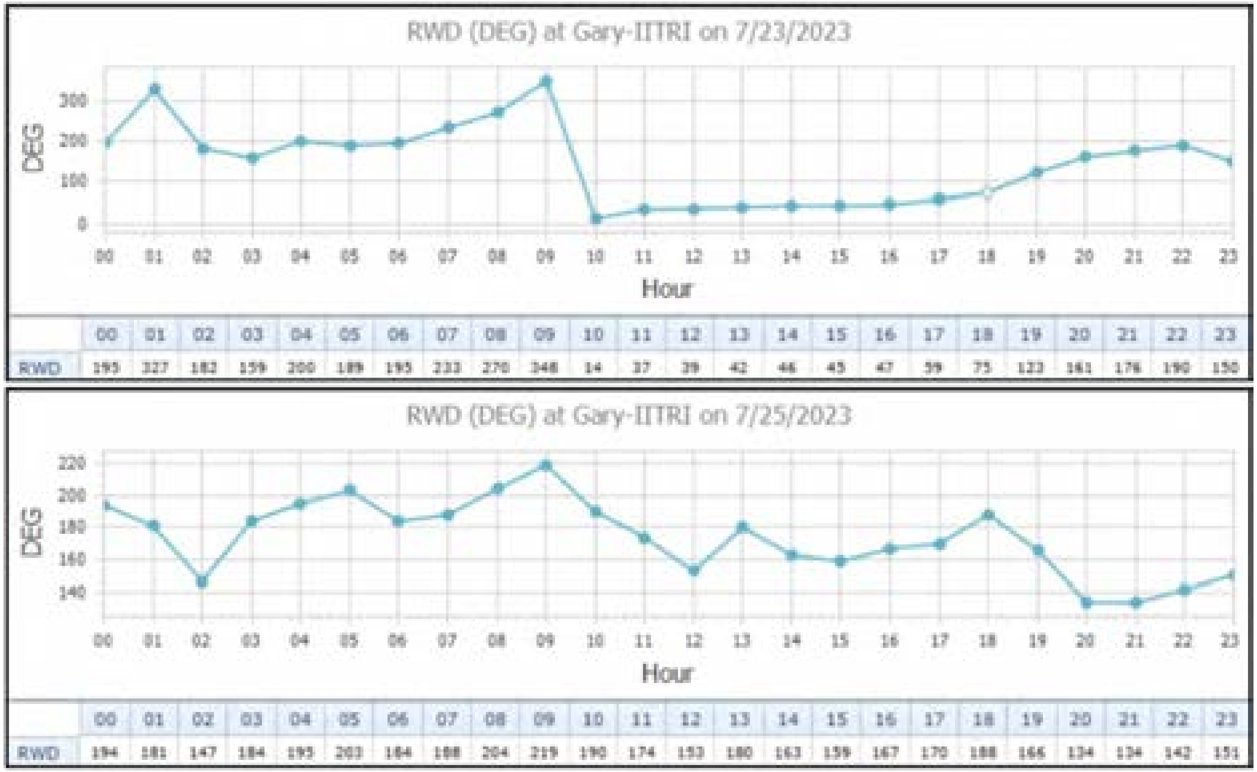


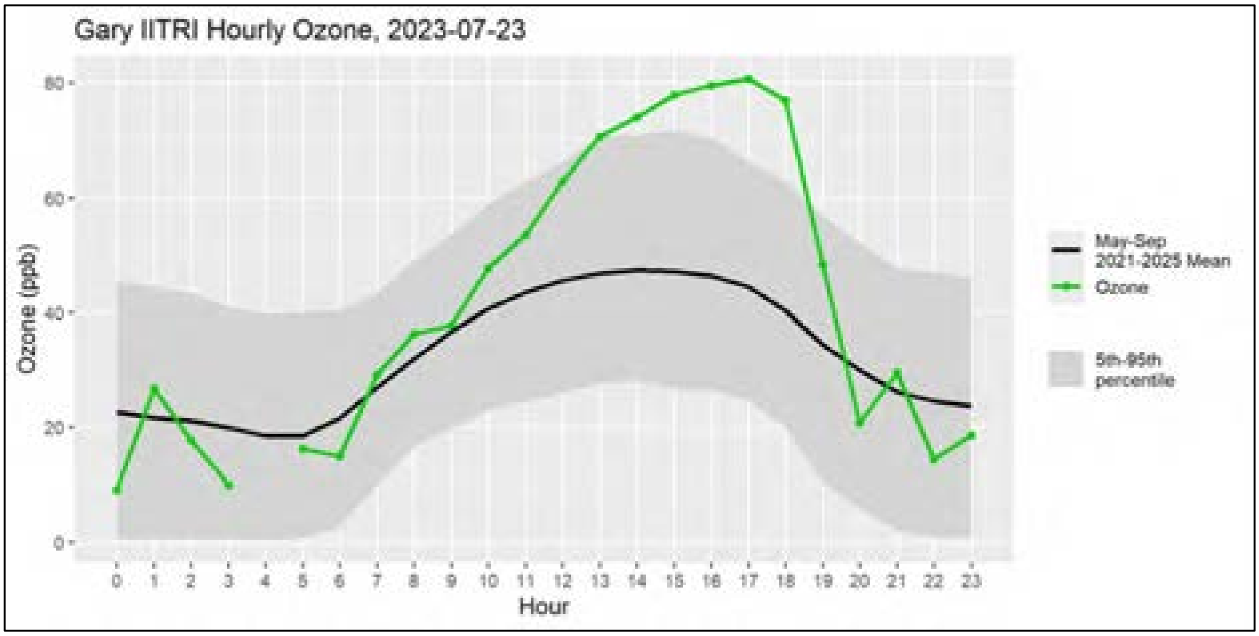
Figure 3.10.7 – Hourly Wind Directions at Gary IITRI for July 23 and 25, 2023



3.10.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for July 23 and 25, 2023 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.10.8 for Gary IITRI, Figure 3.10.9 for Hammond and Figure 3.10.10 for Ogden Dunes. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.10.8 – Ozone Diurnal Pattern for Gary IITRI - July 23 and 25, 2023



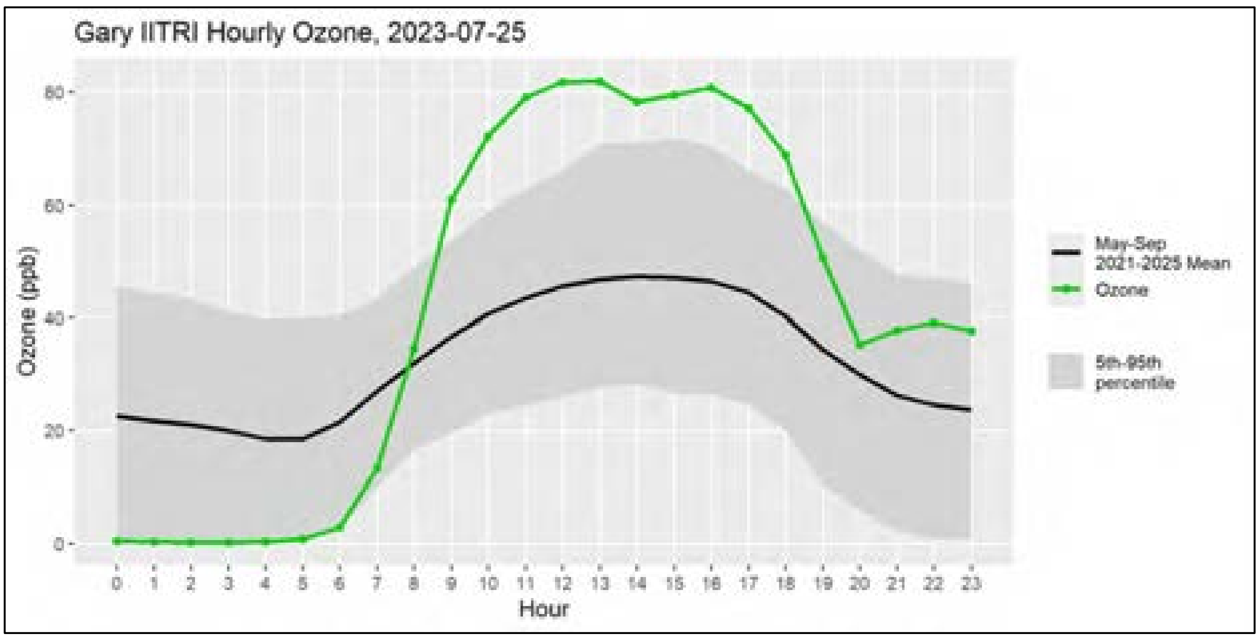
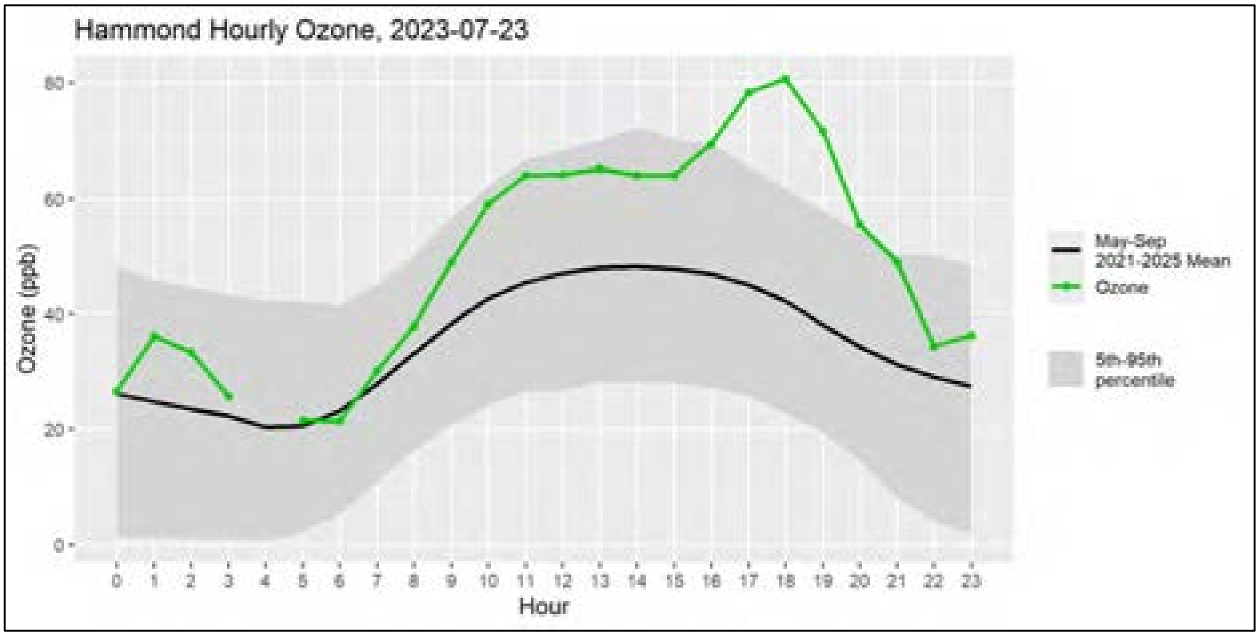


Figure 3.10.9 – Ozone Diurnal Pattern for Hammond - July 23 and 25, 2023



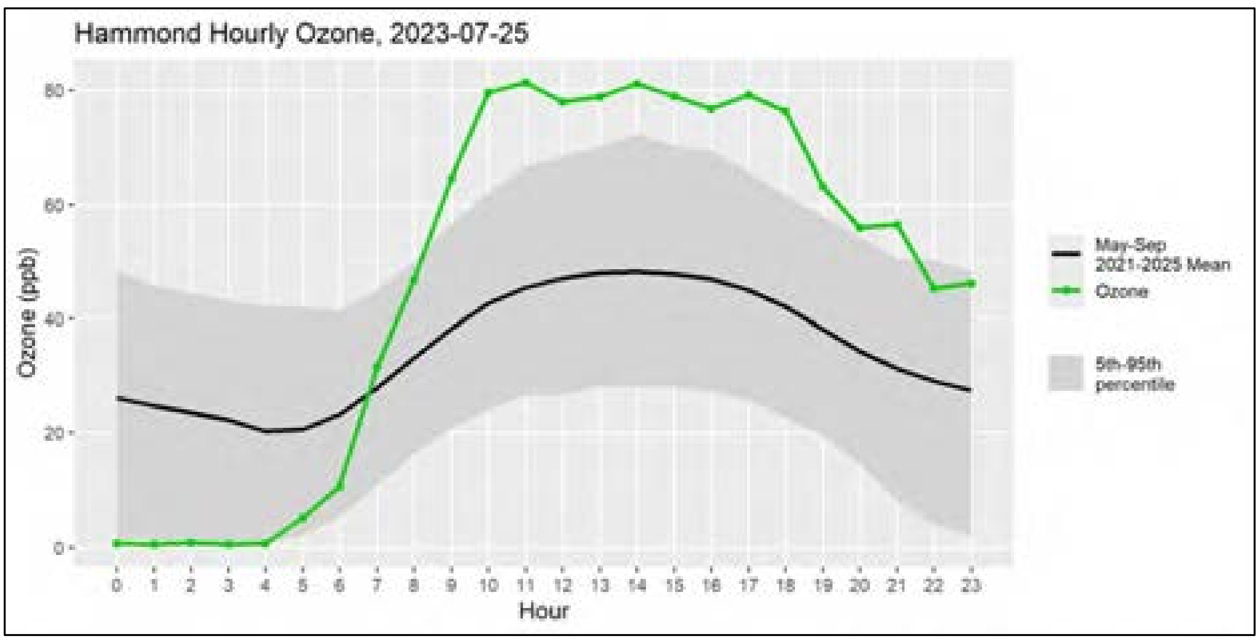
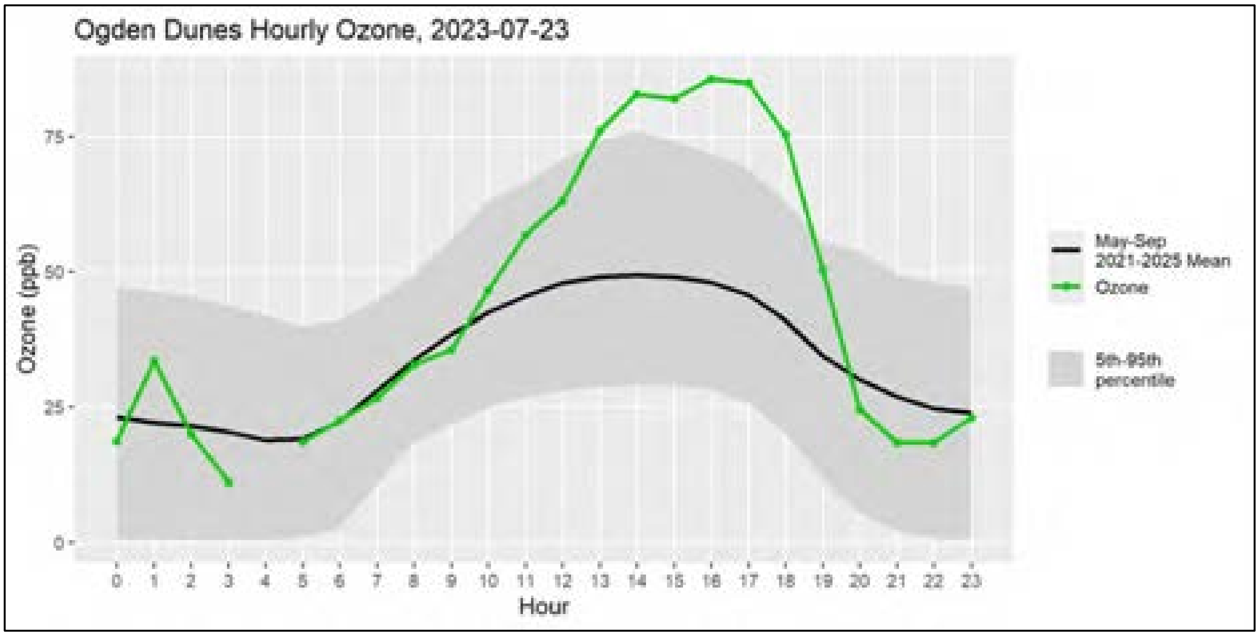
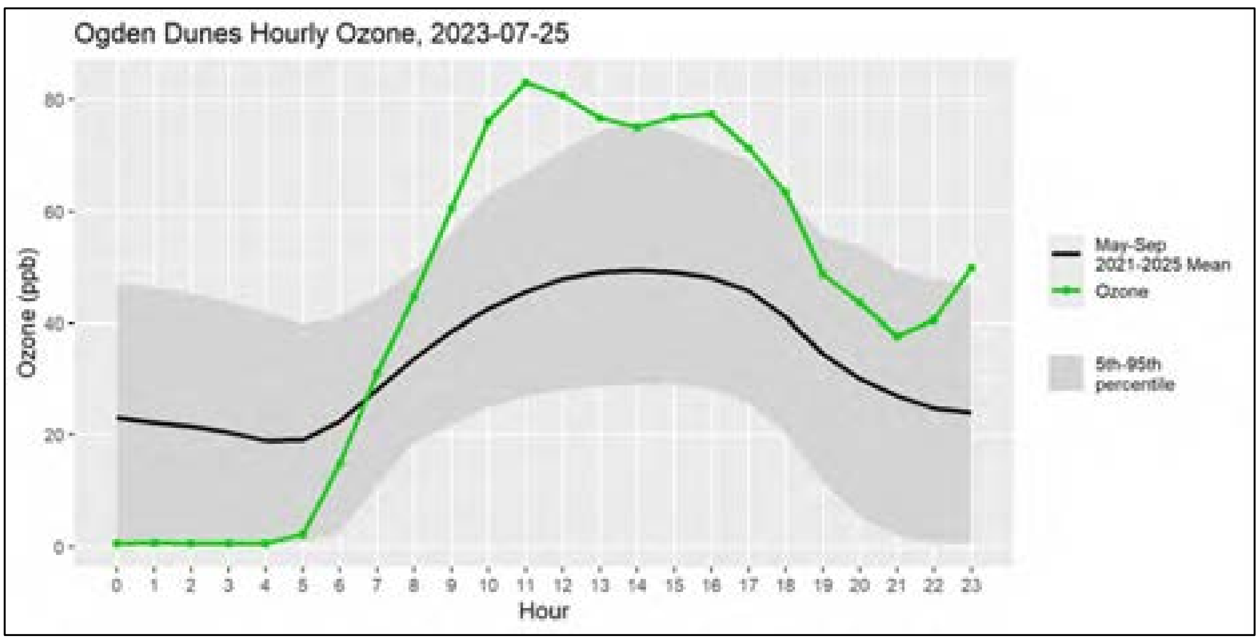


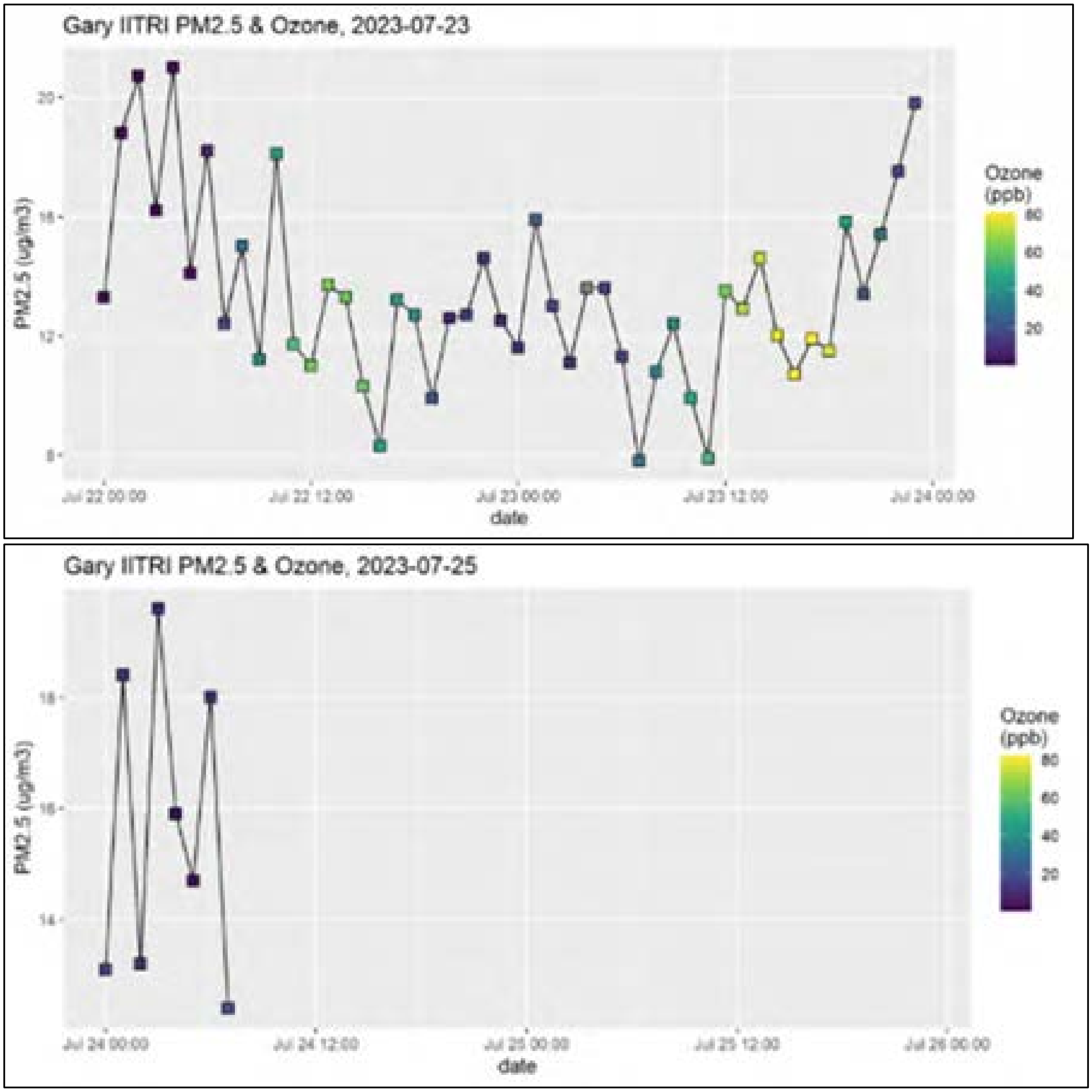
Figure 3.10.8 – Ozone Diurnal Pattern for Ogden Dunes - July 23 and 25, 2023





Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for July 23-25 as shown in Figure 3.10.11. $PM_{2.5}$ concentrations ranged from 8 - 20 µg/m^3 on July 23 and 14 - 18 µg/m^3 on July 25.

Figure 3.10.11 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data July 23 and 25, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.10.2 shows the percentage above the five-year average. All three pollutants were well above the average indicating the influence of wildfire smoke throughout the period.

Table 3.10.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO above 5-year average	Percentage NO2 above 5-year average	Percentage Black Carbon above 5-year average
7/23/2023	104%	118%	167%
7/25/2023	176%	142%	414%

3.10.4 AOD and Satellite Analyses

Figures 3.10.12 and 3.10.13 displays satellite imagery for July 23 and July 25 from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of smoke.

Figure 3.10.12- Aerosol Optical Depth (AOD) July 23-25, 2023
July 23, 2023

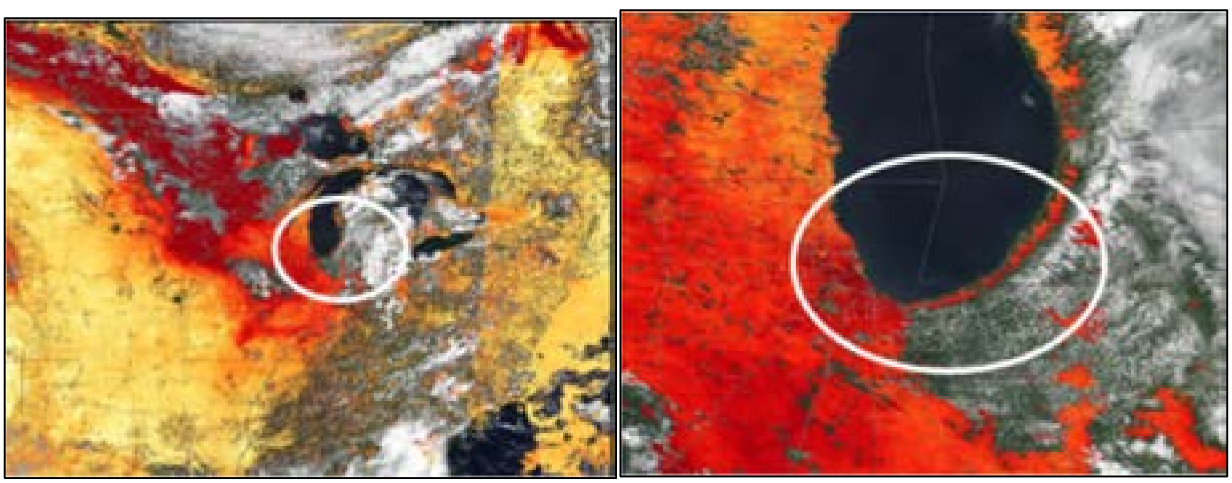
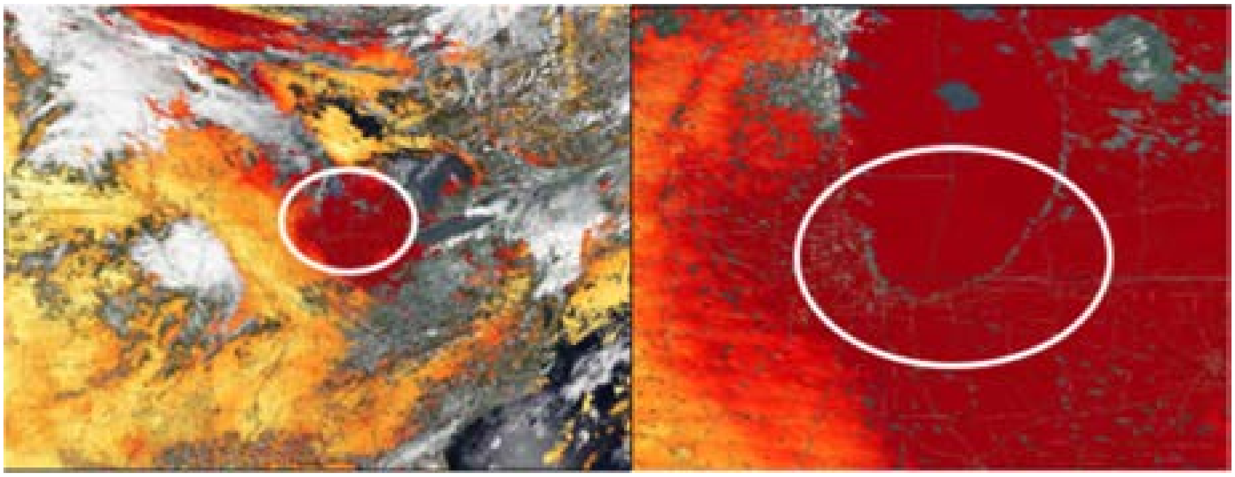


Figure 3.10.13 - Aerosol Optical Depth (AOD) - July 25, 2023



Figures 3.10.14 and 3.10.15 are satellite images captured by NOAA's GOES 18 satellite images of North America from July 23 and 25, 2023. The images show plumes of gray and white smoke extending from western Canada to the upper Midwest states. The smoke began to enter Lake and Porter County on July 23 and continued to move from west to east over the area through July 25. Credit: NOAA NESDIS

Figure 3.10.14 - Satellite Imagery July 23, 2023

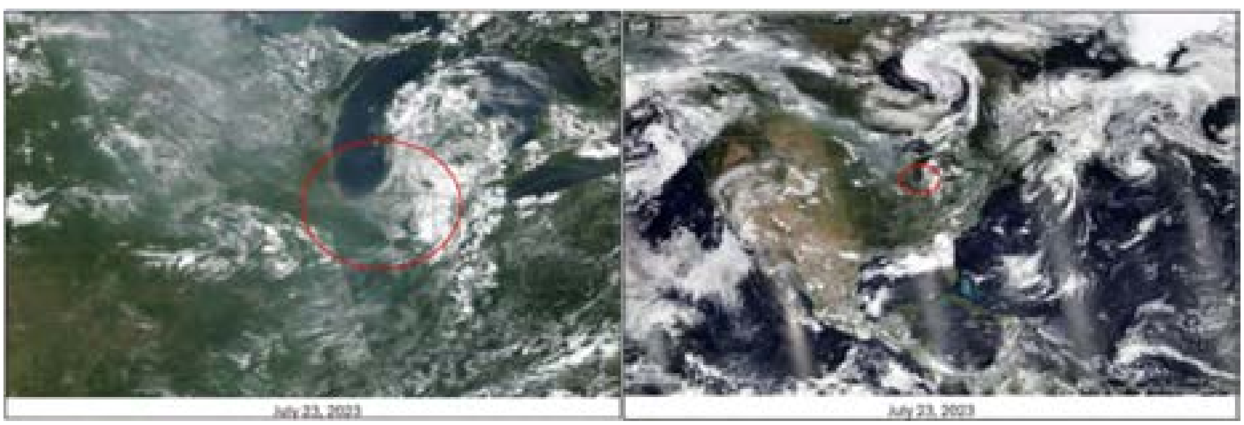
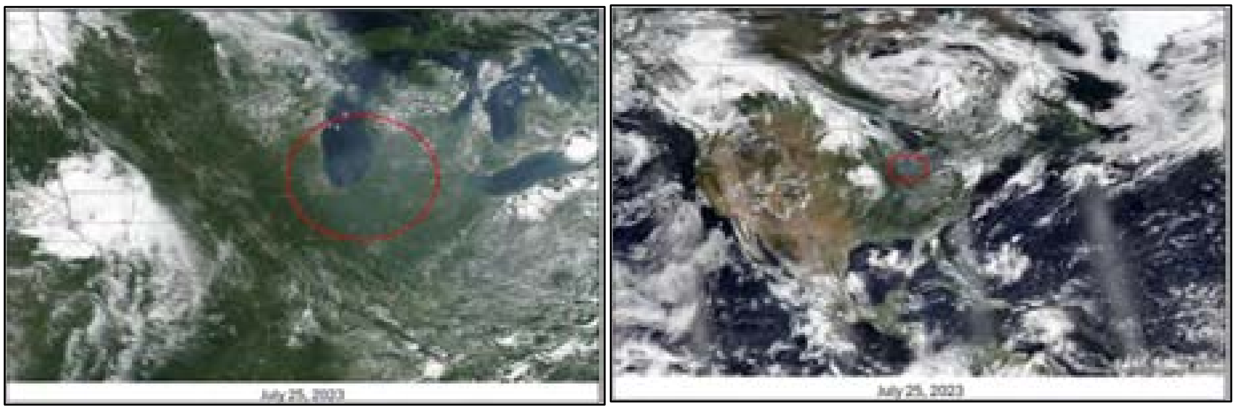


Figure 3.10.15 - Satellite Imagery July 25, 2023



3.10.5 NOAA Smoke Narrative

July 23-25, 2023

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1600Z July 23, 2023

SMOKE:
Canada/United States/Atlantic Ocean/Northern Mexico/Pacific Ocean off the U.S. West Coast and south Mexico/Northern Gulf of Mexico…
The enormous area of smoke primarily from the Canadian wildfires continues to be seen covering virtually all of Canada and most of the U.S. including the eastern half of Alaska, along with the northern half of Mexico, much of the central and northern Atlantic, and parts of the northeastern Pacific off the southwest coast of Canada. Within this larger area of thin density smoke were batches of moderate to thick density smoke. The thick to very thick smoke that covered much of northern Canada within the Northwestern Territories and extending southeast through central Canada and into the Midwestern states of Minnesota and Wisconsin was associated from numerous wildfires in western and northwestern Canada. Some of this moderate smoke from these fires had moved to the southeast/east over eastern Canada, where fires in Quebec were also seen producing localized moderate to thick smoke, as well the northwestern and north central U.S., covering much of Mid-west and Mississippi valley region. Light smoke also spread into southern and northern Mexico and parts of the northern
Gulf of Mexico.

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1600Z July 25, 2023

SMOKE:
Canada/United States/Atlantic Ocean/Northern Mexico/Pacific Ocean off the U.S. West Coast and south Mexico/Northern Gulf of Mexico…
The enormous area of smoke primarily from the Canadian wildfires continues to be seen covering virtually all of Canada and most of the U.S. including most of Alaska, along with the northern half of Mexico and the northeastern Pacific off southern Alaska and southwest coast of Canada. Within this larger area of thin density smoke were batches of moderate to thick density smoke. **The thick to very thick smoke that covered much of northern Canada within the Northwestern Territories and extending southeast through central Canada and into the Midwestern states and Great Lakes region was associated from numerous wildfires in western and northwestern Canada**. The moderate smoke from these fires extended from Alaska and Pacific Ocean off of the southern Alaskan coast, through central Canada, and moving to the southeast/east where it eventually settled into eastern Canada, where fires in Quebec were previously seen producing localized moderate to thick smoke, but cloud cover

precluded today's analysis in the region. **This smoke also extended well over the northwestern and north central U.S., covering much of Midwest, Mississippi valley region and northeastern U.S.**

3.10.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circles on Figures 3.10.16 and 3.10.17 indicate the locations of the Lake and Porter County monitors. Estimated concentrations are from 7-13 × 10^{15} molecules/cm² on June 23 and 5-15 × 10^{15} molecules/cm² on June 25 indicate moderate to extreme wildfire smoke influence.

Figure 3.10.16- TROPOMI Satellite Daily Formaldehyde Monitoring

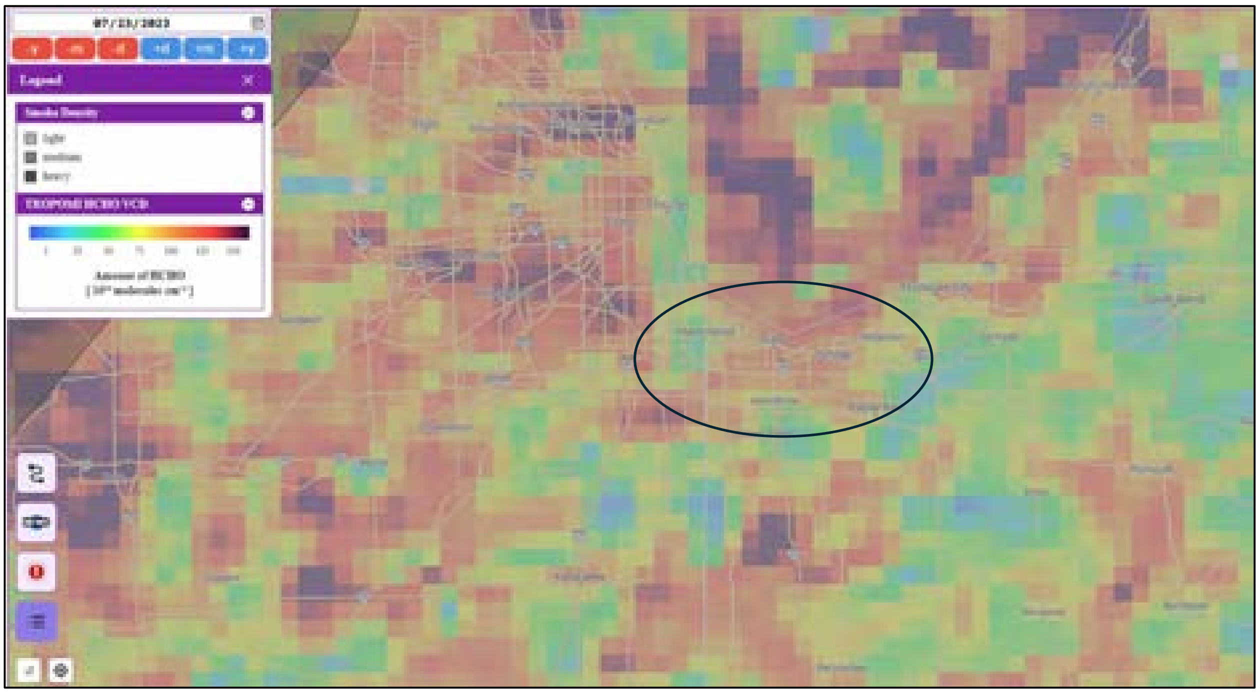


Figure 3.10.17- TROPOMI Satellite Daily Formaldehyde Monitoring

3.10.7 AirNow Smoke Maps

AirNow shows in Figures 3.10.18 through 3.10.25 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.10.18 - AirNow Ozone Map - July 23, 2023

Figure 3.10.19 - AirNow Ozone Map - July 23, 2023

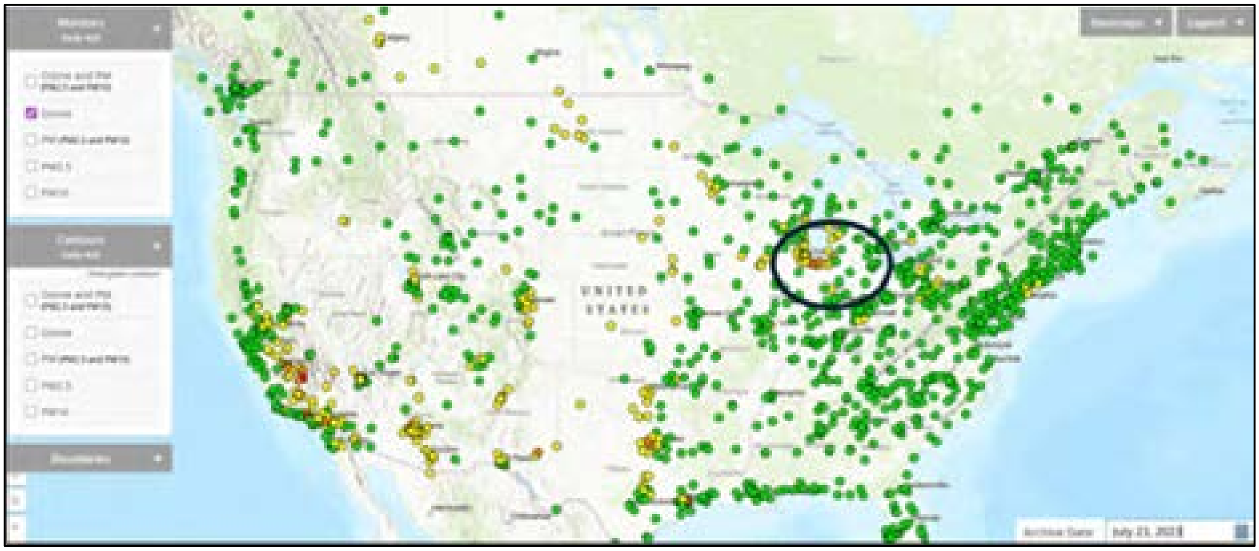


Figure 3.10.20 - AirNow $PM_{2.5}$ Map - July 23, 2023

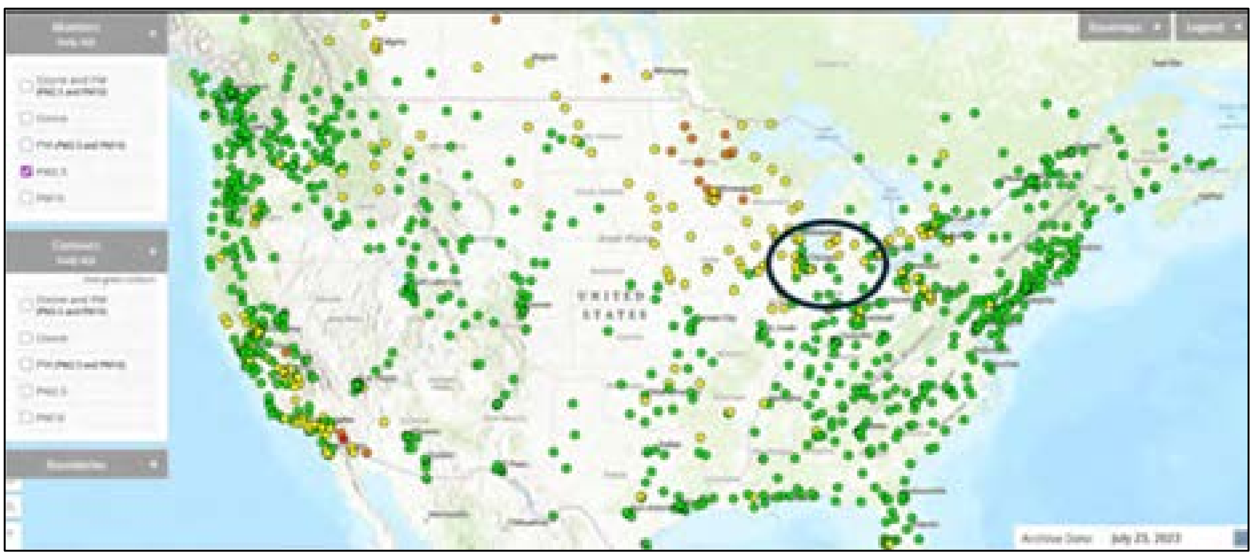


Figure 3.10.21 - AirNow Smoke and Ozone Map - July 23, 2023

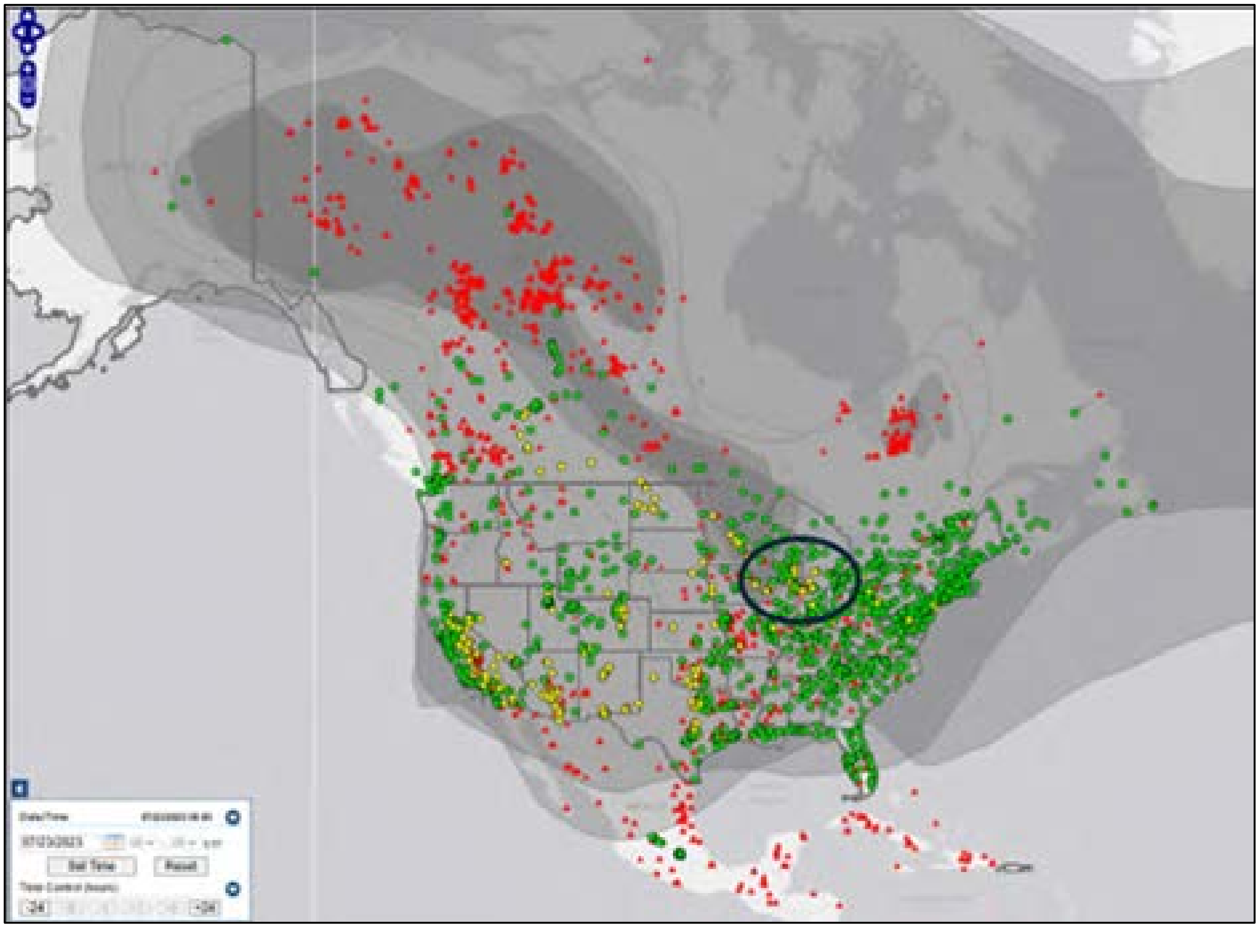


Figure 3.10.22 - AirNow Ozone Map - July 25, 2023

Figure 3.10.23 - AirNow Ozone Map - July 25, 2023

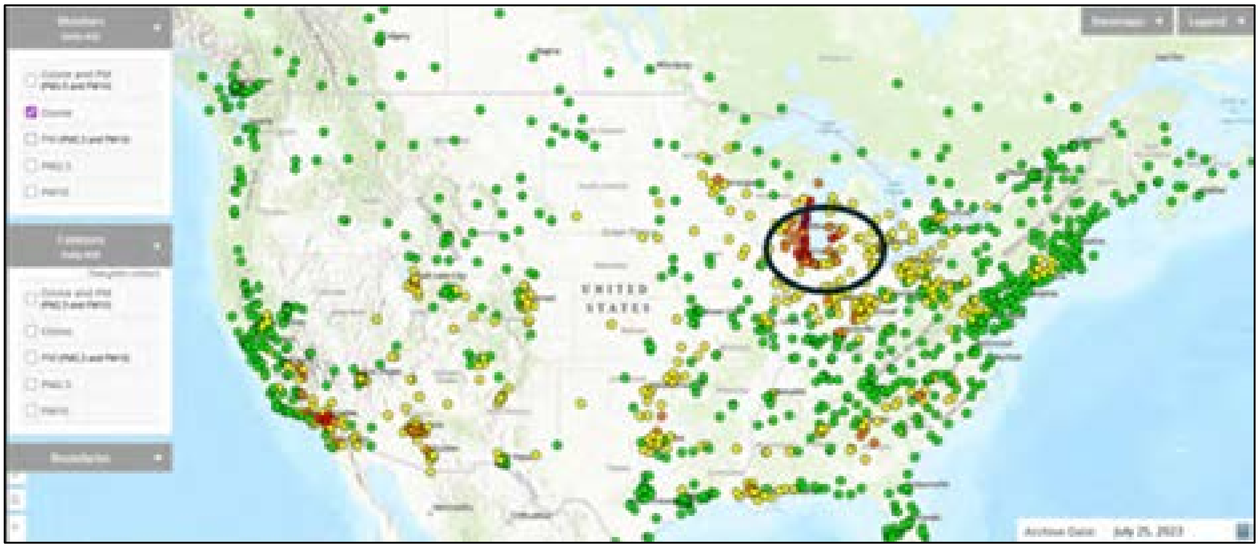
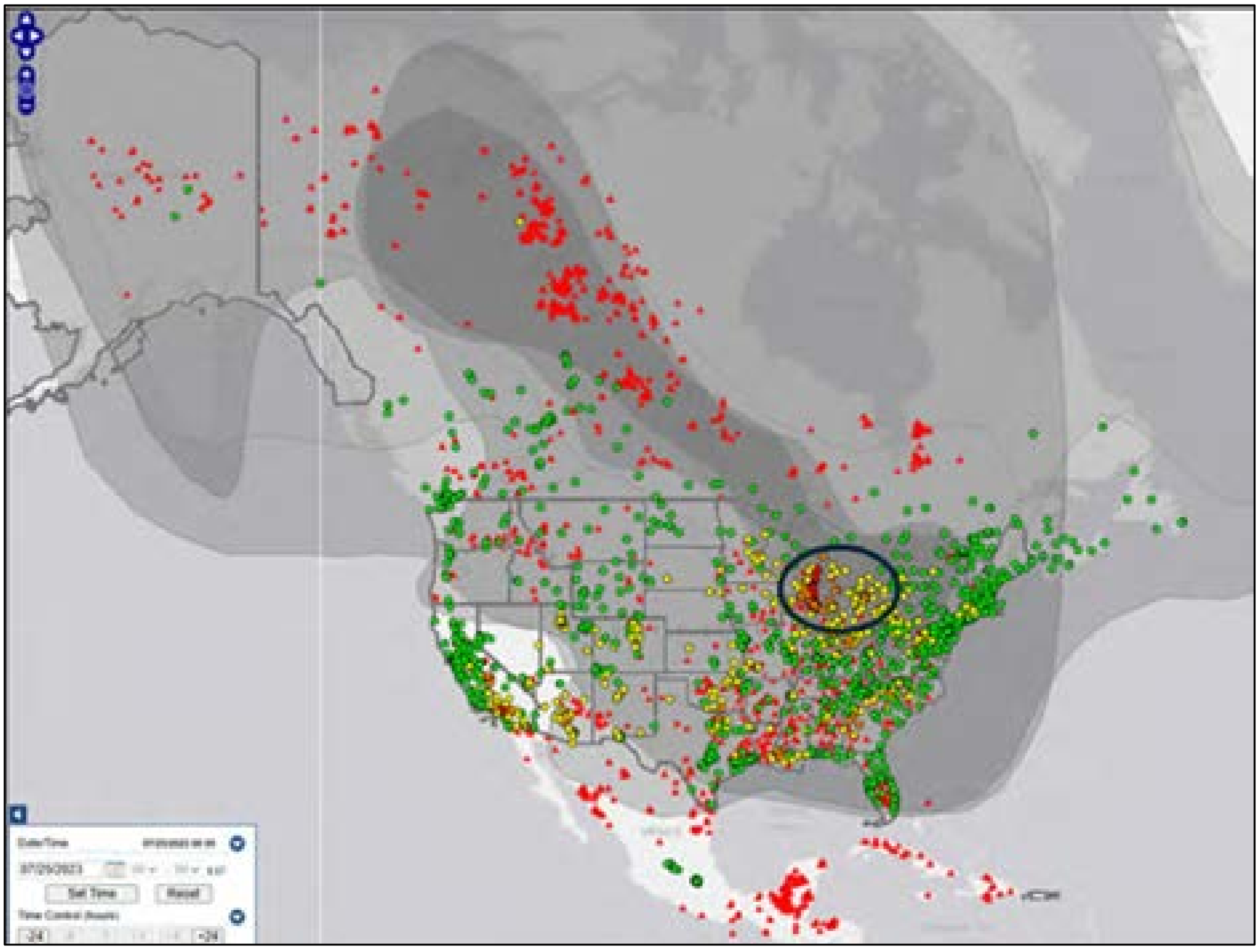


Figure 3.10.24 - AirNow PNM$_{2.5}$ Map - July 25, 2023

Figure 3.10.25 - AirNow Smoke and Ozone Map - July 25, 2023



3.10.8 Statistical Modeling Analyses

Figures 3.10.26 through 3.10.33 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the black circles on each of the maps.

Figure 3.10.26 - GAM Smoke Maps Indicating Smoke Days July 23, 2023

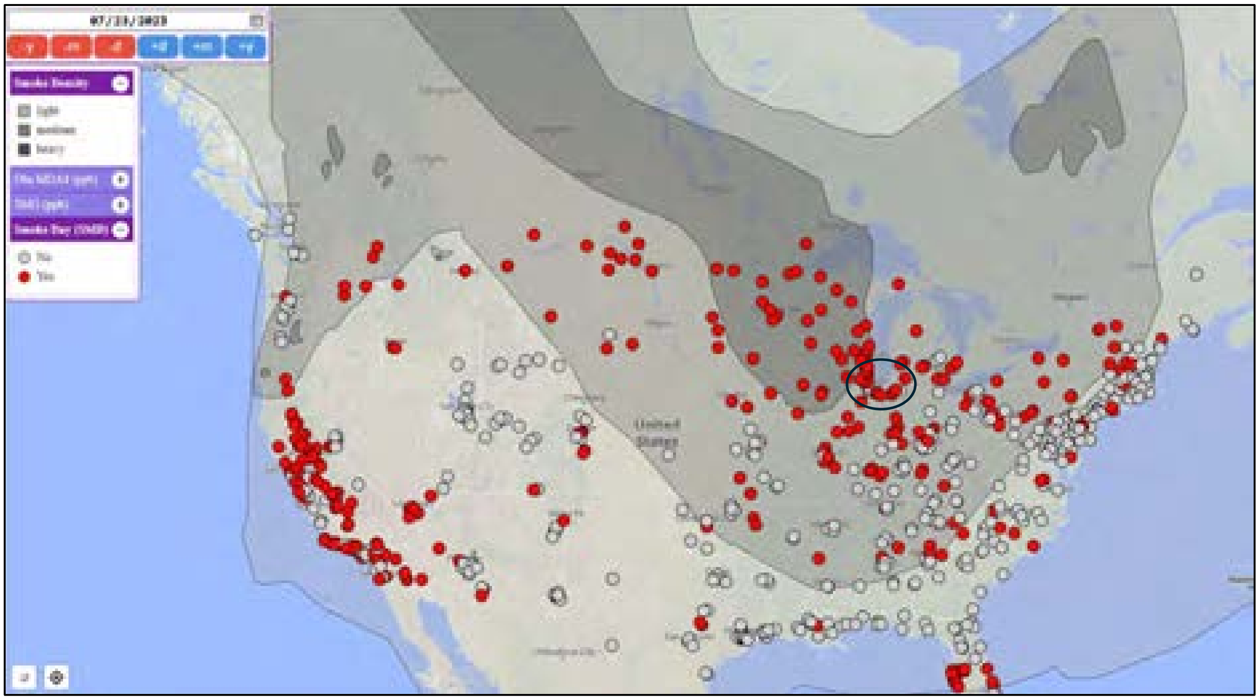


Figure 3.10.27 - GAM Observed Ozone with Smoke days July 23, 2023

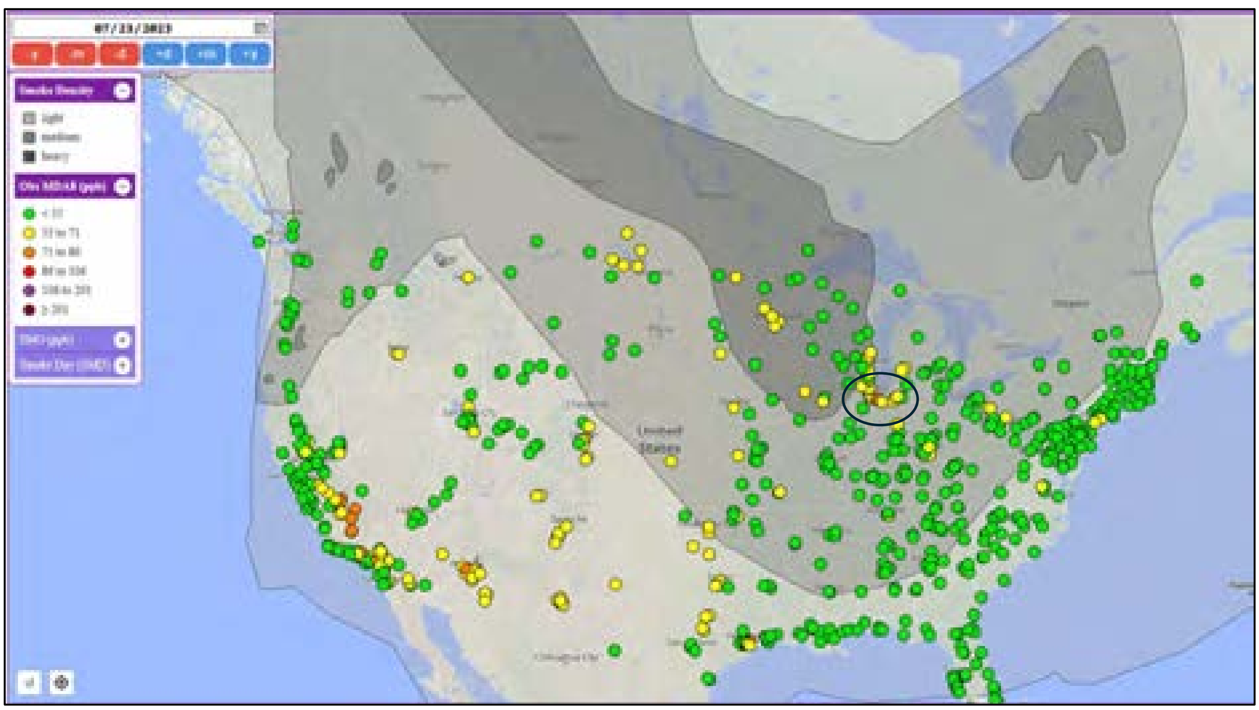


Figure 3.10.28 - GAM Smoke Estimates July 23, 2023

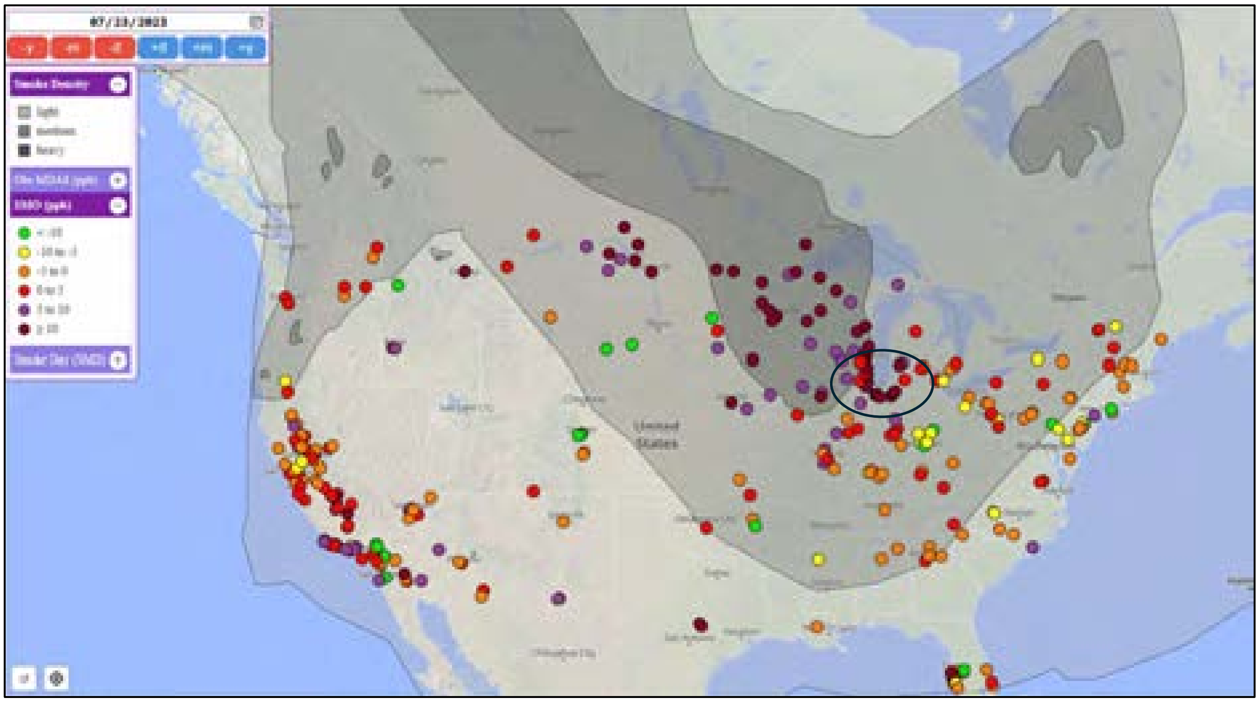


Figure 3.10.29 - EMBER Smoke Estimates July 23, 2023

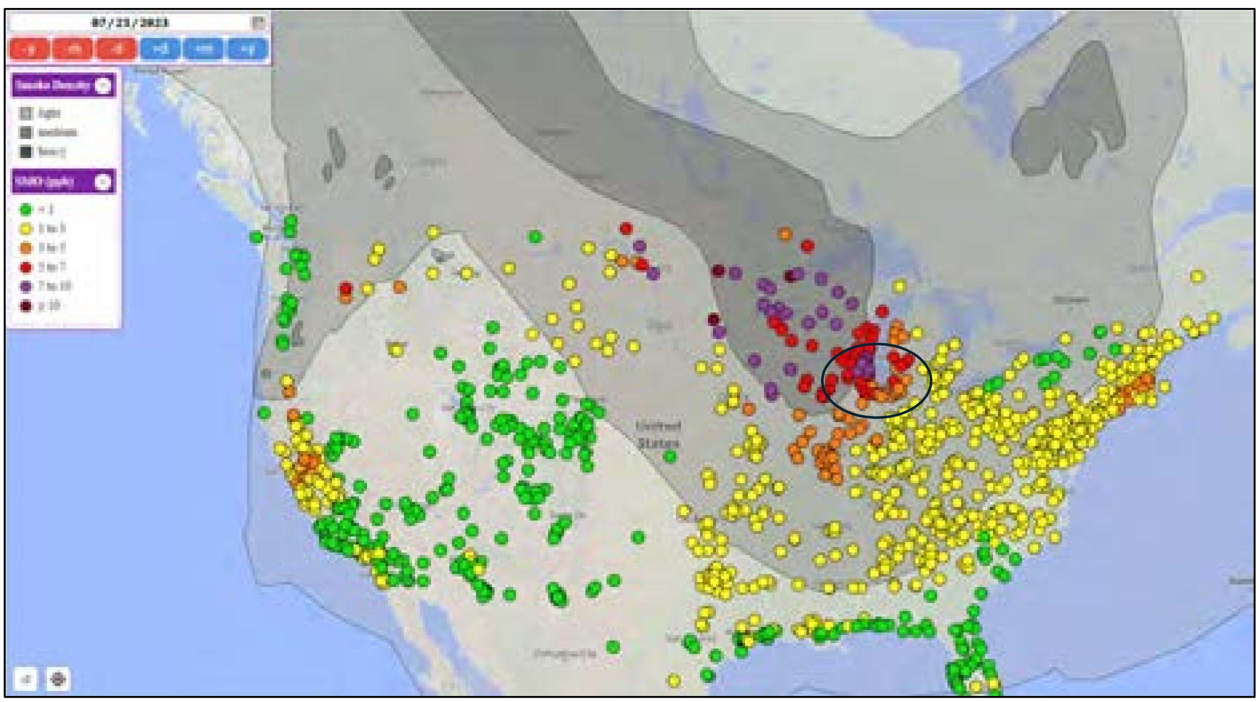


Figure 3.10.30 - GAM Smoke Maps Indicating Smoke Days July 25, 2023

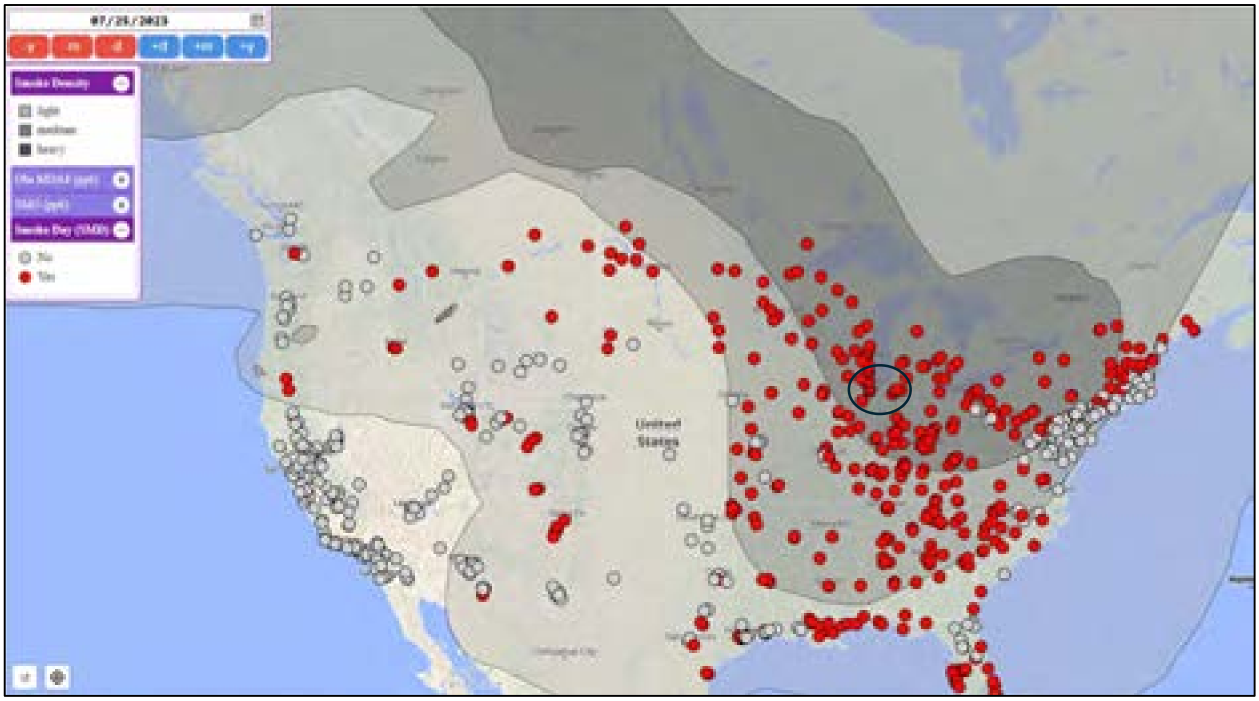


Figure 3.10.31 - GAM Observed Ozone with Smoke days July 25, 2023

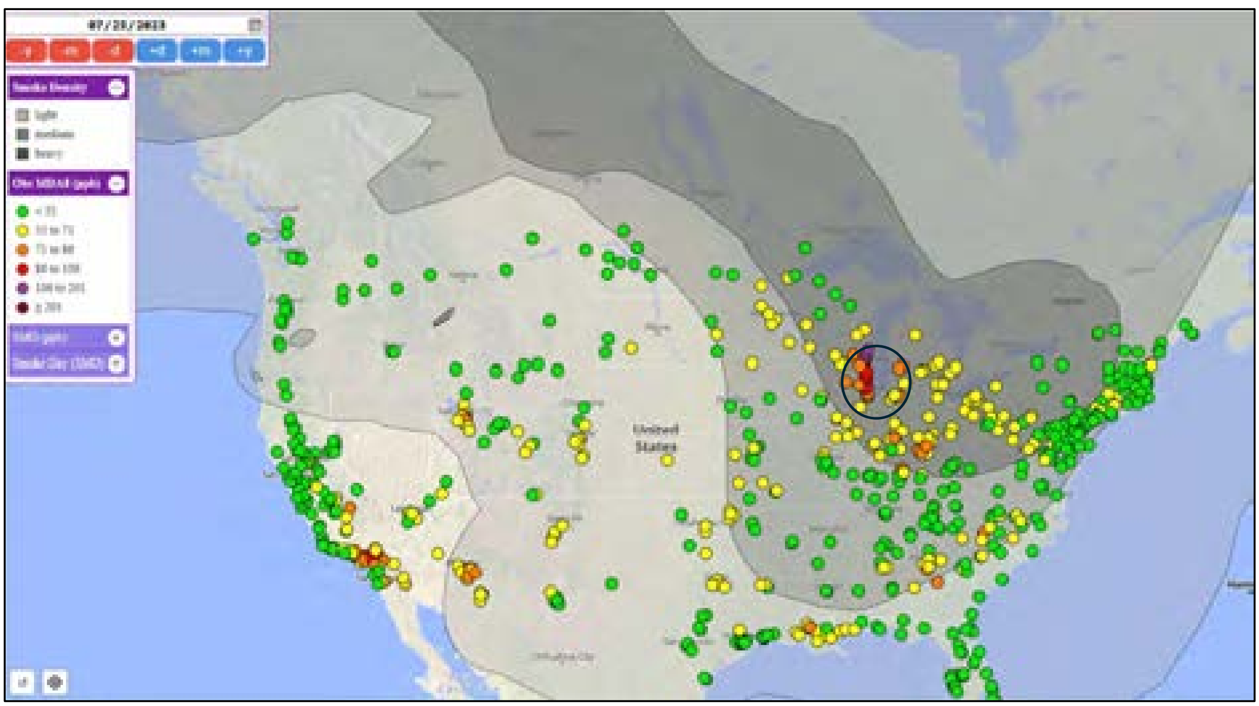


Figure 3.10.32 - GAM Smoke Estimates July 25, 2023

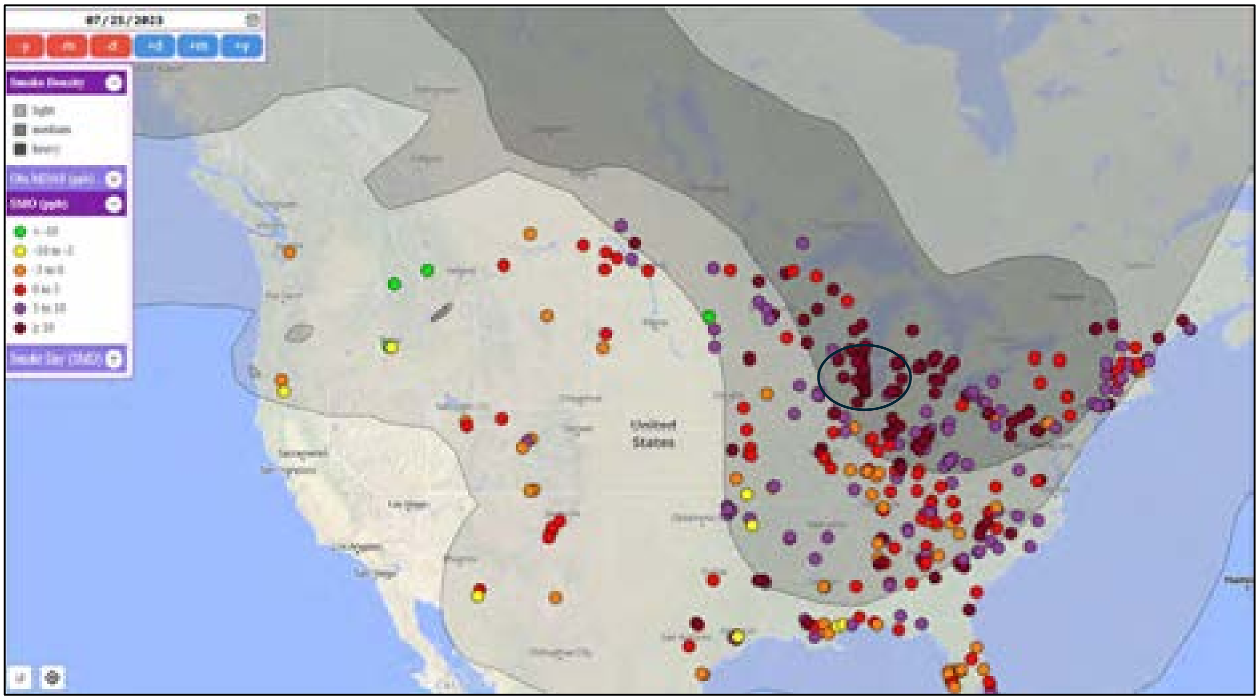
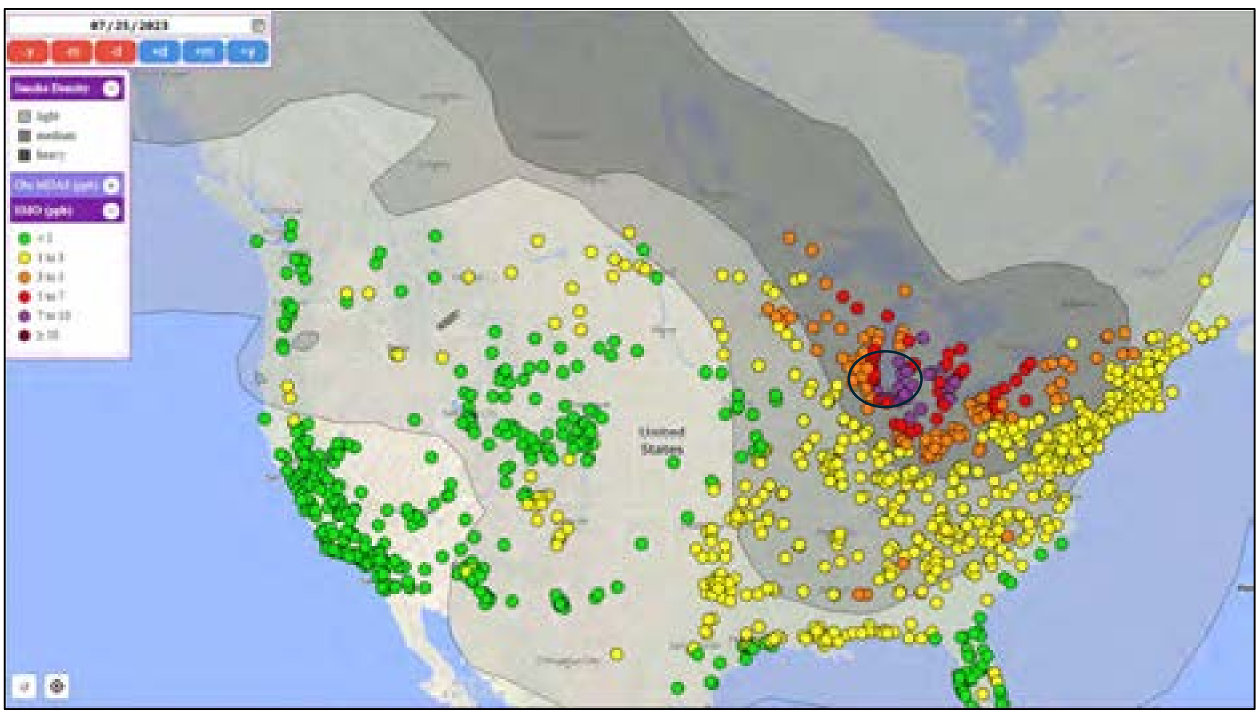


Figure 3.10.33 - EMBER Smoke Estimates July 25, 2023



Tables 3.10.3 and 3.10.4 summarize the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.10.3 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values July 23, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	71	52.1	18.9	63	8
180892008	Hammond	69	NA	NA	60	9
181270024	Ogden Dunes	75	51.7	23.2	63	12
181270026	Valparaiso	63	50.6	12.4	54	9

Table 3.10.4 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values July 25, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	78	NA	NA	71	7
180892008	Hammond	78	NA	NA	68	10
181270024	Ogden Dunes	76	NA	NA	71	5
181270026	Valparaiso	71	NA	NA	60	11

3.10.9 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on July 23 and 25, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Tables 3.10.5 and 3.10.6 show the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 21 ppb lower than the MDA8 ozone concentrations observed on May 30 with the maximum matching day MDA8 ozone concentration of 81 ppb.

Table 3.10.5 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values July 23, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	75	63.6	54

Table 3.10.6 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values July 25, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	76	81.0*	55.5

* Indicates Matching days were influenced by wildfire smoke

3.10.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. Figures 3.10.34 and 3.10.35 show the trajectories with three starting heights, 50 m (green), 100 m (blue), and 500 m (red) for July 23 and 25. Figures 3.10.36 and 3.10.3 7 show the higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red) for July 23 and 25. The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. July 23 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure 3.10.38 and 3.10.39 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over the wildfires in Manitoba, Saskatchewan and Alberta. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps

Figure 3.10.34 – Back Trajectories July 23, 2023: 50, 100 and 500 meters (-72 hours)

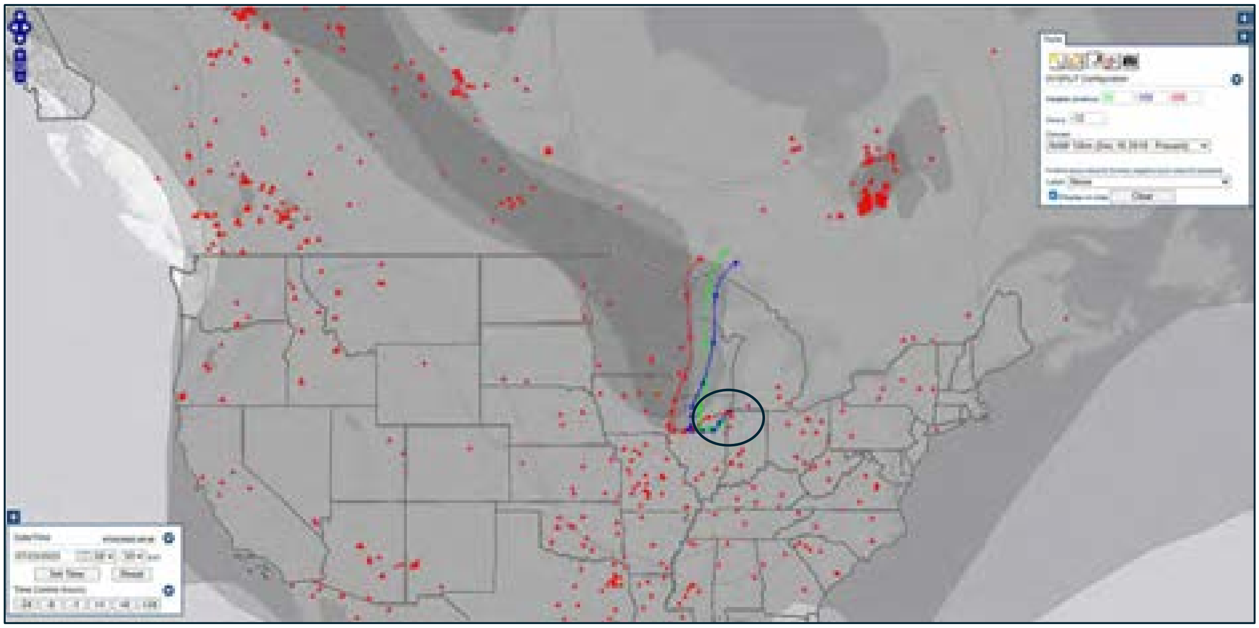


Figure 3.10.35 – Back Trajectories July 25, 2023: 50, 100 and 500 meters (-72 hours)

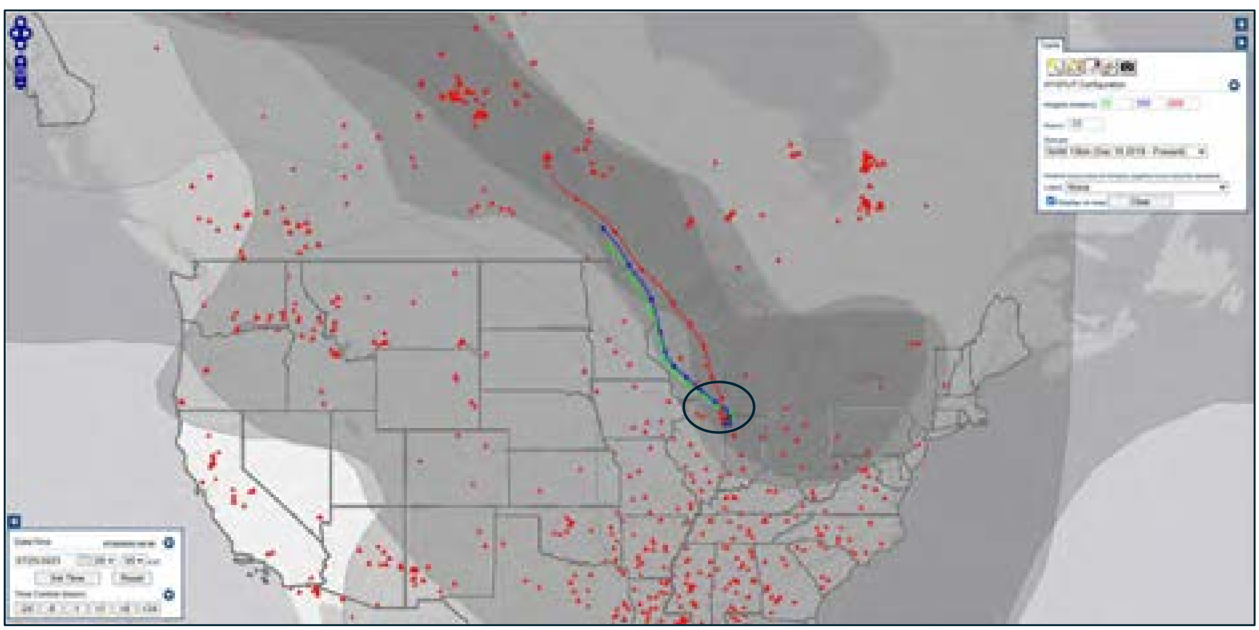


Figure 3.10.36 – Back Trajectories July 23, 2023: 1000, 2000 and 3000 meters (-72 hours)

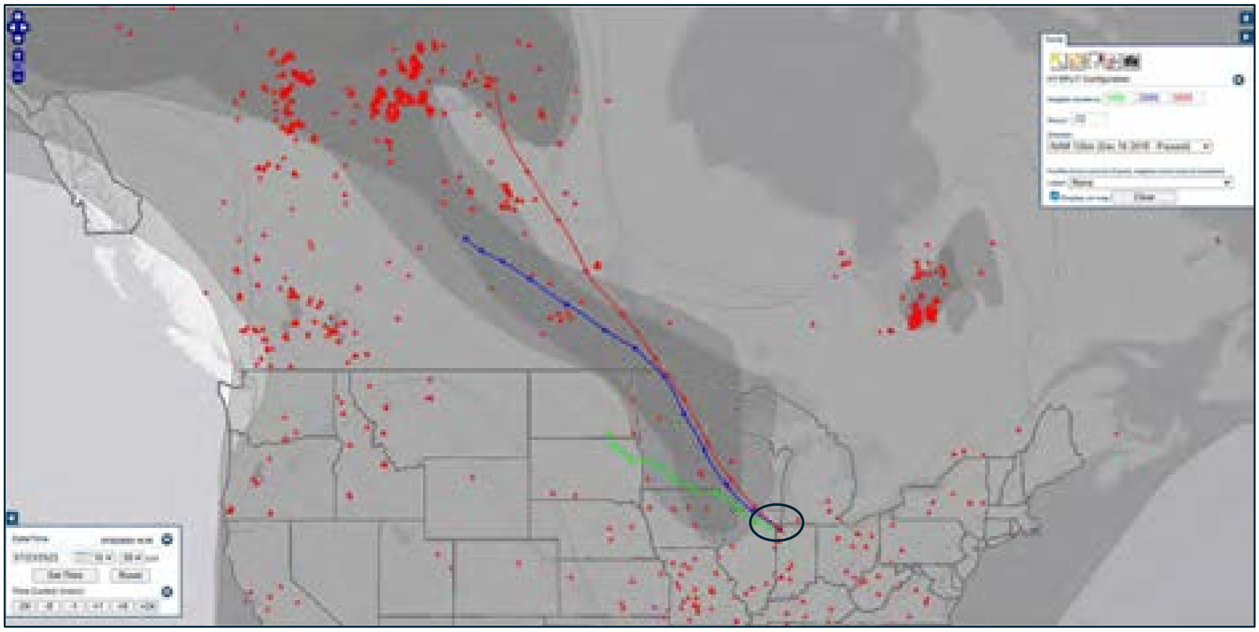


Figure 3.10.37 – Back Trajectories July 25, 2023: 1000, 2000 and 3000 meters (-72 hours)

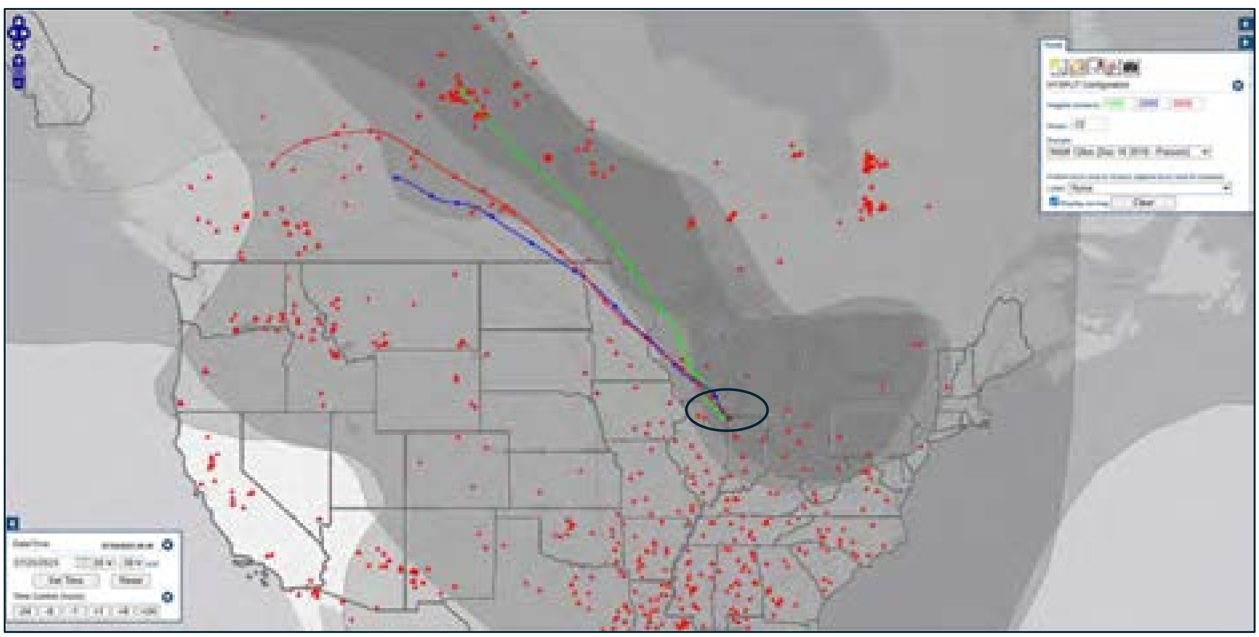


Figure 3.10.38 - Long-Range Back Trajectories from July 23, 2023 (100, 500 and 1000 meters - 168 hours)

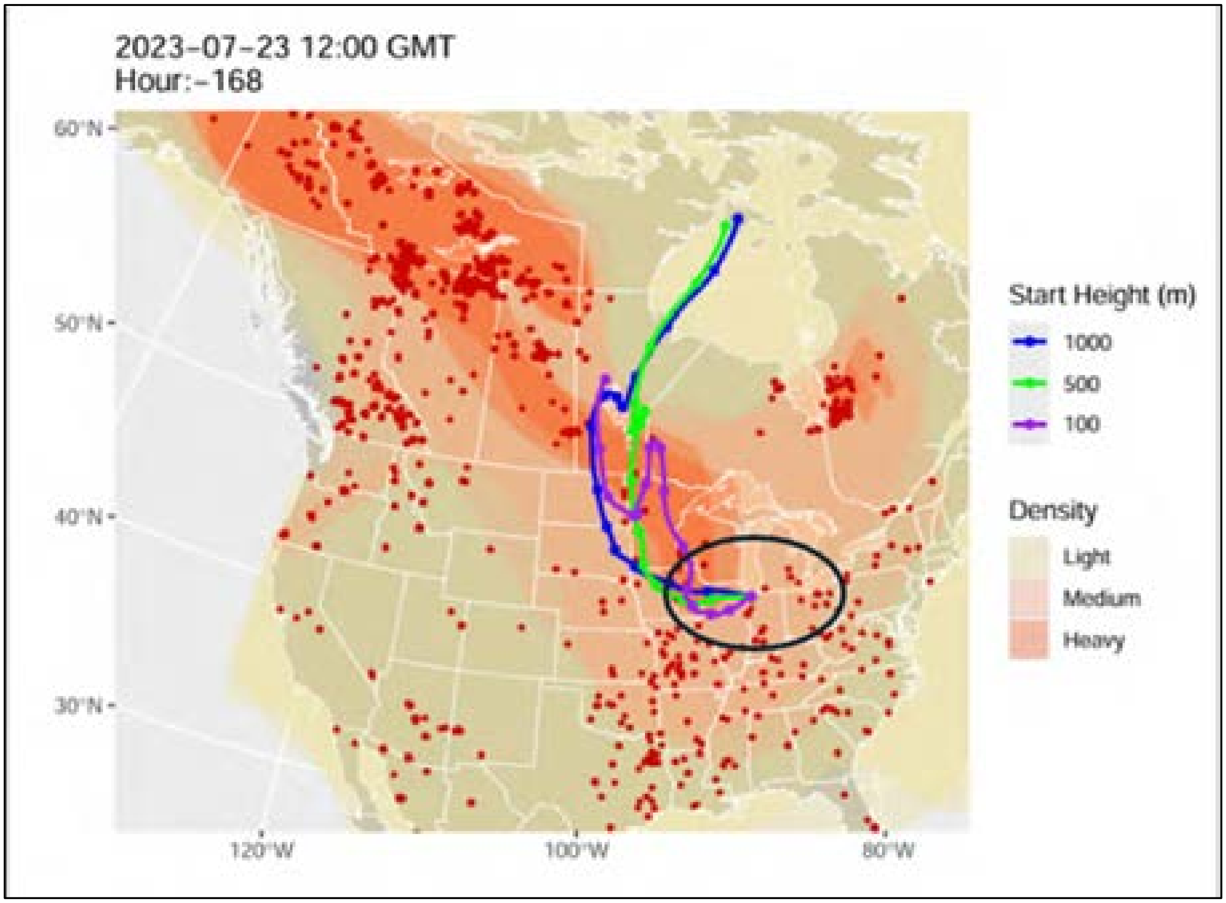
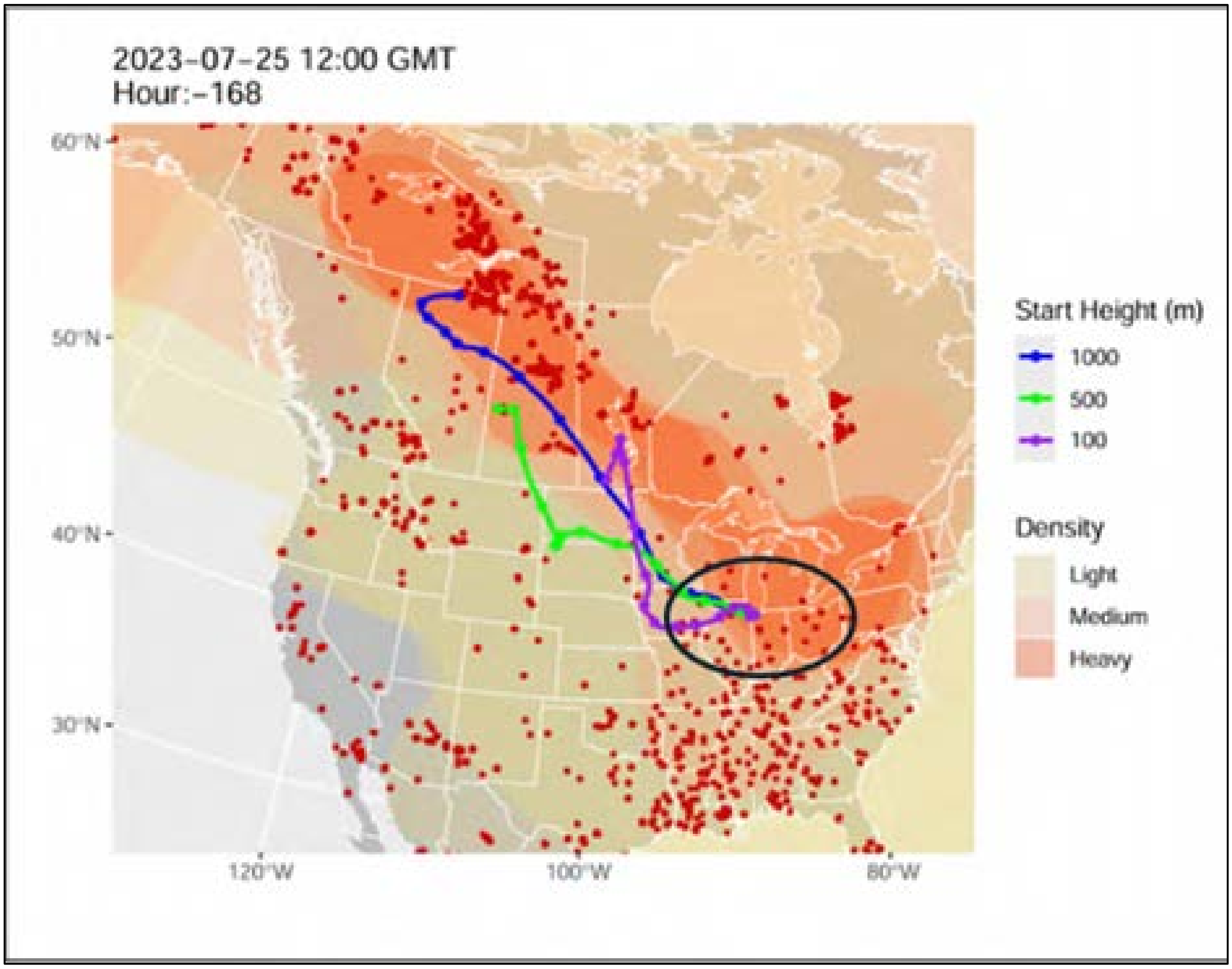


Figure 3.10.39 - Long-Range Back Trajectories from July 25, 2023 (100, 500 and 1000 meters - 168 hours)



3.10.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figures 3.10.40 and 3.10.41 indicate the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.10.40 HRRR Smoke Model – July 23, 2023

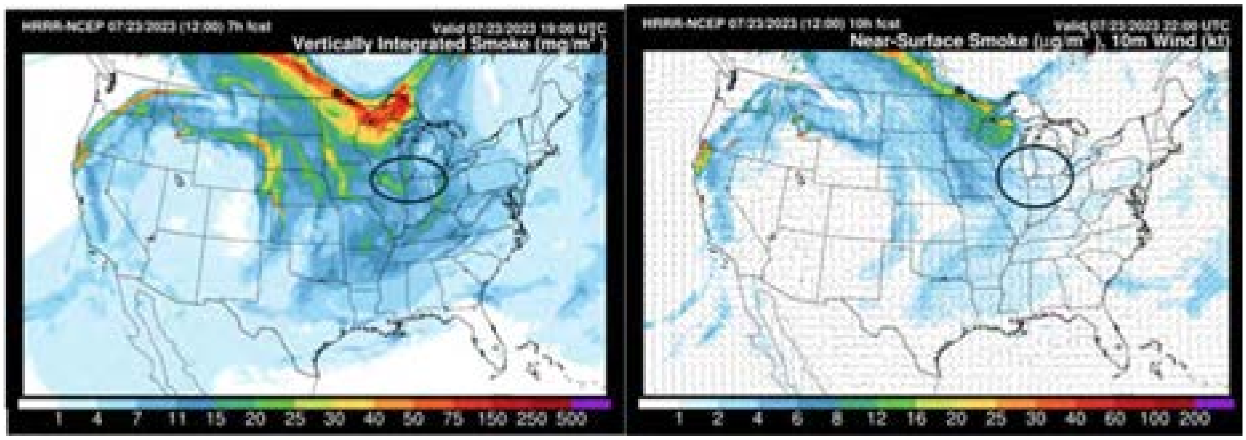
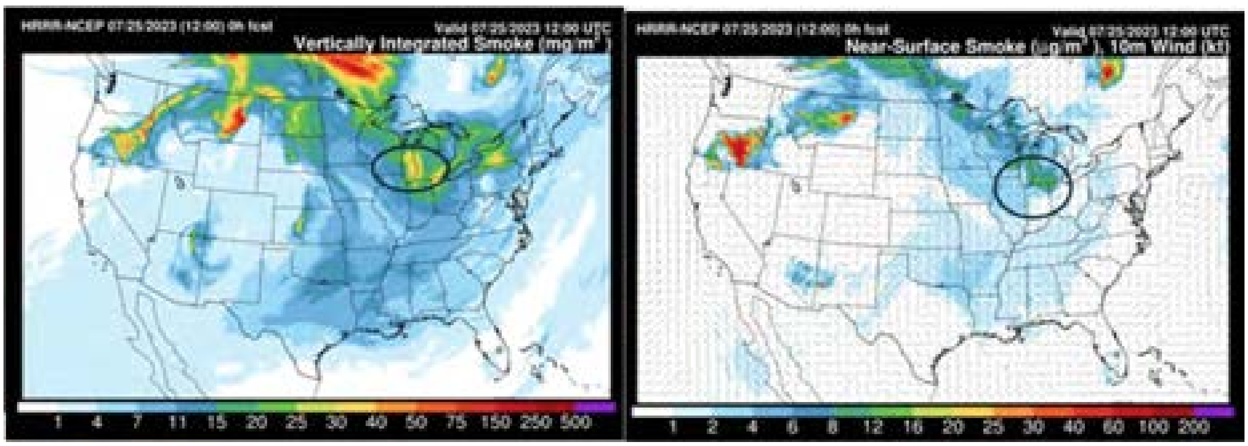


Figure 3.10.41 HRRR Smoke Model – July 25, 2023



3.10.12 Media Mentions

Why can't Canada just put the fires out? Here are 5 answers to key questions

Canadian wildfire smoke lingers, unhealthy air quality in most of SE Wisconsin

Wildfire smoke sparks Clean Air Action Day in West Michigan

Canadian wildfires burning land at record pace

Smoke from hundreds of Canadian wildfires blankets northern US cities with air pollution

3.10.13 Summary of Requested Exclusion of July 23 and 25, 2023

Table 3.10.6 - Summary Table - Gary IITRI

Event Date	July 23, 2023	July 25, 2023
MDA8 Ozone Concentration (PPB)	71	78
Does Ozone Concentration exceed the 95th Percentile?	Yes	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes	Yes
GAM predicted MDA8 ozone (PPB)	52.1	NA
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	8	7
Matching day MDA8 ozone (max., avg.) (PPB)	63.6, 54	81*, 55.5
HYSPLIT indicated wildfire regions	Shaw Fire, Smith Fire and Vermette Fire, Saskatchewan	
Do HRRR Models indicate smoke?	Yes	Yes
Media Mentions	Yes	Yes
Clear causal relationship established?	Yes	Yes

3.11 August 3, 2023

3.11.1 Executive Summary

On August 3, 2023, Northwest Indiana experienced ozone exceedances across three Lake and Porter County monitors (Table 3.11.1), with values ranging from 75-81 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM and EMBER analyses estimate 2-23 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to the Pembina Fire Complex, Alberta and St. Mary's River Fire, British Columbia.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of August 3, 2023, as an exceptional event under U.S. EPA guidelines.

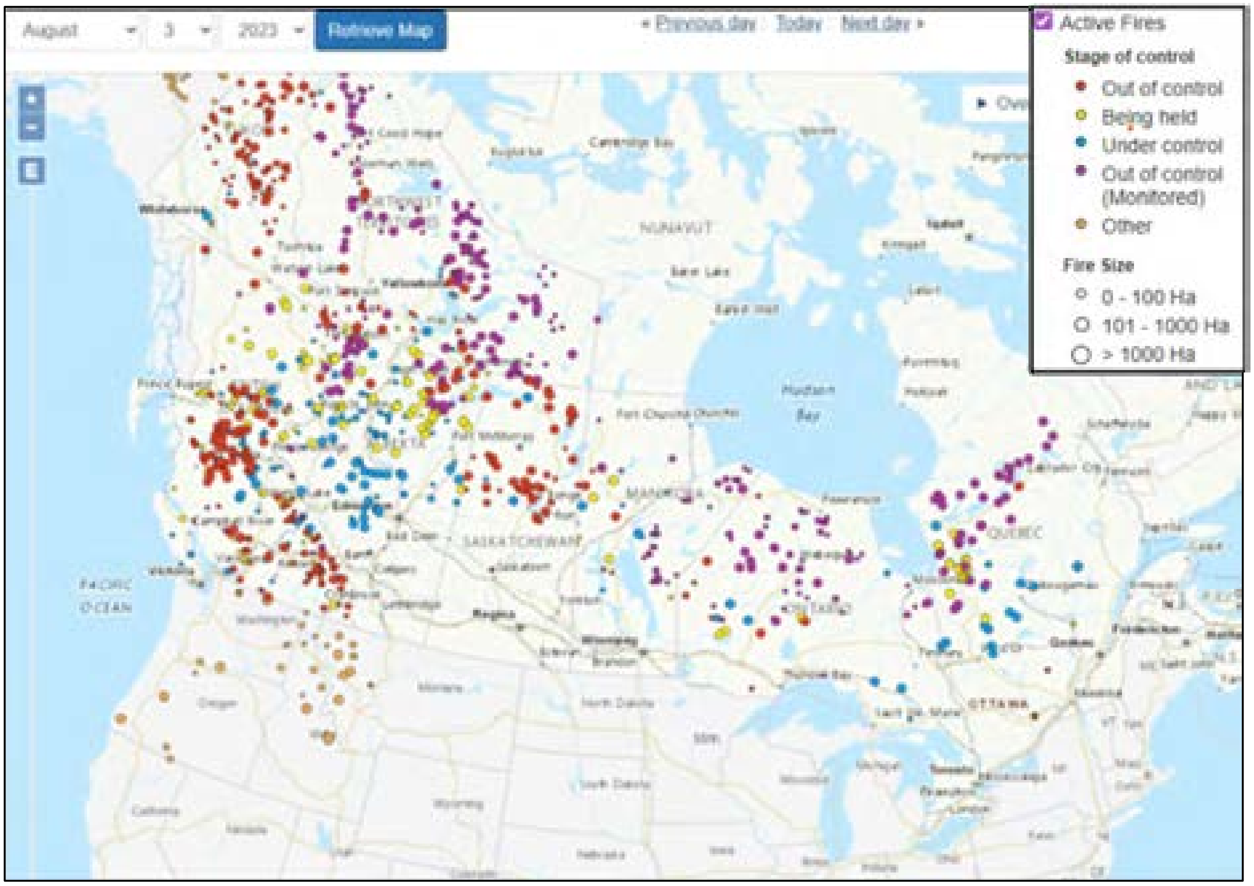
Table 3.11.1 August 3, 2023 Lake and Porter County MDA 8-Hour Ozone Values (ppb)

Date	Gary -IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
August 3, 2023	75	81	81	60

On August 3, 2023, multiple Canadian wildfires, as shown in Figure 3.11.1, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS Major contributors to the smoke plumes that reached Lake and Porter counties in August 2023 included:

- Pembina Fire Complex, which was first detected on May 4, 2023, this human-caused blaze was designated as a full-response incident. By mid-July, it had consumed approximately 216,197 acres (~87,500 hectares) under active suppression operations that included heavy equipment, aircraft, and extensive fireguard construction.
- St. Mary's River Wildfire, which was the most critical fire near Cranbrook, British Columbia burning approximately 4,640 hectares (roughly 46 square km) at its peak. The fire started on July 17, 2023, approximately 10 km northeast of Cranbrook, suspected to be caused by downed power lines during heavy winds.

Figure 3.11.1- Canadian Wildfires August 3, 2023

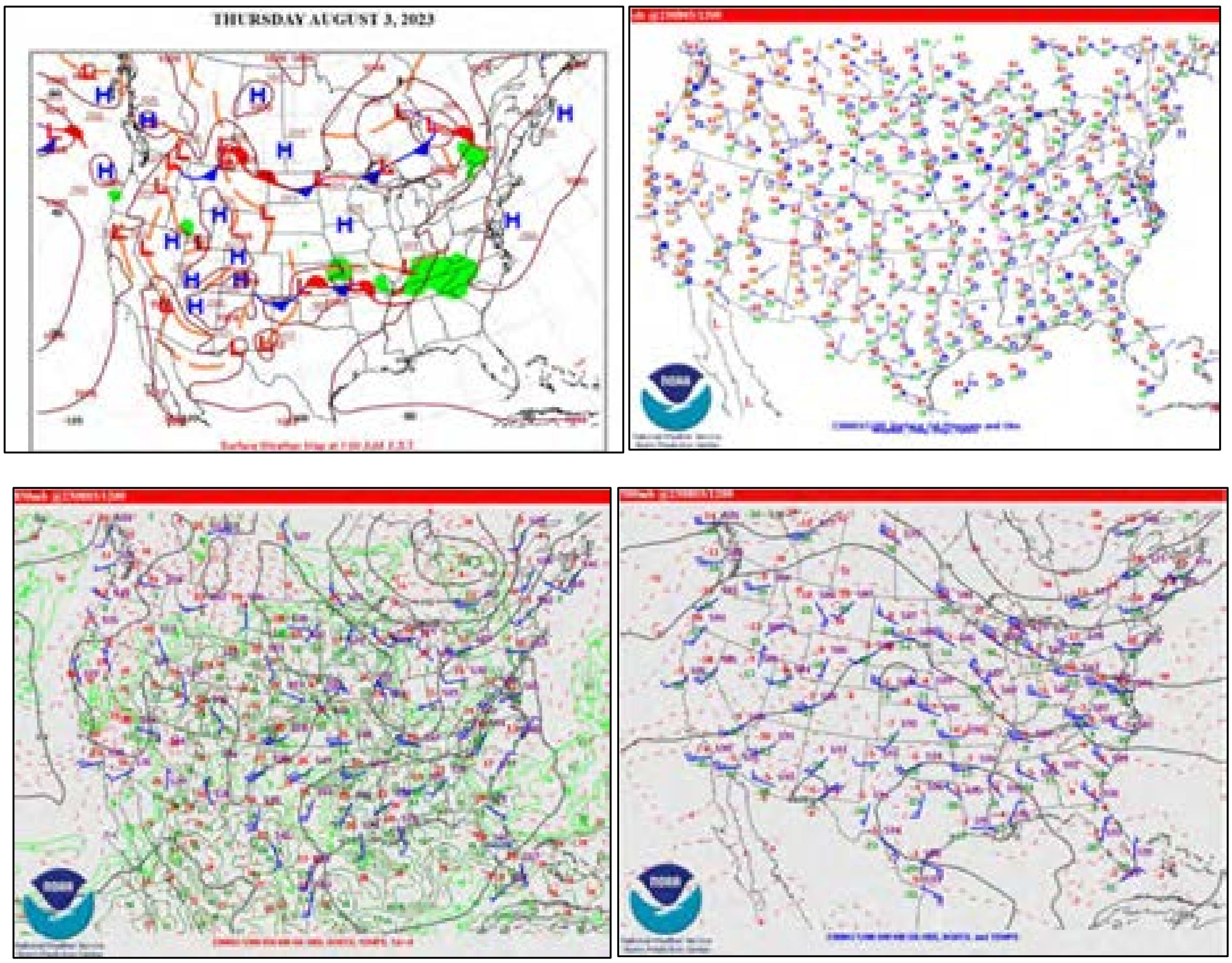


3.11.2 Meteorological Episode Overview

Broad upper air ridge was evident of the northern Plains on August 3 with deep upper air trough over the upper northeast portion of the U.S. This upper air configuration allowed wildfire smoke from the southwest Canada and northwest U.S. to be transported into the Midwest. A series of cold fronts, moving from the west-northwest to the east-southeast helped to transport and reinforce the wildfire smoke into the area. As surface fronts passed through the area, drier, smoke-filled air filtered into Lake and

Porter counties under sunny skies. Air temperatures remained in the upper 80's °F and relative humidity levels above 40% and light southwest winds at the surface. Remnant light smoke was recirculated through the Midwest and additional smoke from the southwest Canadian and northwest U.S. fires was transports aloft, enhancing the elevated levels of ozone throughout the area under sunny skies. This weather pattern remained in place for several days as fronts brought more smoke into northwest Indiana. Figure 3.11.2 shows the surface, 850 mb and 500 mb maps of the weather conditions on August 3.

Figure 3.11.2 - Surface, 850 and 500 mb Plots from 12Z on August 3, 2023



Wind rose (Figure 3.11.3) and pollution rose (3.11.4) analyses were taken from the Gary IITRI meteorological station. Wind directions on August 3 were primarily from the northeast, southwest and southeast. The pollution rose, using Ogden Dunes ozone, indicates that the highest ozone readings were from the northeast, as smoke continued to be transported into Lake and Porter counties, contributing to ozone production. Figure 3.11.5 shows the hourly distribution of wind directions throughout the day, with prolonged smoke transport from the ongoing wildfires in western Canada, the Pacific Northwest US and Alaska.

Figure 3.11.3- Gary IITRI Windrose

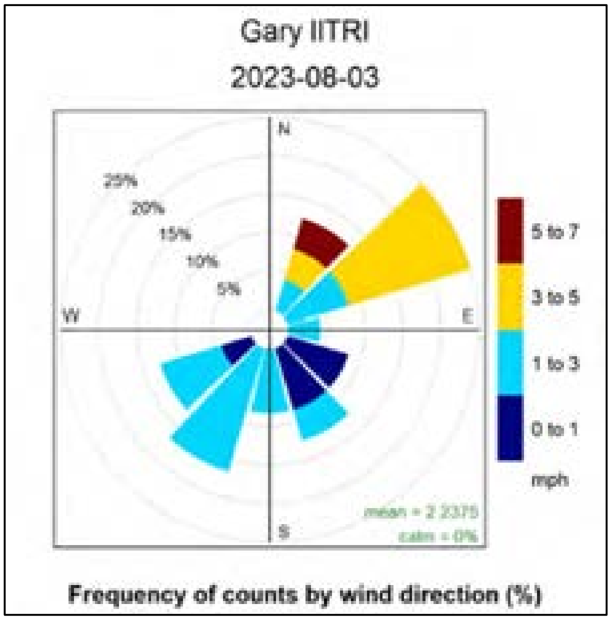


Figure 3.11.4 Gary ITRII Pollution Rose

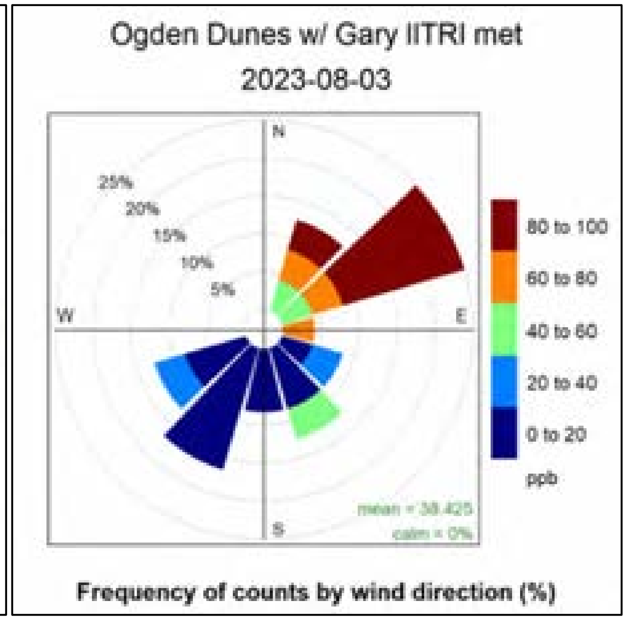


Figure 3.11.5 - Hourly Wind Directions at Gary IITRI for August 3, 2023

3.11.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for August 3, 2023 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.11.6 for Gary IITRI, Figure 3.11.7 for Hammond and Figure 3.11.8 for Ogden Dunes. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.11.6 - Ozone Diurnal Pattern for Gary IITRI- August 3, 2023

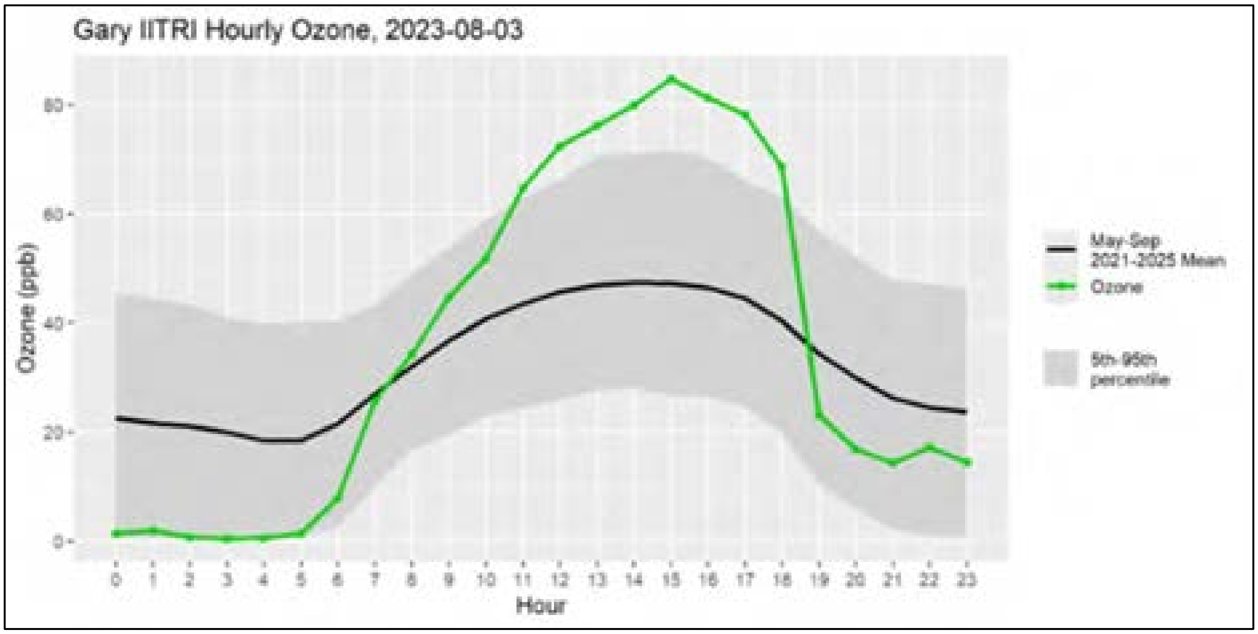


Figure 3.9.7 - Ozone Diurnal Pattern for Hammond - August 3, 2023

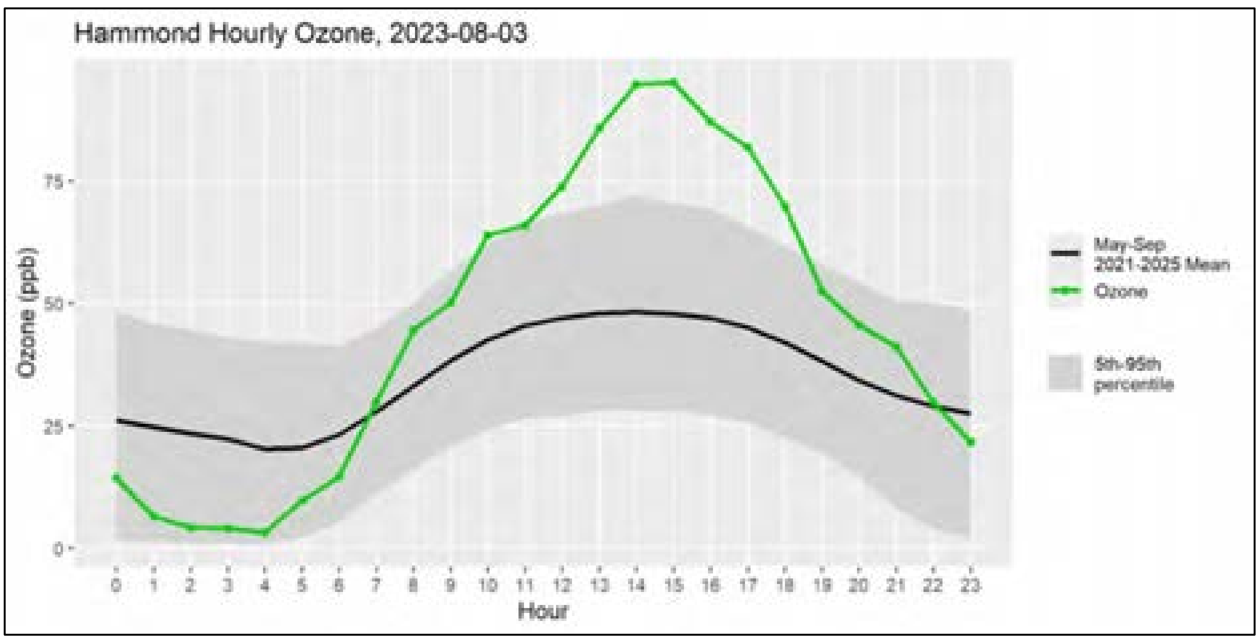
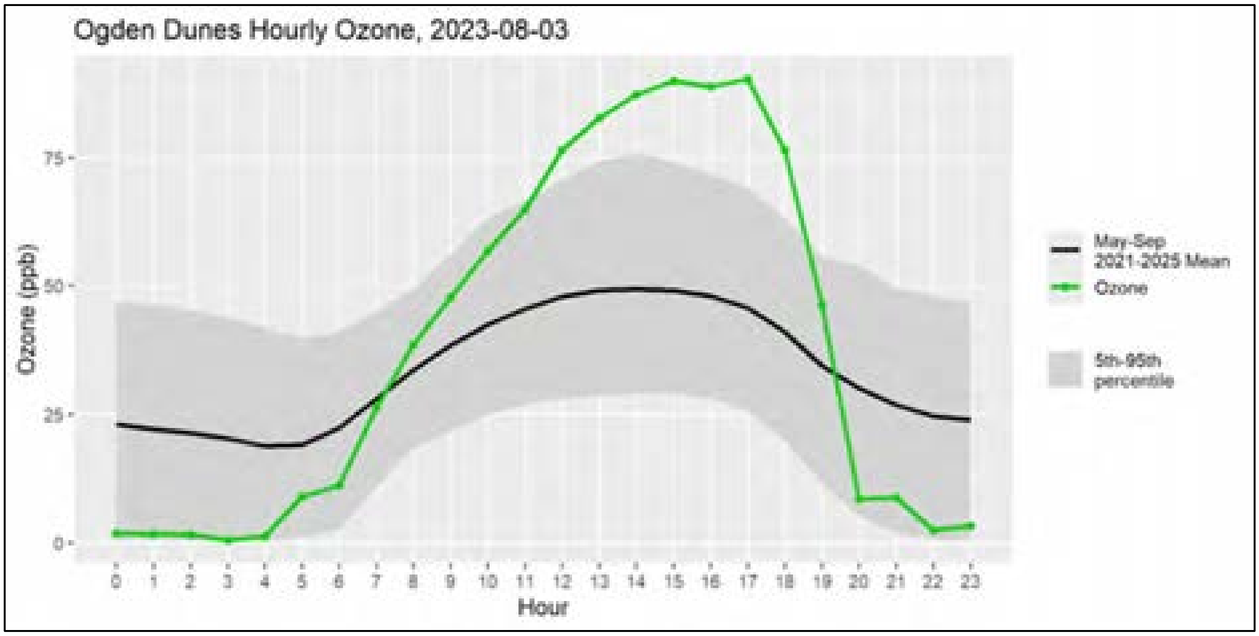
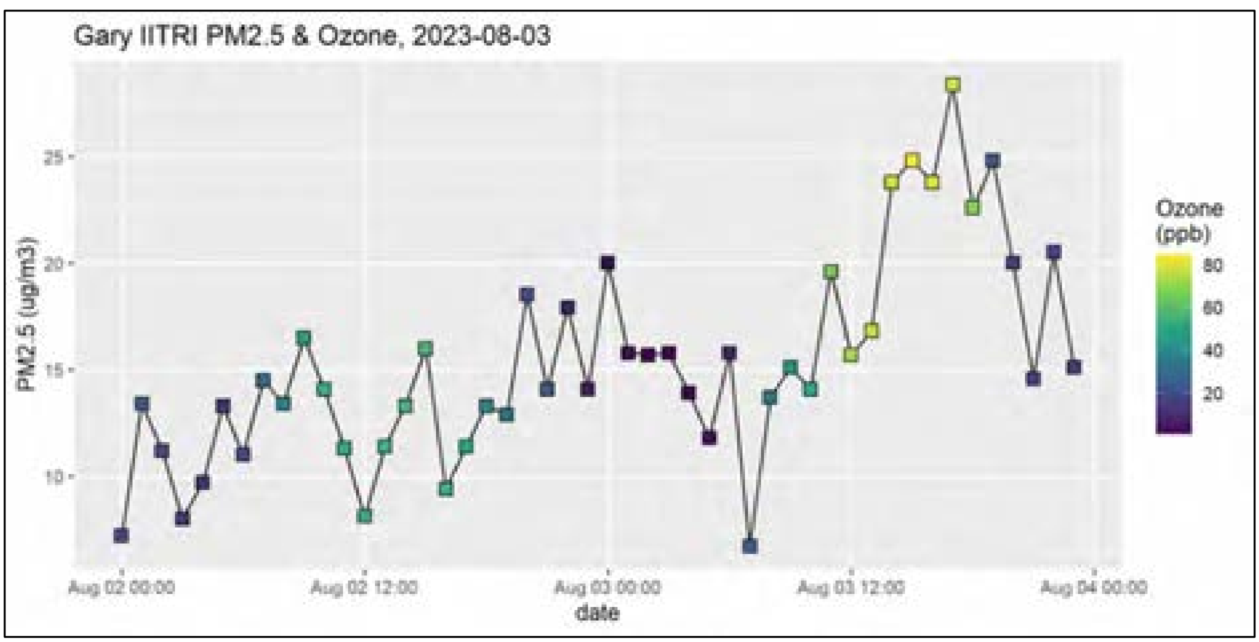


Figure 3.9.8 - Ozone Diurnal Pattern for Ogden Dunes - August 3, 2023



Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for August 3 as shown in Figure 3.11.9. $PM_{2.5}$ concentrations ranged from 12 - 30 µg/m^3.

Figure 3.11.9 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data August 3, 2023



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.11.2 shows the percentage above the five-year average. All three pollutants were well above the average, pointing to the presence of wildfire smoke.

Table 3.11.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
8/3/2023	104%	162%	241%

3.11.4 AOD and Satellite Analyses

Figure 3.11.10 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of smoke.

Figure 3.11.10- Aerosol Optical Depth (AOD) August 3, 2023

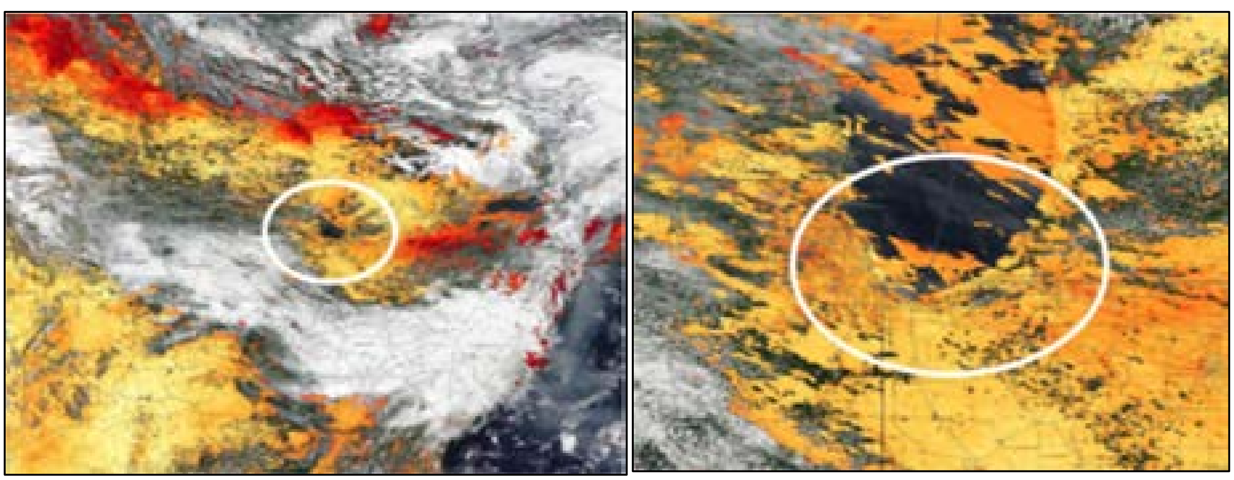
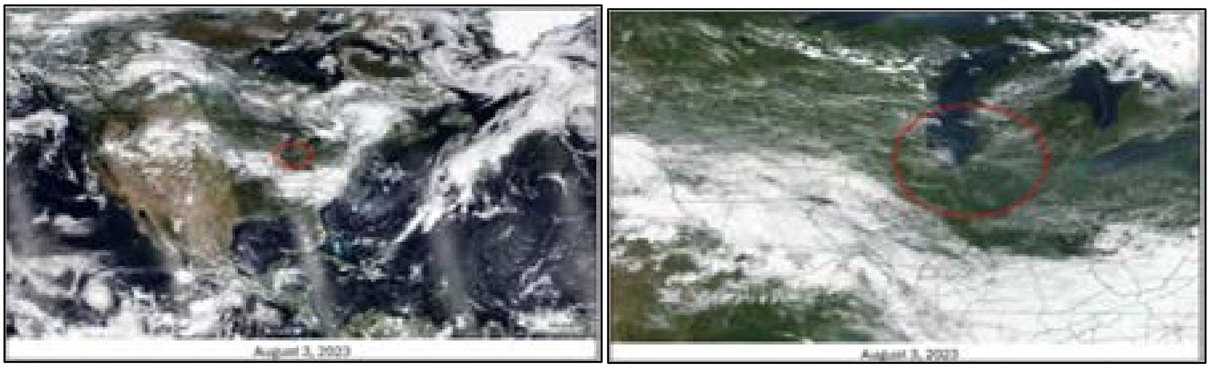


Figure 3.11.11 shows the satellite images captured by NOAA's GOES 18 satellite images of North America taken August 3, 2023 shows smoke extending from western Canada to the upper Midwest states as the northern hemisphere (left) and upper Midwest (right) images. Credit: NOAA NESDIS

Figure 3.11.11 - Satellite Imagery August 3, 2023



3.11.5 NOAA Smoke Narrative

Wednesday, August 3, 2023

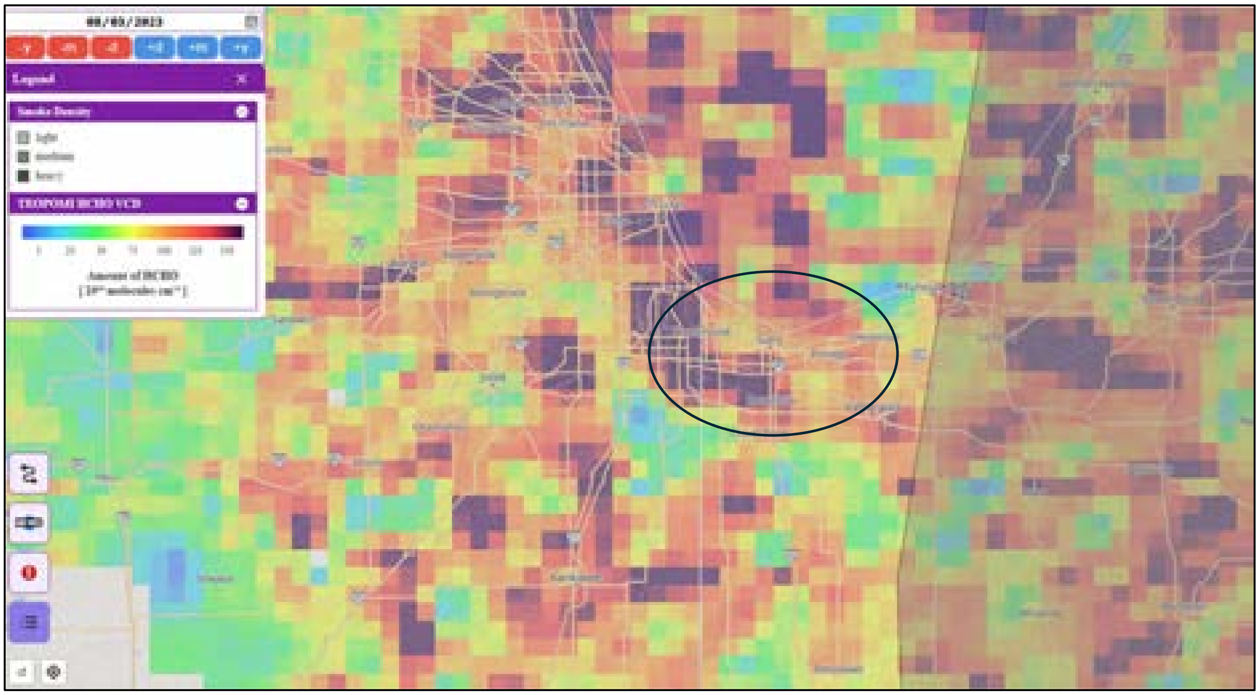
DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1700Z August 3, 2023

SMOKE:
United States, including Alaska, Canada, Atlantic Ocean and North Pacific Ocean….
Fires over western Canada, the Pacific Northwest of the United States and Alaska were producing a very large area of smoke that continues to be seen over most of the Eastern, Central and Northwest portions of the United States, most of Canada, eastern Alaska, the Atlantic Ocean and portions of the North Pacific Ocean. Within this area a very large area of moderate density smoke was seen over much of northwestern and central Canada to as far east as western Quebec. Areas of the highest density smoke were seen along the coastline of the Eastern United States extending from the New York City area south to near Norfolk, over southern Alberta and central Saskatchewan and also over northern portions of the Northwest Territories.

3.11.6 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.11.12 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 7-18 × 10^{15} molecules/cm^2 indicate strong to extreme wildfire smoke influence.

Figure 3.11.12 - TROPOMI Satellite Daily Formaldehyde Monitoring



3.11.7 AirNow Smoke Maps

AirNow shows in Figures 3.11.13 through 3.11.16 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.11.13 - AirNow Smoke Ozone and $PM_{2.5}$ - August 3, 2023

Figure 3.11.14 - AirNow Ozone Map - August 3, 2023

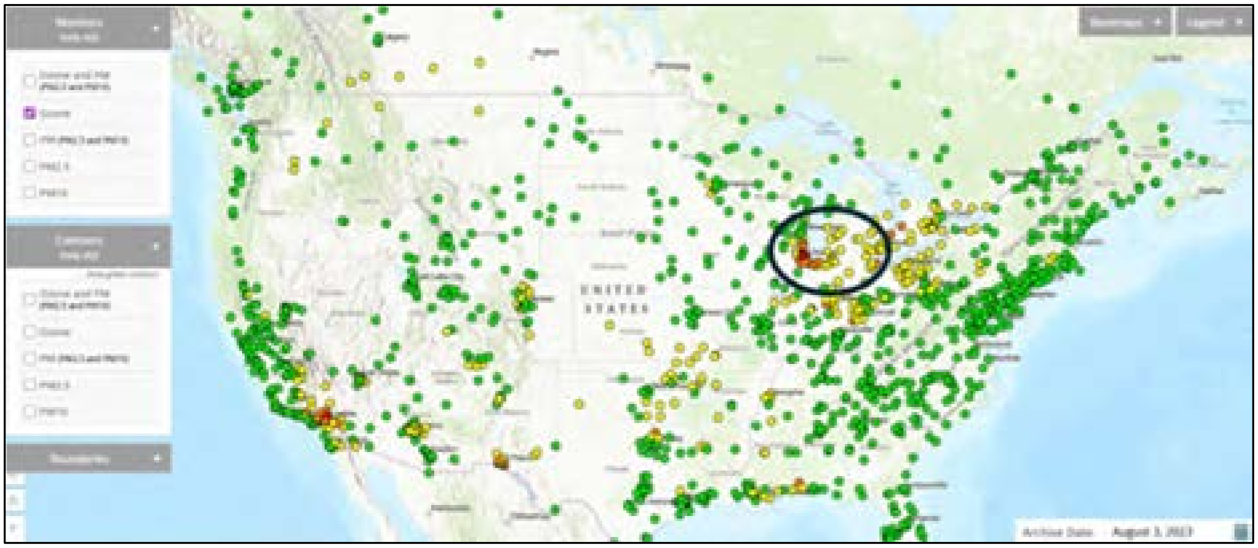


Figure 3.11.15 - AirNow $PM_{2.5}$ Map - August 3, 2023

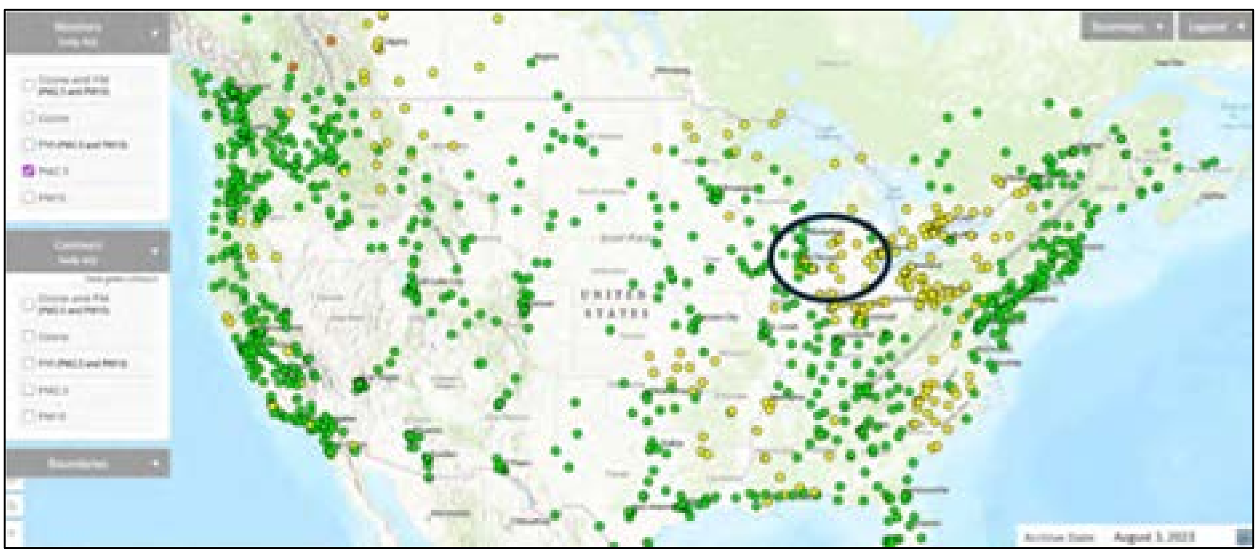
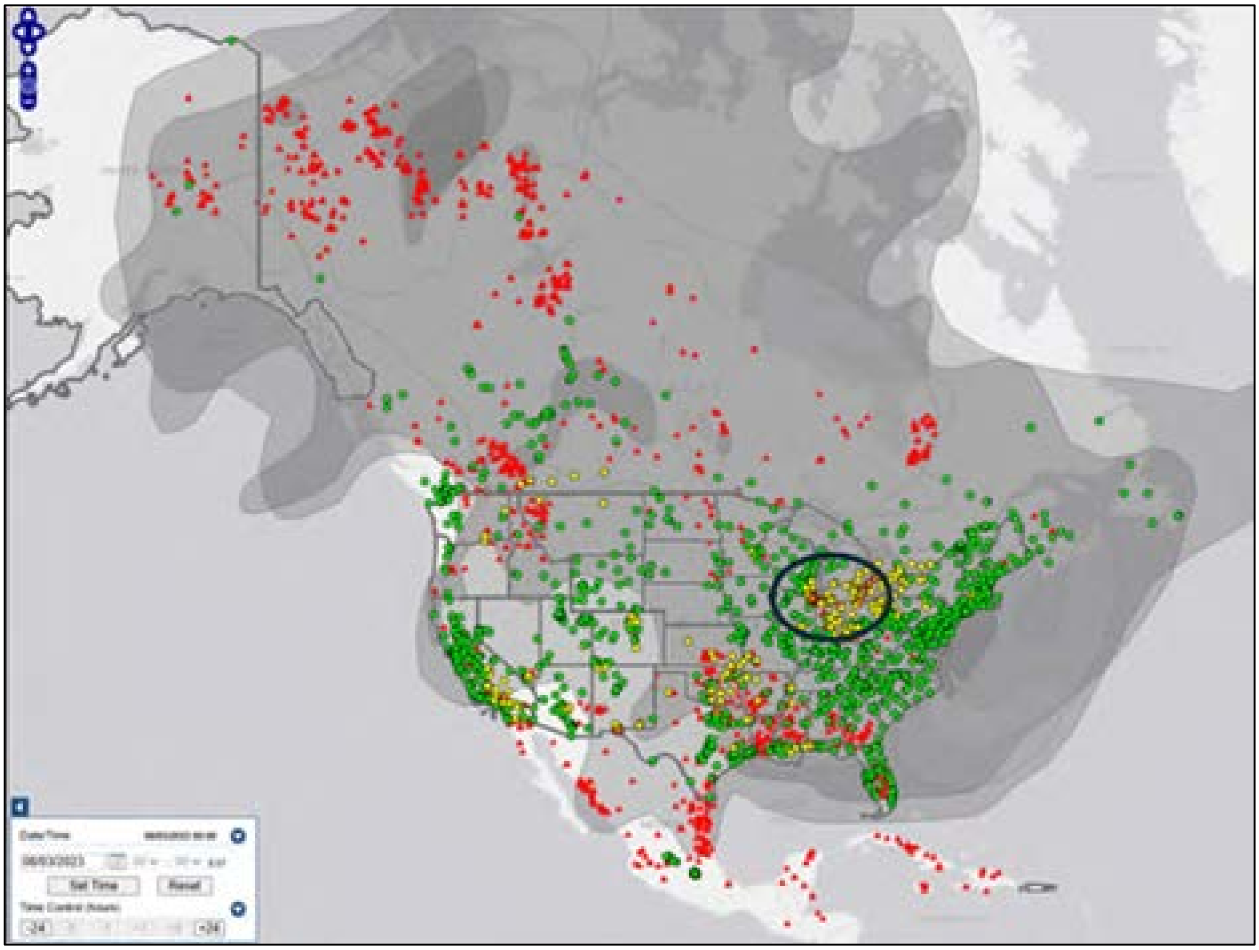


Figure 3.11.16 - AirNow Smoke and Ozone Map - August 3, 2023



3.11.8 Statistical Modeling Analyses

Figures 3.11.17 through 3.11.19 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER. Northwest Indiana is indicated by the black circles on each of the maps.

Figure 3.11.17 - GAM Smoke Maps Indicating Smoke Days - August 3, 2023

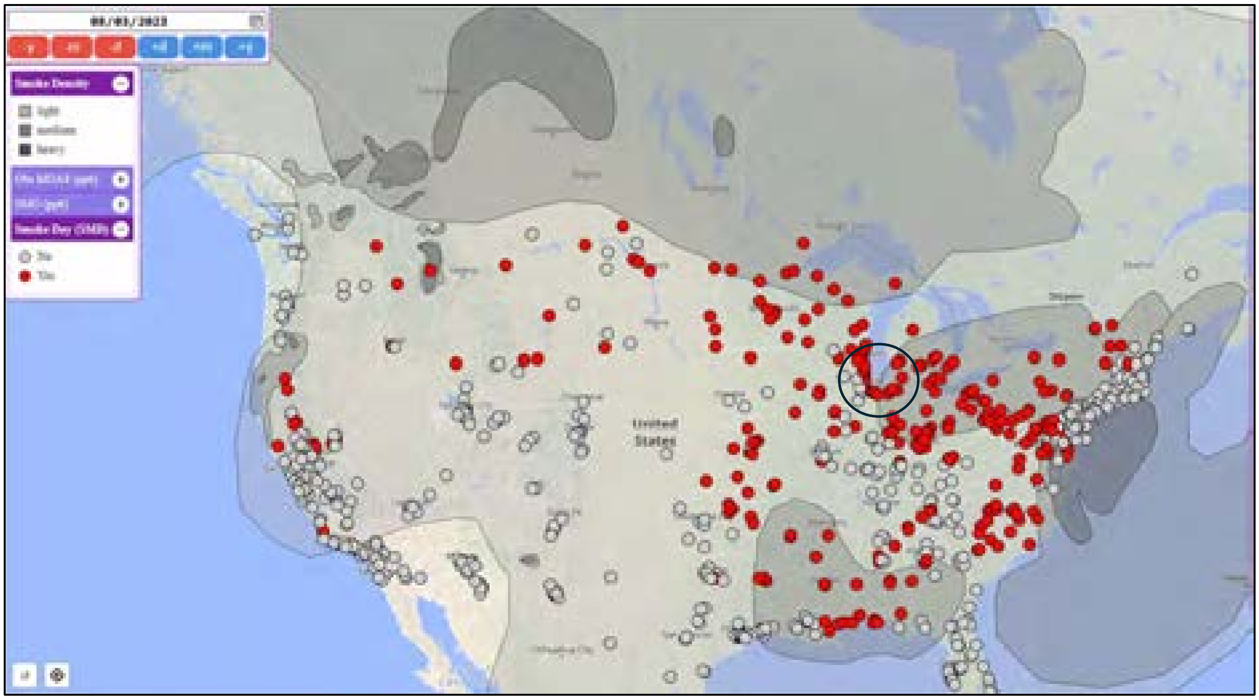


Figure 3.11.18 - GAM Observed Ozone with Smoke Days - August 3, 2023

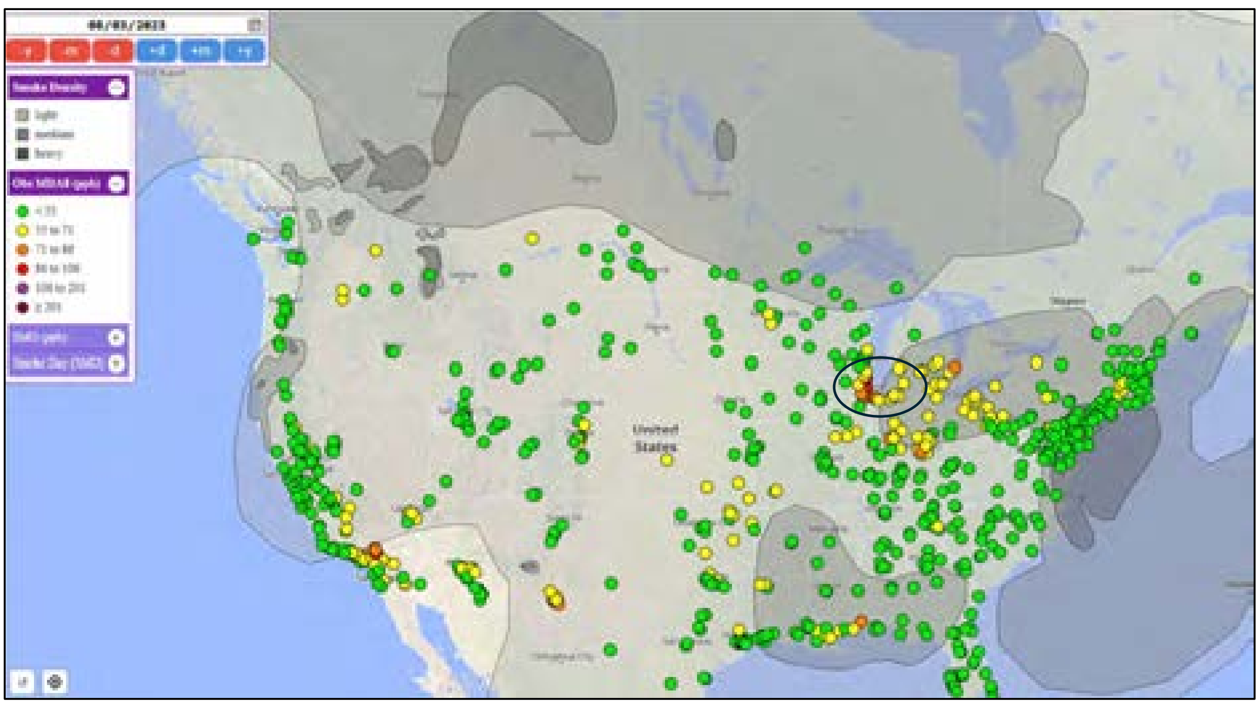


Figure 3.11.19 - GAM Smoke Estimates - August 3, 2023

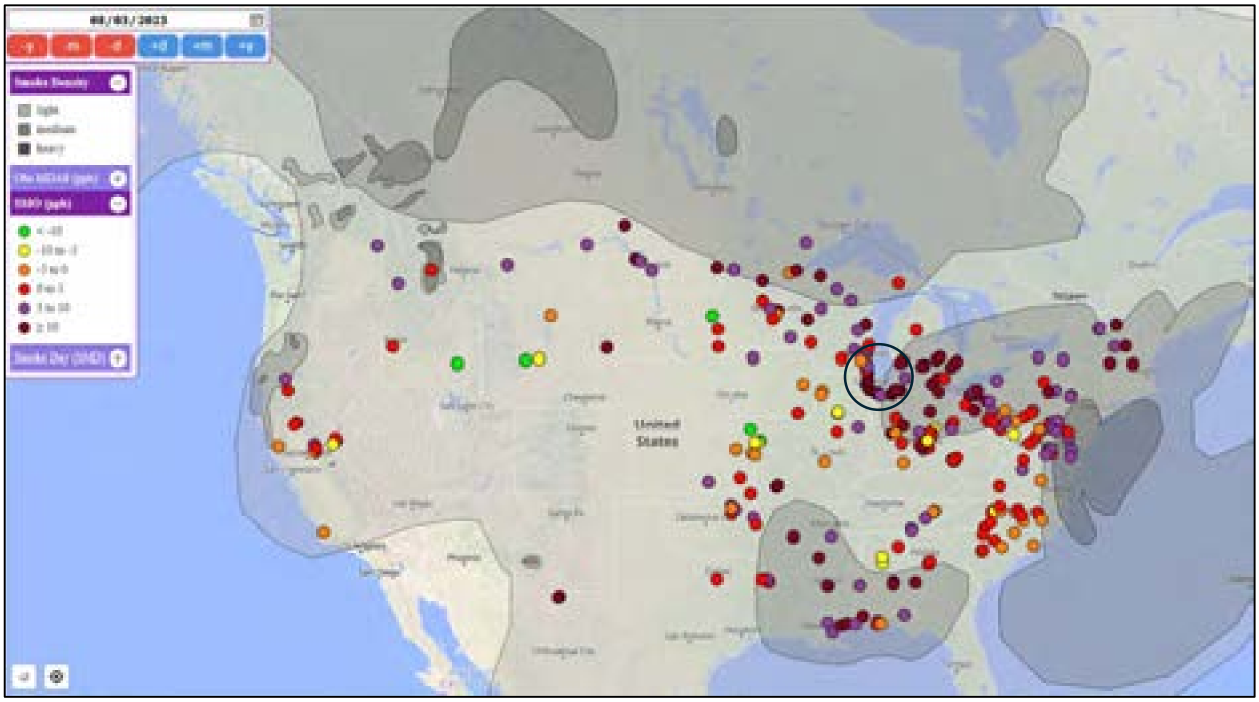


Figure 3.11.20 - EMBER Smoke Estimates - August 3, 2023

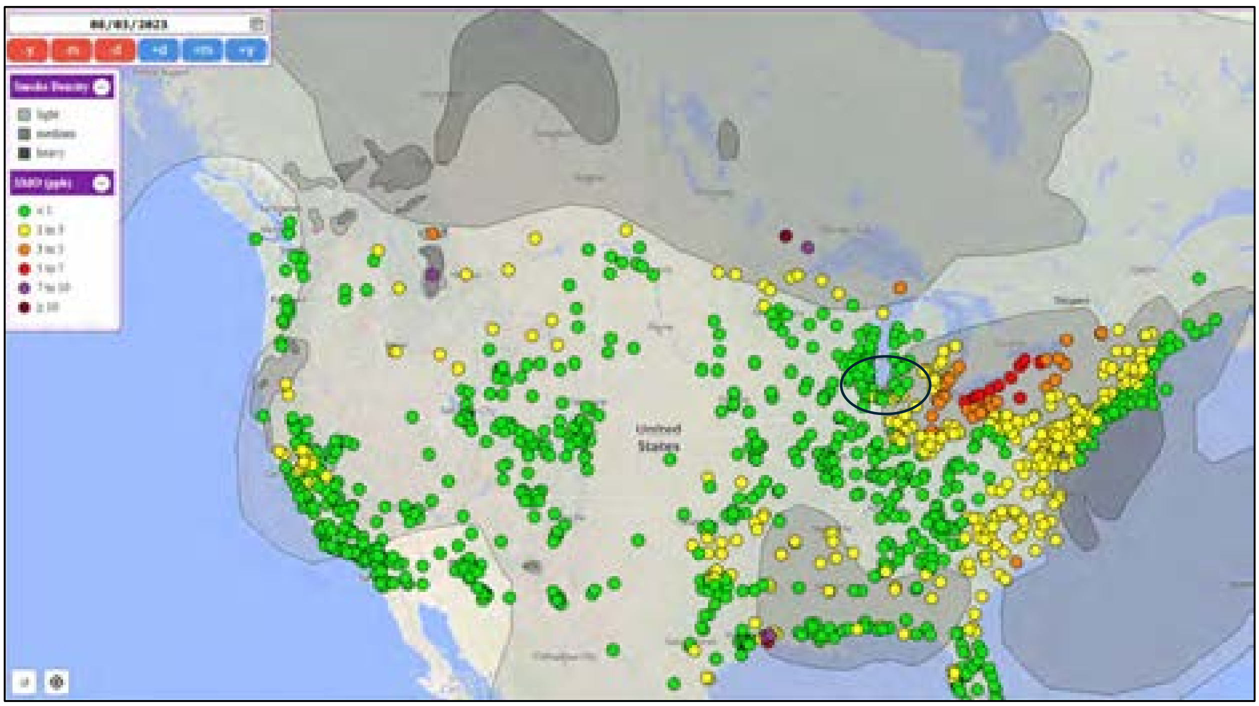


Table 3.11.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.11.3 - Observed versus GAM/EMBER Predicted MDA 8-hour Ozone Values August 3, 2023

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	75	61.8	13.2	66	9
180892008	Hammond	81	NA	NA	79	2
181270024	Ogden Dunes	81	58.1	22.9	66	15
181270026	Valparaiso	60	54.7	5.3	64	-4

3.11.9 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on August 3, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.11.4 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 17 ppb lower than the MDA8 ozone concentrations observed on August 3, with the maximum matching day MDA8 ozone concentration of 75 ppb.

Table 3.11.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values August 3, 2023

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	81	75*	64.2

* Indicates Matching days were influenced by wildfire smoke

3.11.10 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this $PM_{2.5}$ event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. Figure 3.11.21 shows the trajectories at three starting heights, 50 m (green), 100 m (blue), and 500 m (red). Figure 3.11.22 is at higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. These trajectories use the NAM 12 km dataset. The HMS smoke layers become less opaque as the density of smoke increases. August 3 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure 3.11.23 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) have the upper air being directly over the wildfires in Manitoba, and British Columbia. These long-term trajectories use the Reanalysis data set. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.11.21 – Back Trajectories August 3, 2023: 50, 100 and 500 meters (-72 hours)

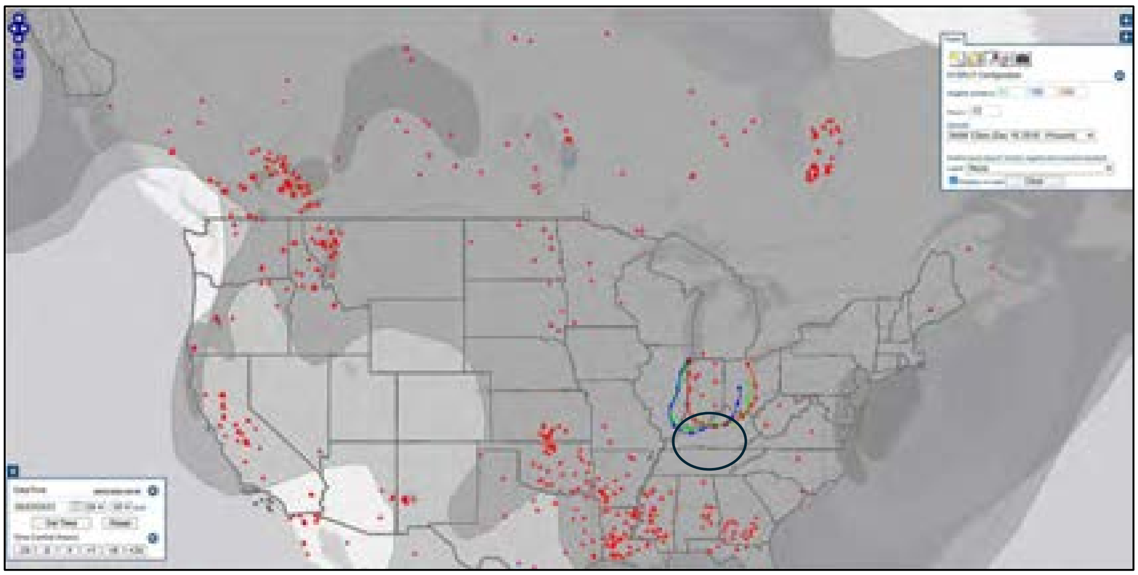


Figure 3.11.22 – Back Trajectories August 3, 2023: 1000, 2000 and 3000 meters (-72 hours)

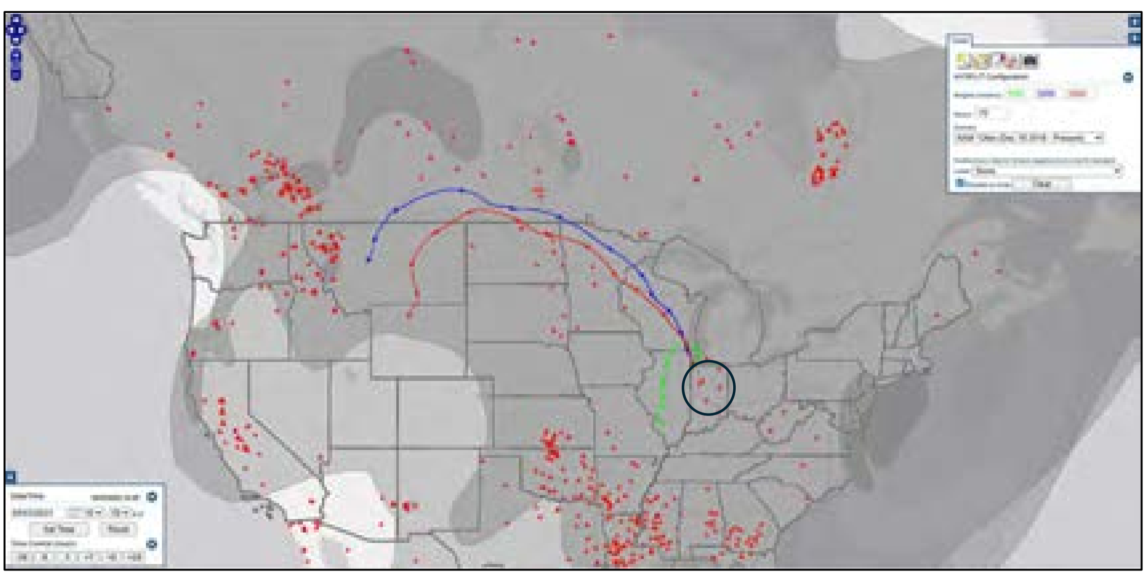
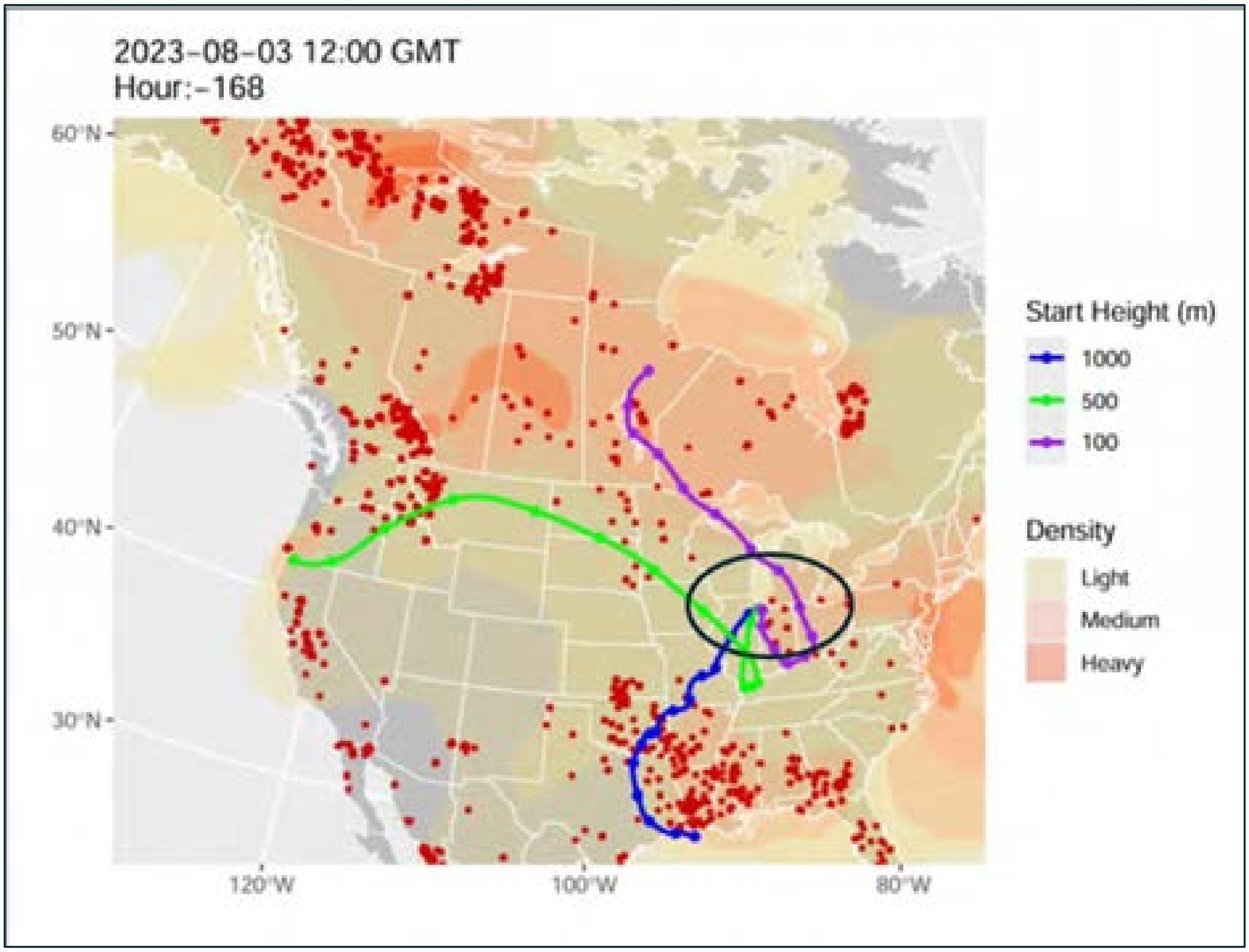


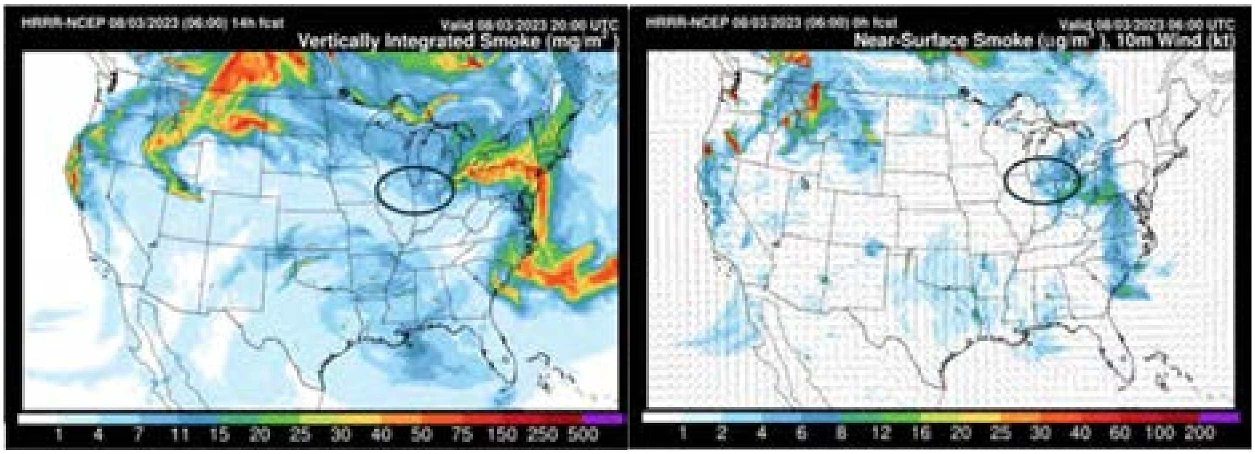
Figure 3.11.23 - Long-Range Back Trajectories from August 3, 2023 (100, 500 and 1000 meters - 168 hours)



3.11.11 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.11.24 indicates the vertically integrated smoke column map on the left and the near surface smoke map on the right.

Figure 3.11.24 HRRR Smoke Model – August 3, 2023



3.11.12 Media Mentions

Wildfire Smoke from Canada Blankets the U.S. Midwest in Haze of Bad Air Quality

Canada On Fire

Provincial Wildfire Status Update – July 24, 2023

Air quality alert issued for NW Indiana due to ozone, wildfire smoke

Cranbrook, B.C., airport reopens after cancelling flights due to nearby wildfire

3.11.13 Summary of Requested Exclusion of August 3, 2023

Table 3.11.5 - Summary Table - Gary IITRI

Event Date	August 3, 2023
MDA8 Ozone Concentration (PPB)	75
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	NA
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone (PPB)	61.8
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	9
Matching day MDA8 ozone (max., avg.) (PPB)	75*, 64.2
HYSPLIT indicated wildfire regions	Pembina Fire Complex, Alberta and St. Mary's River
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

3.12 June 11 – 12, 2025 Ozone Event

3.1.12 Executive Summary

On June 11 and 12 2025, Northwest Indiana experienced ozone exceedances across a portion of the Lake and Porter County monitors, with high ozone values ranging from 73-77 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM analyses estimate 6 - 15 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to the Shoe/Camp Fire, Saskatchewan, and Flin Flon Fire, Manitoba.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of June 11 and 12, 2025, as an exceptional event under U.S. EPA guidelines.

Table 3.12.1 June 11, 2025 Lake and Porter County MDA 8-Hour Ozone Values (PPB)

Date	Gary -IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
June 11, 2025	68	77	69	68

Table 3.12.2 June 12, 2025 Lake and Porter County MDA 8-Hour Ozone Values (PPB)

Date	Gary -IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
June 12, 2025	67	68	76	73

On June 11-12, 2025 multiple Canadian wildfires, as shown in Figures 3.12.1 and 3.12.2, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in June 2025 included the:

- Shoe Fire and the Camp Fire, which were among the largest in Canada in 2025. These fires burned from early-May through mid-August, burning over 565,000 hectares (approximately 1.4 million acres) at their peak.
- "Flin Flon Fire" (WE017), which originated near Creighton, Saskatchewan, and quickly crossed the border into Manitoba, growing into a massive complex that eventually scorched over 515,000 hectares.

Figure 3.12.1 – Canadian Wildfires June 11, 2025

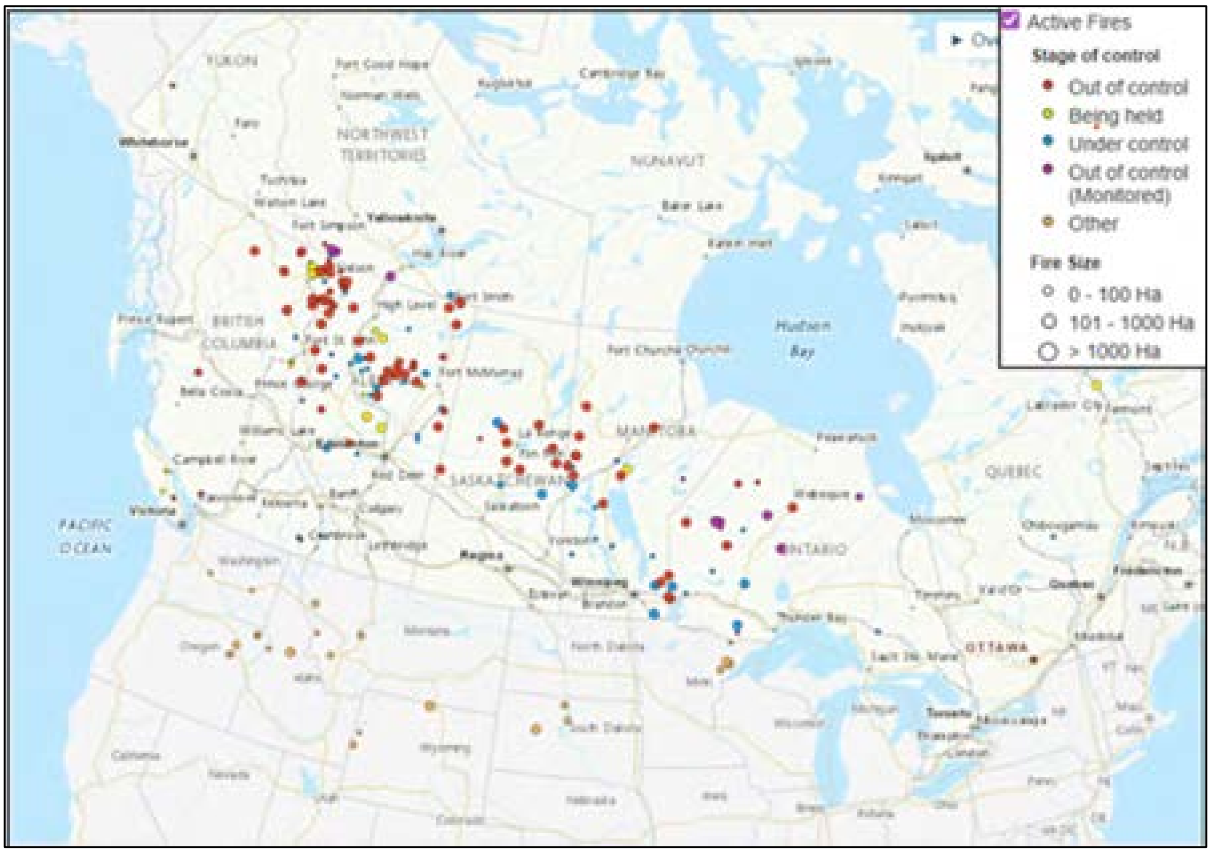
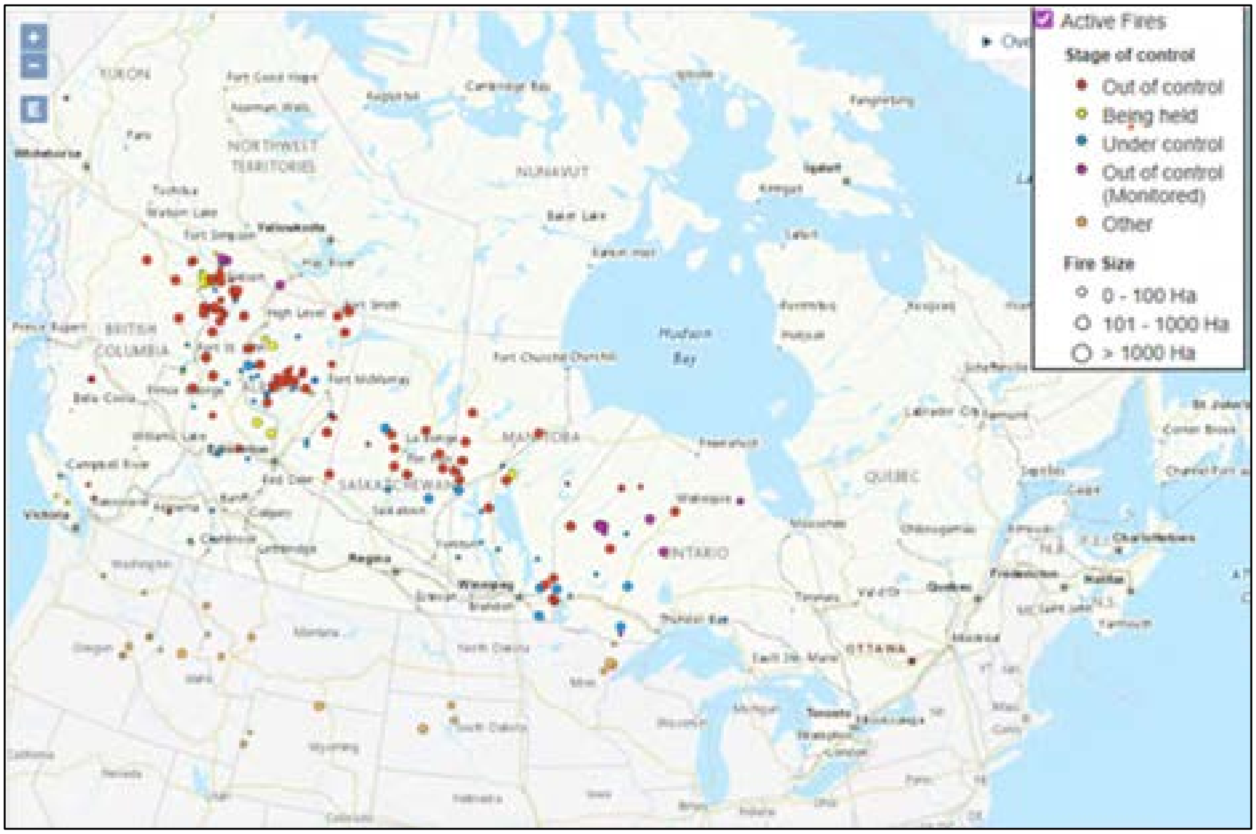


Figure 3.12.2 – Canadian Wildfires June 12, 2025



3.12.2 Meteorological Episode Overview

Zonal flow was evident over the western half of the U.S. while a broad upper air trough was present over the northeast U.S. on June 11. This upper air set up was key in transporting wildfire smoke from western and central Canadian provinces of British Columbia, Alberta, Saskatchewan and Manitoba. A cold front moving from the west-northwest to the east-southeast helped to transport and reinforce the wildfire smoke from the wildfires in those Canadian provinces into the northwest Indiana area. Out ahead of the front, sunny skies with air temperatures in the mid and upper 80's °F and lower humidity levels helped make conducive ozone conditions. The smoke was persistent throughout the vertically integrated and near surface forecast maps on June 11 and June 12. The presence of this light to moderate smoke produced elevated levels of ozone throughout the northern portion of Indiana. This weather pattern remained in place for several days as fronts brought more smoke into northwest Indiana. Figure 3.12.3 shows the surface, 850 mb and 500 mb maps of the conditions on June 11 and Figure 3.12.4 shows surface, 850 mb and 500 mb maps of the conditions on June 12.

Figure 3.12.3 - Surface, 850 and 500 mb Plots from 12Z on June 11, 2025

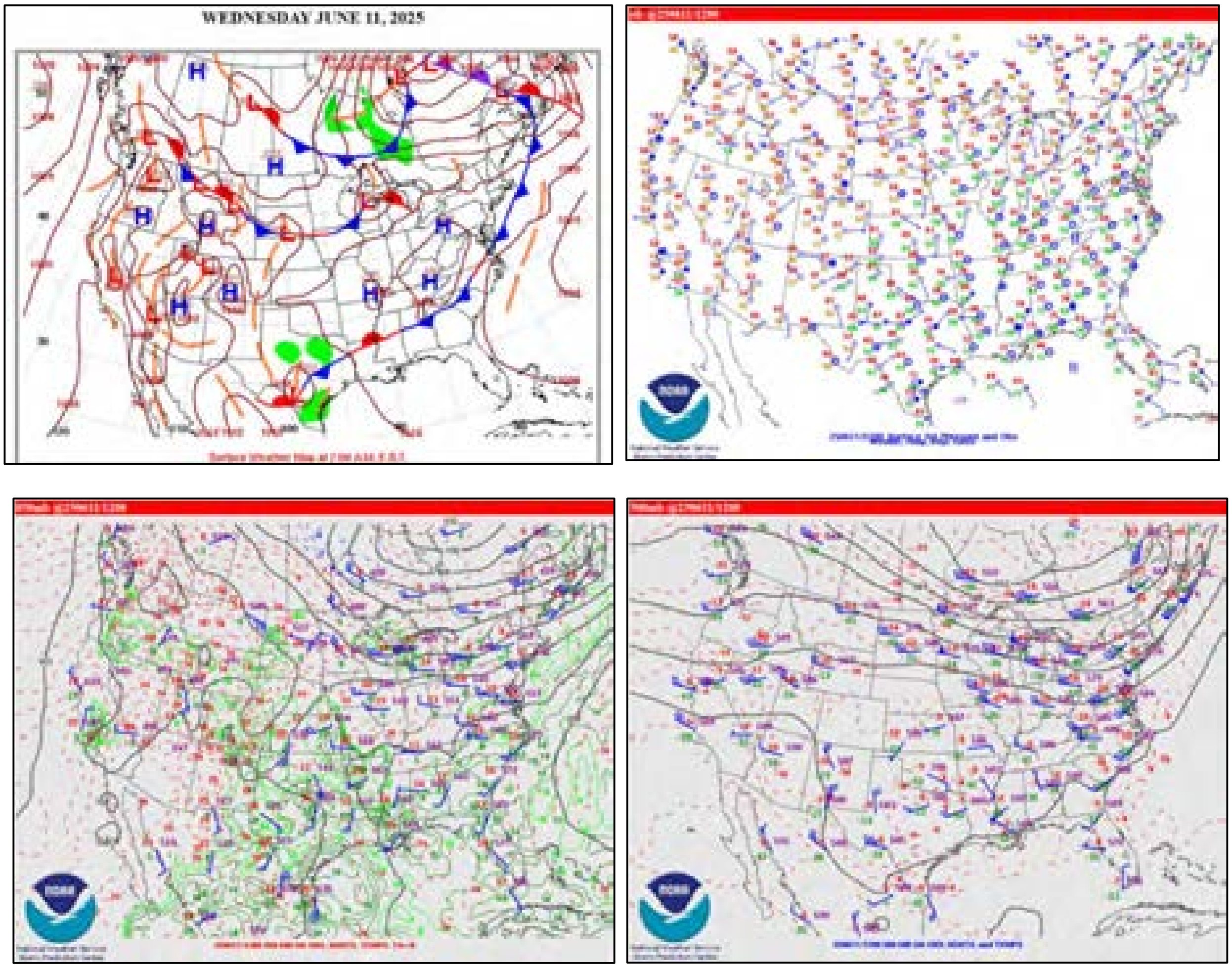
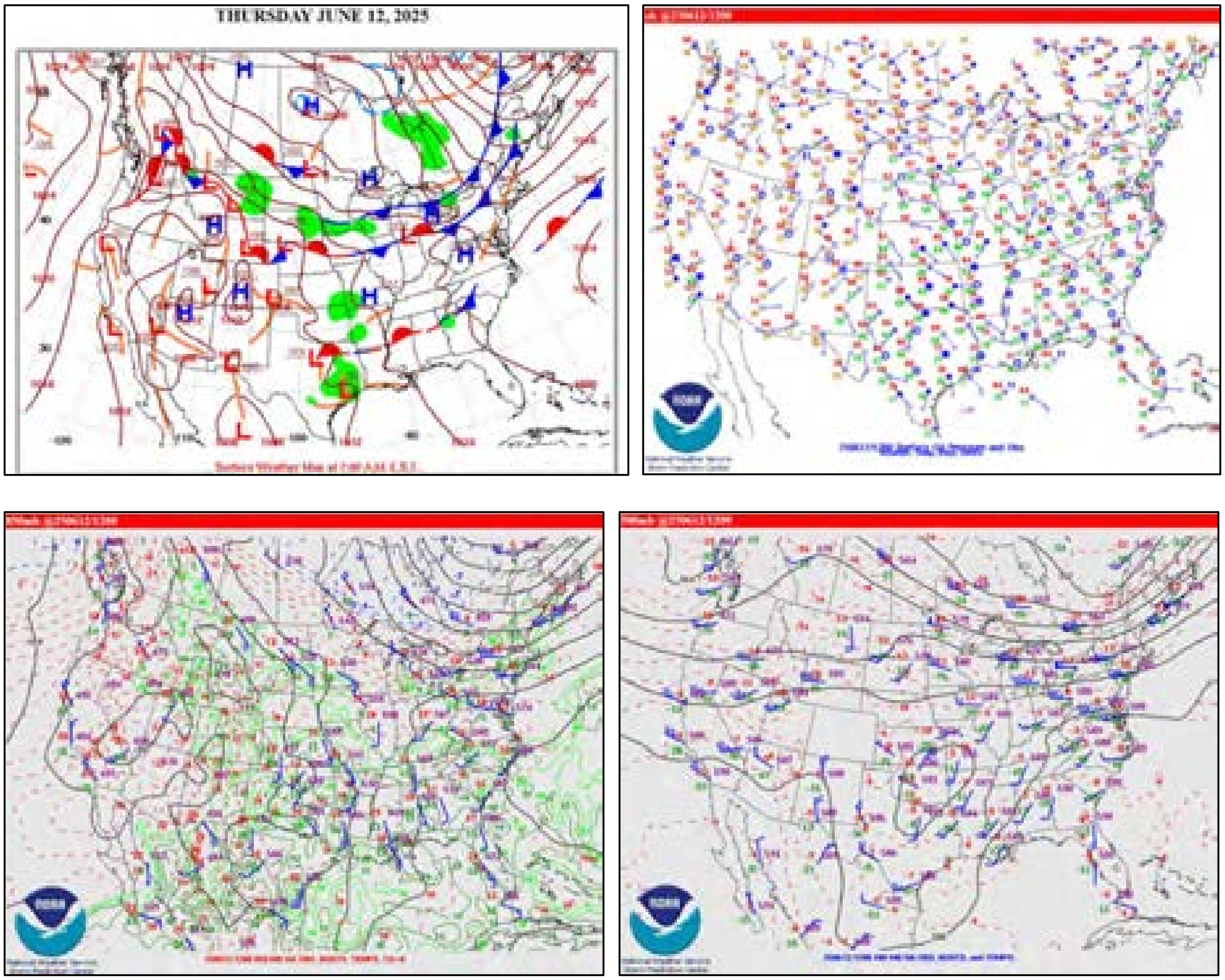


Figure 3.12.4 - Surface, 850 and 500 mb Plots from 12Z on June 12, 2025



Wind rose (Figure 3.12.5) and pollution rose (Figure 3.12.6) analyses were taken from the Gary IITRI/Ogden Dunes meteorological station for June 11 as winds were light and southerly, beginning primarily from the southwest before shifting as a frontal boundary moved through. A surface high positioned between frontal boundaries over the Great Lakes and Ohio Valley trapped smoke across the state on the 11. By the 12, the northern boundary sagged southward, bringing additional smoke and allowing upper-level smoke to mix down to the surface. Conditions remained warm, with wildfire smoke present throughout the vertical column, as confirmed by satellite imagery, GAM analysis, and NASA AOD products. Wind and pollution roses from both the 11 and 12 also indicate elevated ozone levels. Elevated ozone was measured on both days. HYSPLIT back trajectories link air masses directly to Canadian fire regions.

These conditions resemble those seen in 2023, when wildfire smoke, known to contain volatile organic compounds (VOCs), intermediate- and semi-volatile organic compounds (IVOCs and SVOCs) which likely contributed to enhanced ozone production in the lower troposphere during summer. Reference: [Understanding Volatile Organic Compound]

[Emissions from Wildfires in the Western US with Modeling Comparisons - Climate Program Office](#)

Figure 3.12.5- Gary IITRI Windrose

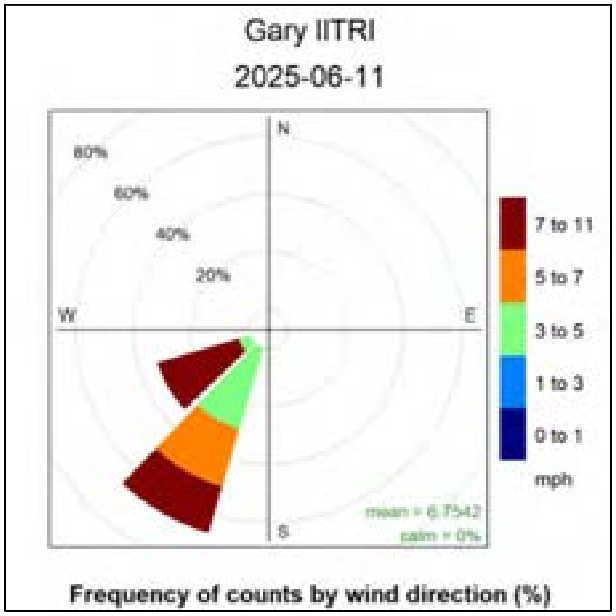


Figure 3.12.6 Gary ITRII Pollution Rose

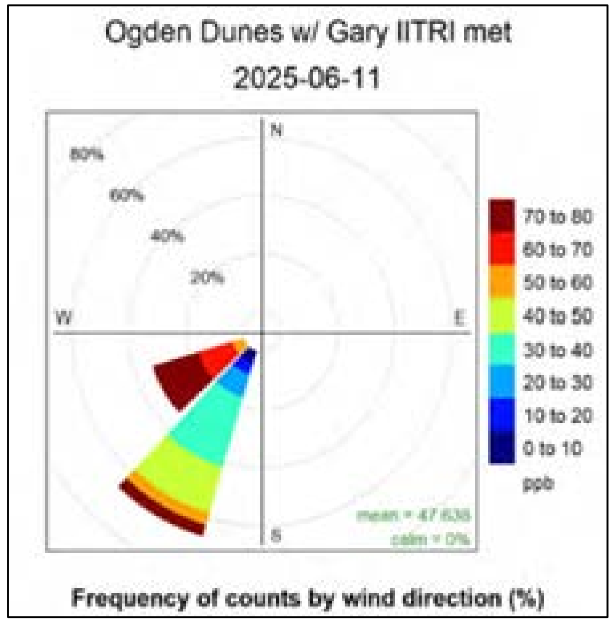
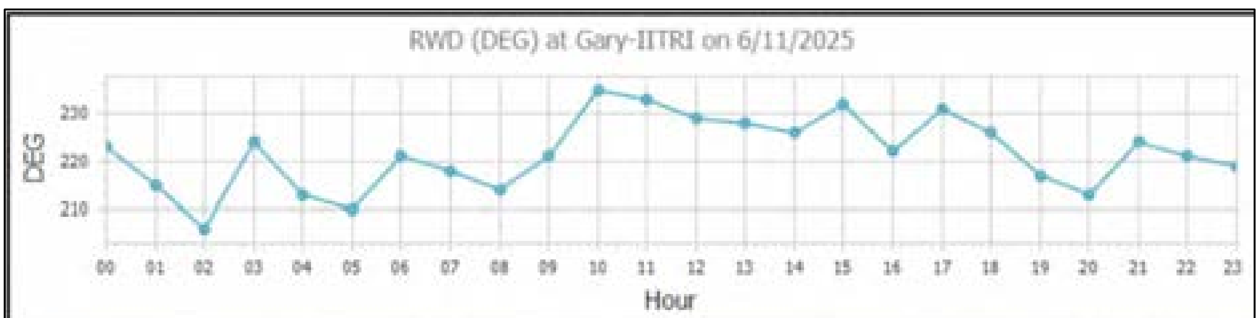


Figure 3.12.7 - Hourly Wind Directions at Gary IITRI for June 11, 2025



	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RWD	223	215	206	224	213	210	221	218	214	221	235	233	229	228	226	232	222	231	226	217	213	224	221	219

Figure 3.12.8- Gary IITRI Windrose

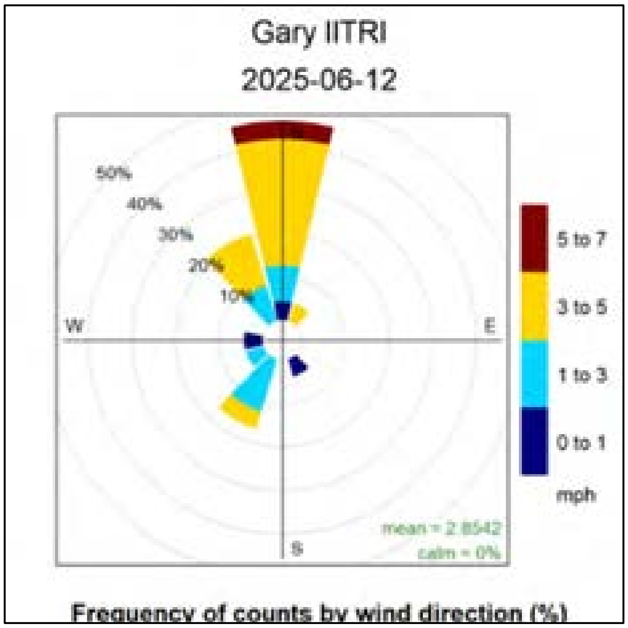


Figure 3.12.9 Gary ITRII Pollution Rose

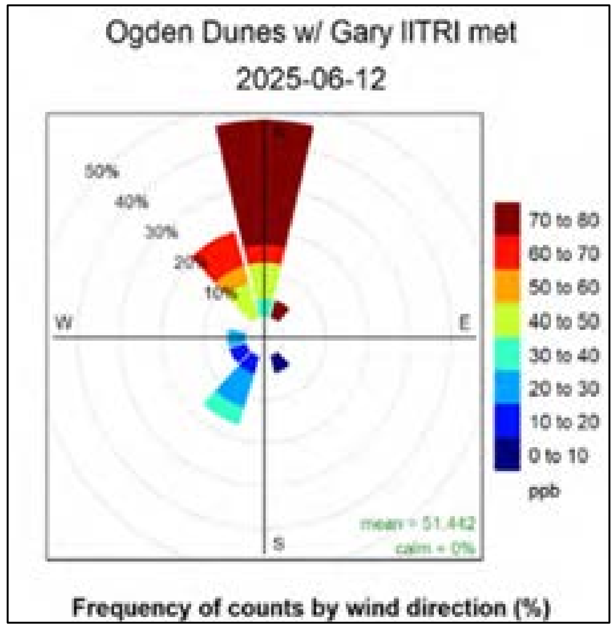
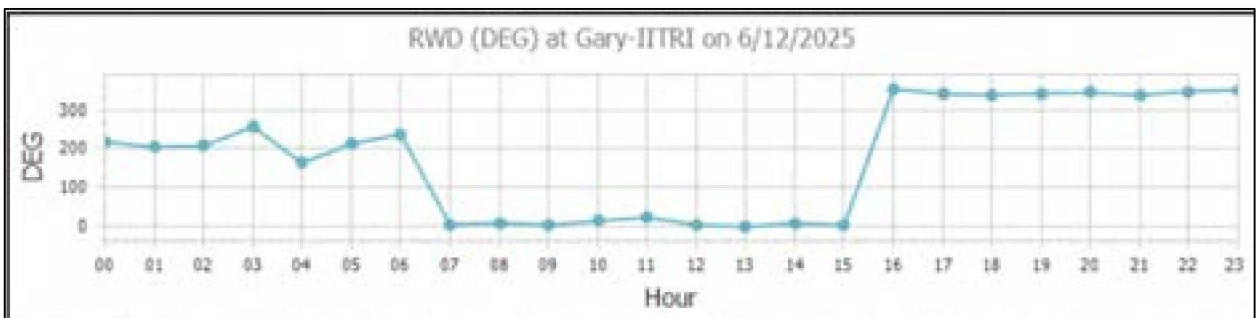


Figure 3.12.10 - Hourly Wind Directions at Gary IITRI for June 12, 2025

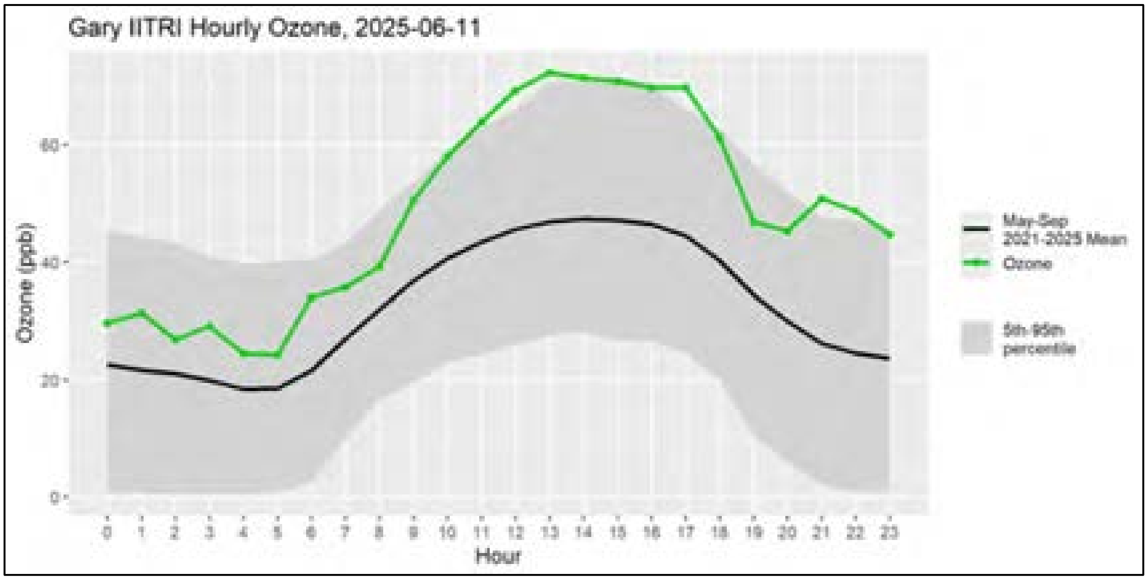


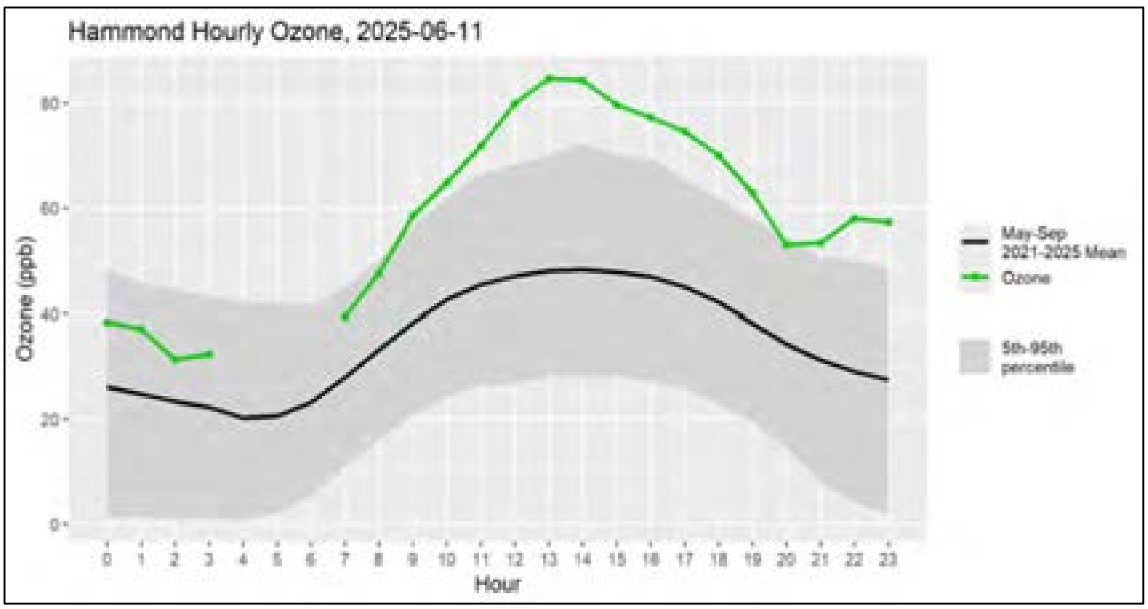
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RWD	218	205	208	257	164	213	238	3	10	4	15	24	3	0	9	4	355	341	340	343	345	339	348	352

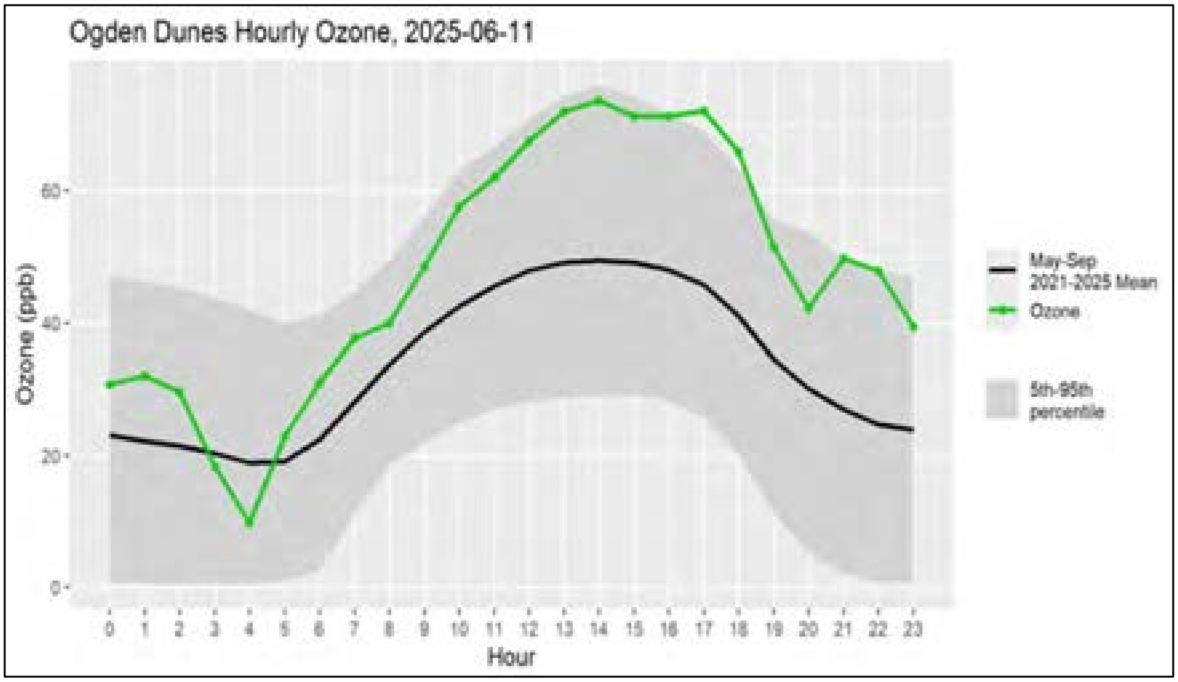
3.12.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for June 11-12, 2025 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figures 3.12.11 and 3.12.12**.** For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.12.11 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes June 11, 2025

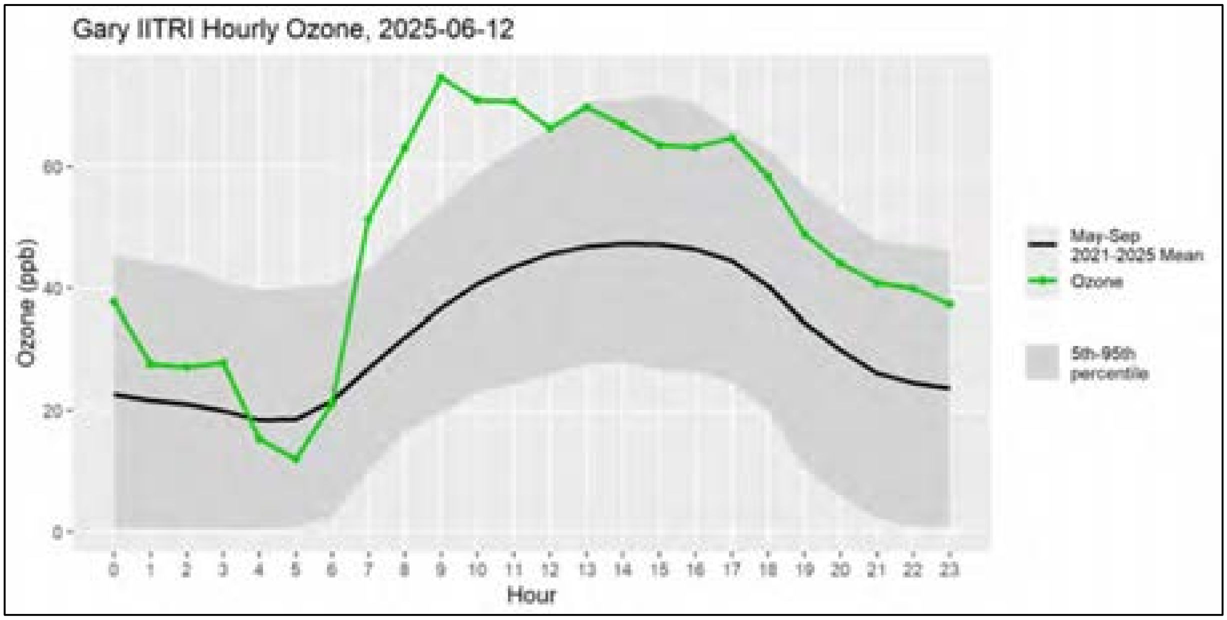


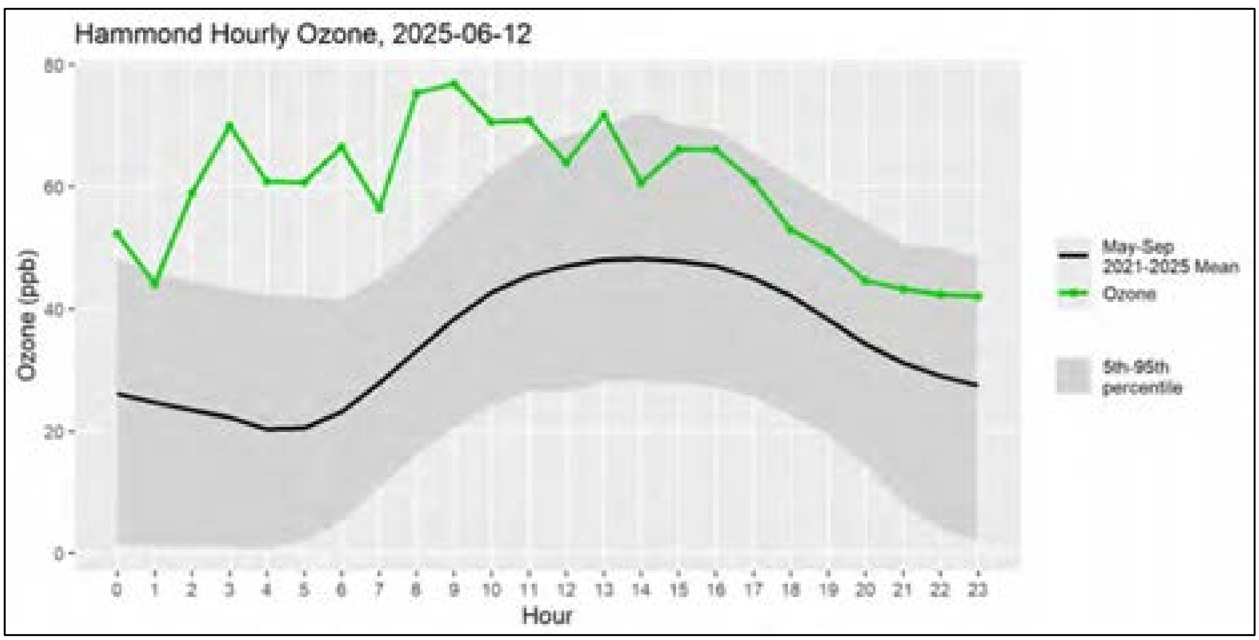


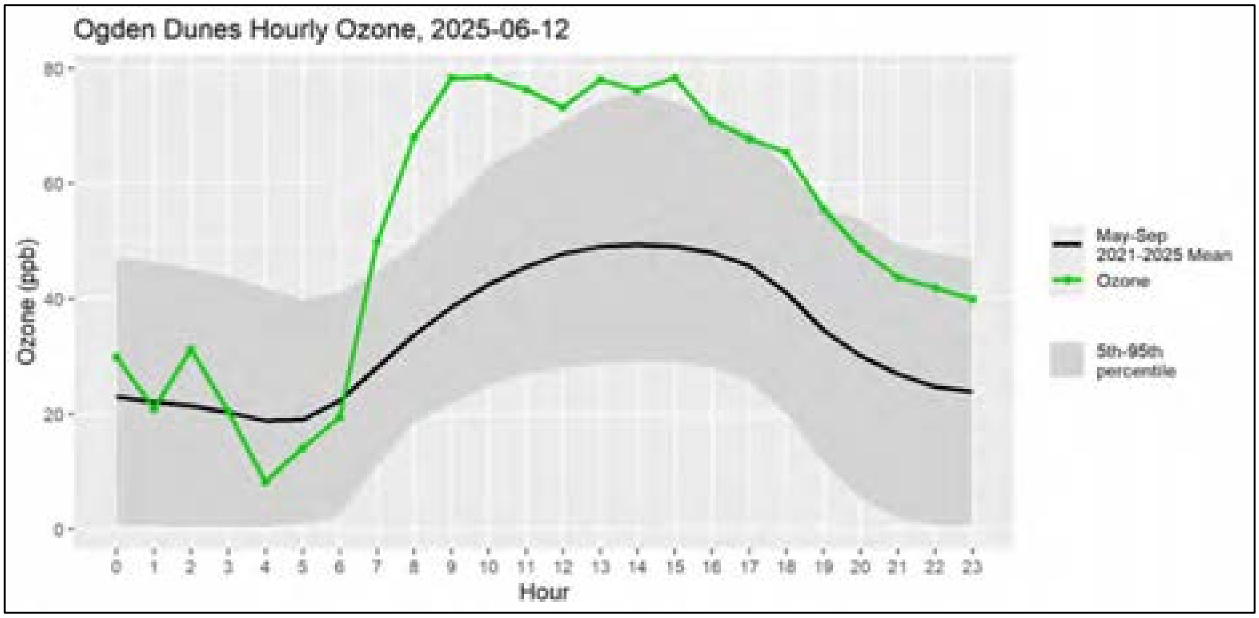


Ogden Dunes Hourly Ozone, 2025-06-11
Ozone (ppb)
60
40
20
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Hour
May-Sep
2021-2025 Mean
Ozone
5th-95th
percentile

Figure 3.12.12 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes June 12, 2025

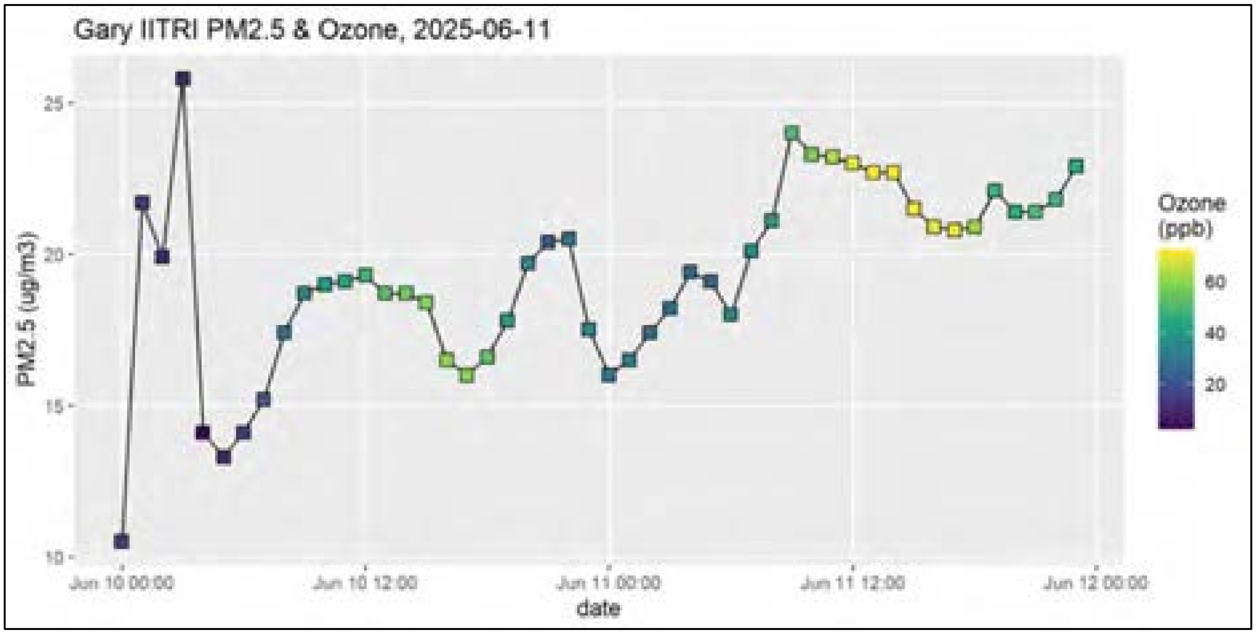


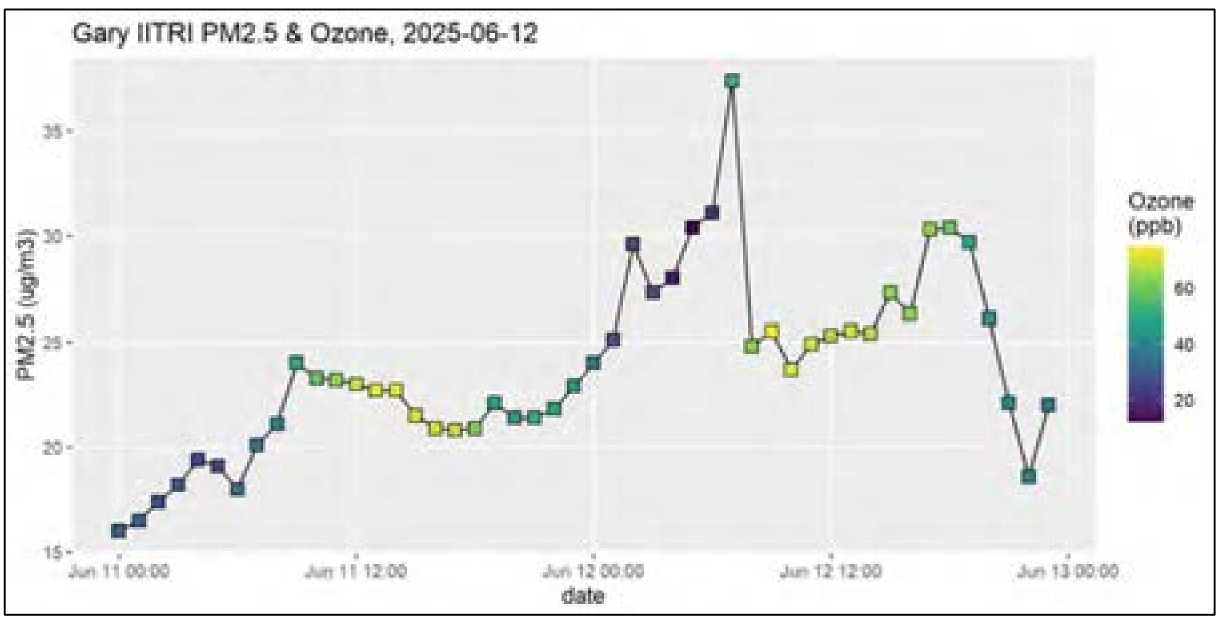




Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for June 11-12 as shown in Figure 3.12.13. $PM_{2.5}$ concentrations ranged from 15-37 ug/m^3.

Figure 3.12.13 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly data June 11-12, 2025





IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.12.3 shows the percentage above the five-year average. CO and BC were well above the average, NO_2 was slightly below the average.

Table 3.12.3 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO above 5-Year average	Percentage NO2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
6/11/2025	142%	84%	123%
6/12/2025	134%	80%	215%

3.12.4 AOD and Satellite Analyses

Figures 3.12.14 and 3.12.15 display satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of smoke.

Figure 3.12.14- Aerosol Optical Depth (AOD) June 11, 2025

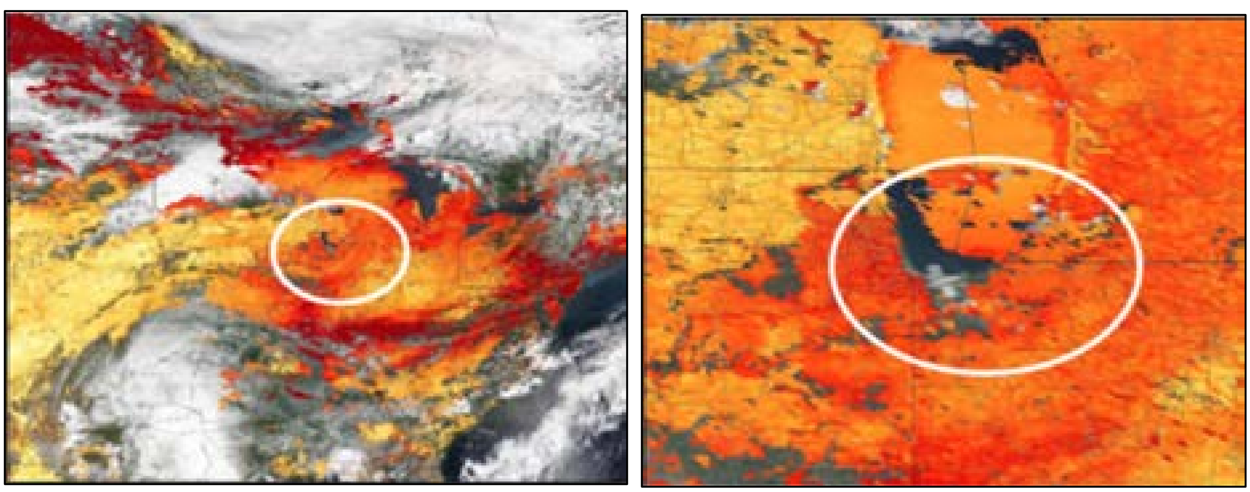
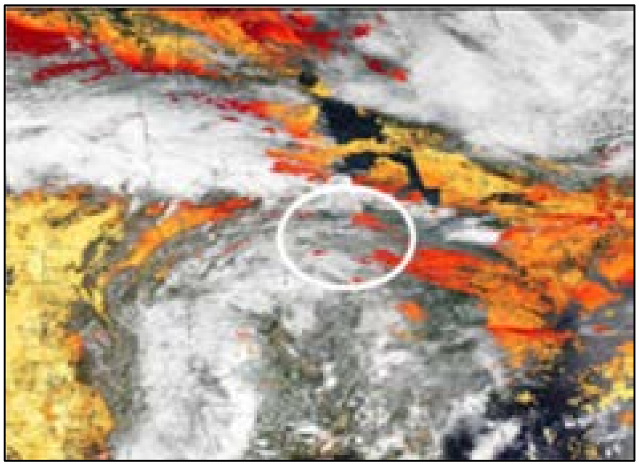
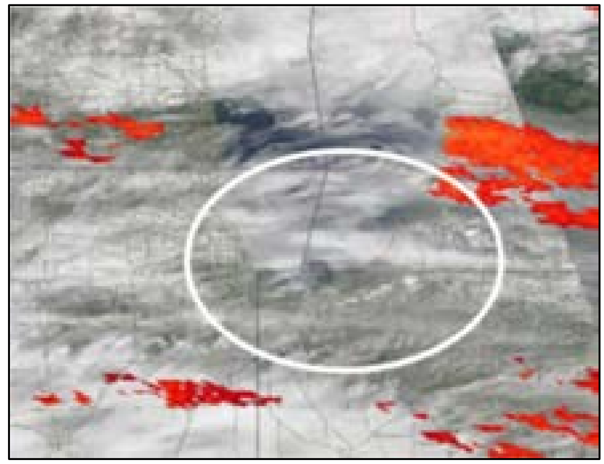


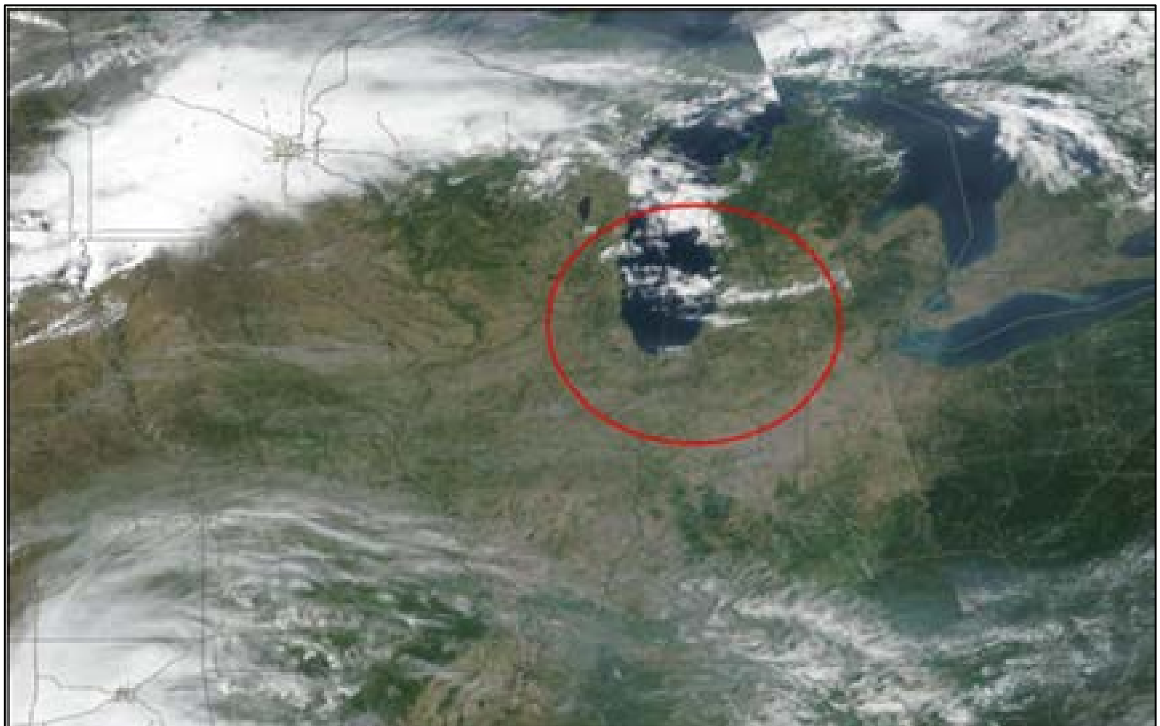
Figure 3.12.15- Aerosol Optical Depth (AOD) June 12, 2025



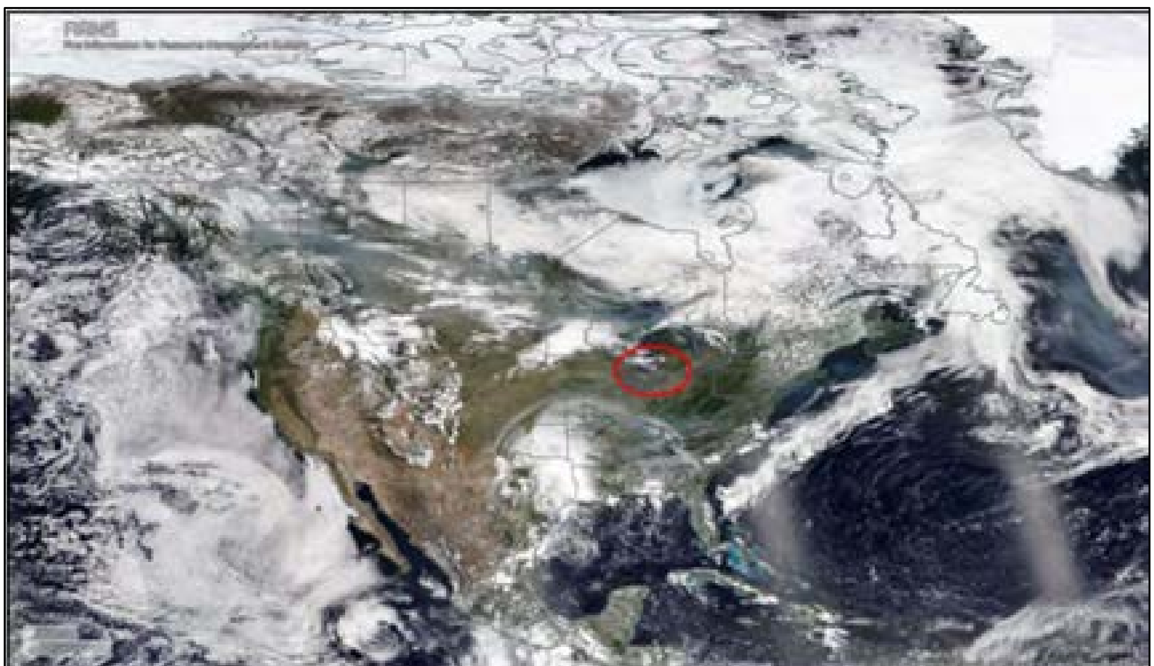


Figures 3.12.16 and 3.12.17 display three satellite images indicate Canadian wildfire smoke coming from Manitoba, Saskatchewan and Alberta. The image for June 11 and 12 shows smoke working into northern Indiana.

Figure 3.12.16 - Satellite Imagery June 11, 2025

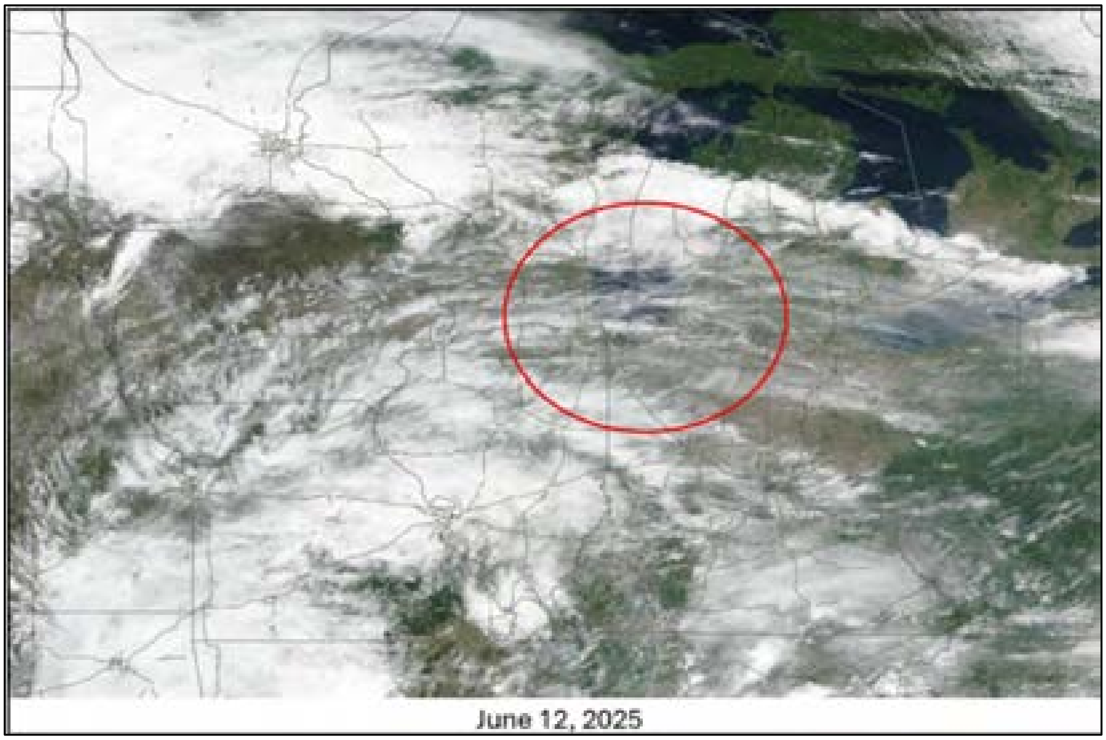


June 11, 2025



June 11, 2025

Figure 3.12.17 - Satellite Imagery June 12, 2025



The right and left images captured by NOAA's GOES 18 satellite for North America taken June 11-12, 2025 shows clouds and a plume of gray smoke extending from western Canada to the upper Midwest states. Credit: NOAA NESDIS

3.12.5 NOAA Smoke Narrative

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 1400Z June 11, 2025

SMOKE:

Canada/Central and Eastern United States/Atlantic Ocean/Europe... **Wildfire activity through Central and western Canada continues to produce moderate-to-thick smoke extending westward over Northern Yukon and Central-Eastern Alaska and east-southeastward into the Northern** Canada/Central and Eastern United States/Atlantic Ocean/Europe... **Wildfire activity through Central and western Canada continues to produce moderate-to-thick smoke extending westward over Northern Yukon and Central-Eastern Alaska and east-southeastward into the Northern Plains, Midwest, and Great Lakes, Ohio Valley and Mid-Atlantic states**, with higher concentrations found around Northeastern British Columbia and Central-Southern Alberta and Saskatchewan.

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY
THROUGH 1430Z June 12, 2025

SMOKE:

Alaska/Canada/Central and Eastern United States/Atlantic Ocean... **Wildfire activity throughout Western and Central Canada continues to produce light-to-moderate density smoke impacting a large area including Central Alaska, Northwestern and Central Canada, the Mid-Western and Eastern United States,** and extending off the coast of New England and Newfoundland over the Northwestern Atlantic. Areas of higher smoke concentration are seen stretching from Northeastern British Columbia to Central Alberta and Southern Saskatchewan. A second large smoke plume also linked to the Canadian wildfires continues to disperse eastward over the Northern Atlantic.

3.12.6 TEMPO Satellite Nitrogen Dioxide

TEMPO sensors use NO_2 as one indicator to identify and track wildfire plumes. Figures 3.12.18 and 3.12.19 show NO_2 concentrations elevated in northwest Indiana.

Figure 3.12.18 TEMPO Hourly NO_2 Concentrations June 11, 2025

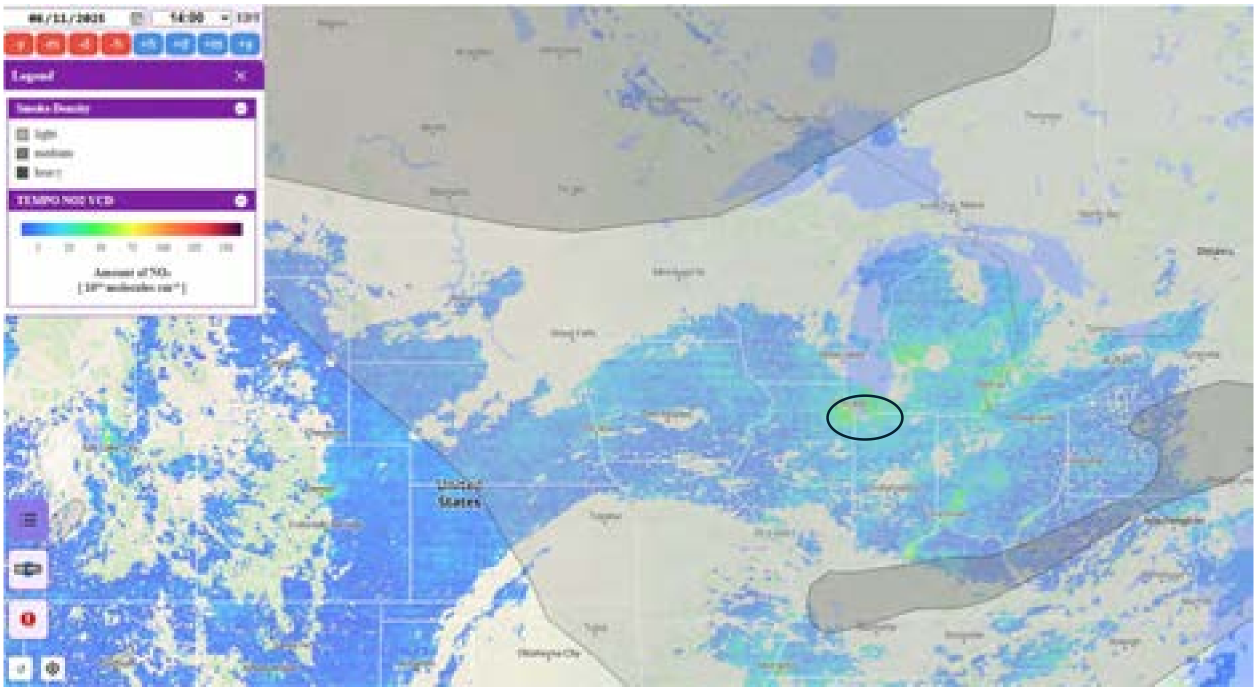
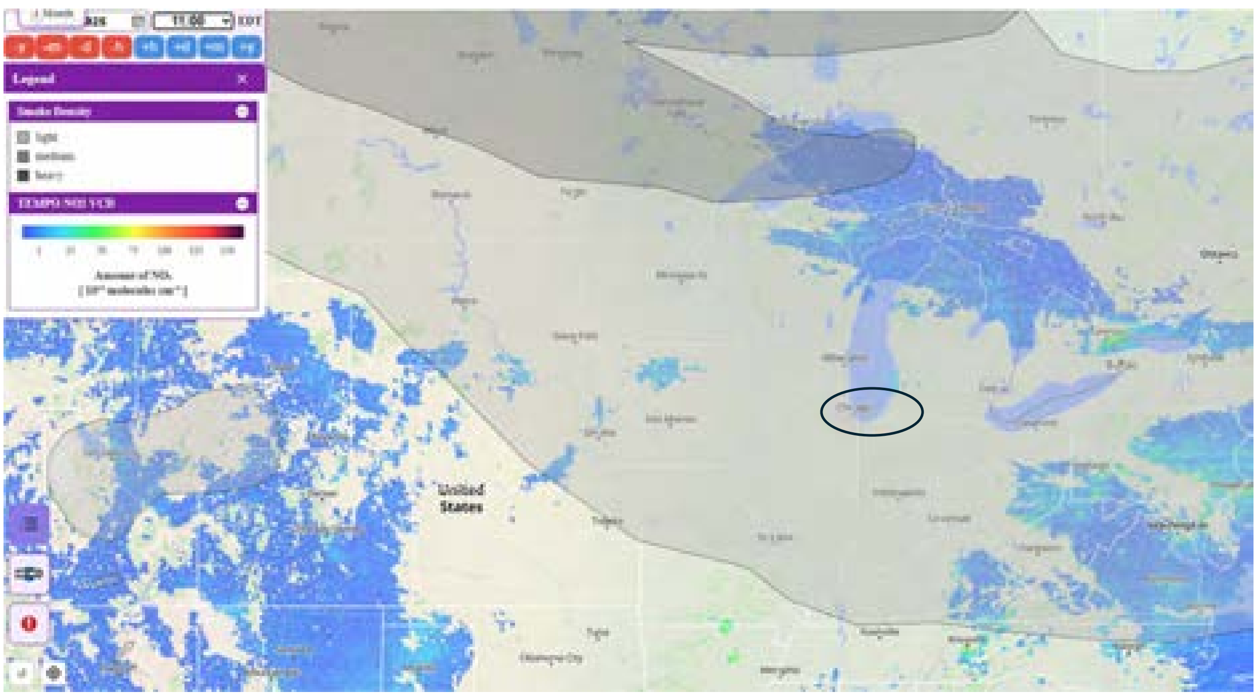


Figure 3.12.19 TEMPO Hourly NO_2 Concentrations June 12, 2025



3.12.7 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figures 3.12.20 and 3.12.21 indicate the location of the Lake and Porter County monitors. Estimated concentrations for June 11 are from 7-23 × 10^{15} molecules/cm² and for June 12 8-28 × 10^{15} molecules/cm² indicate strong to extreme wildfire smoke influence.

Figure 3.12.20- TROPOMI Satellite Daily Formaldehyde Monitoring

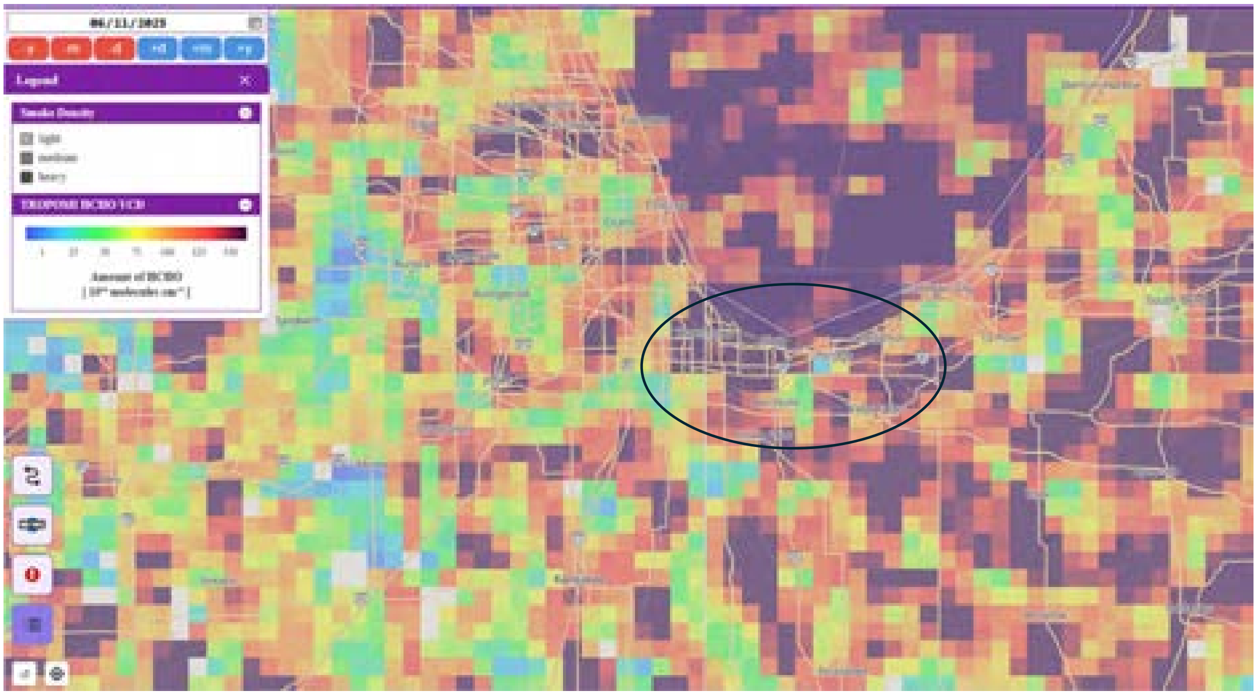
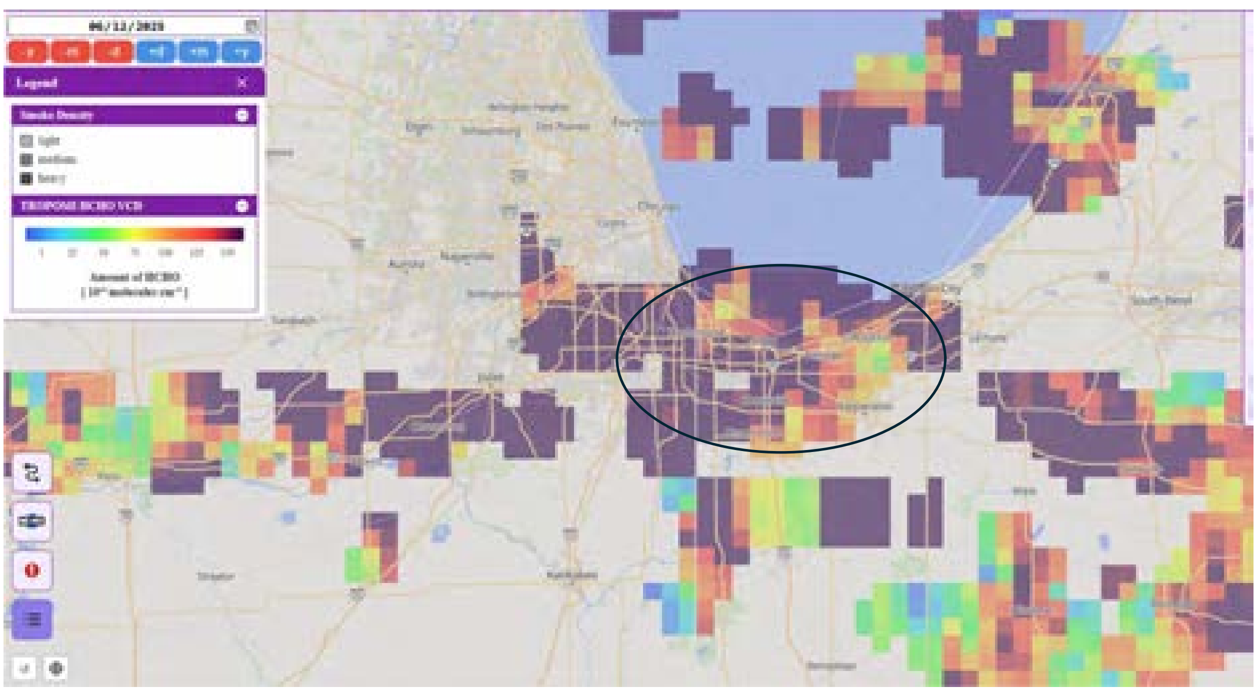


Figure 3.12.21- TROPOMI Satellite Daily Formaldehyde Monitoring



3.12.8 AirNow Smoke Maps

AirNow shows in Figures 3.12.22 through 3.12.29 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.12.22 - AirNow Ozone Map - June 11, 2025

Figure 3.12.23 - AirNow $PM_{2.5}$ Map - June 11, 2025

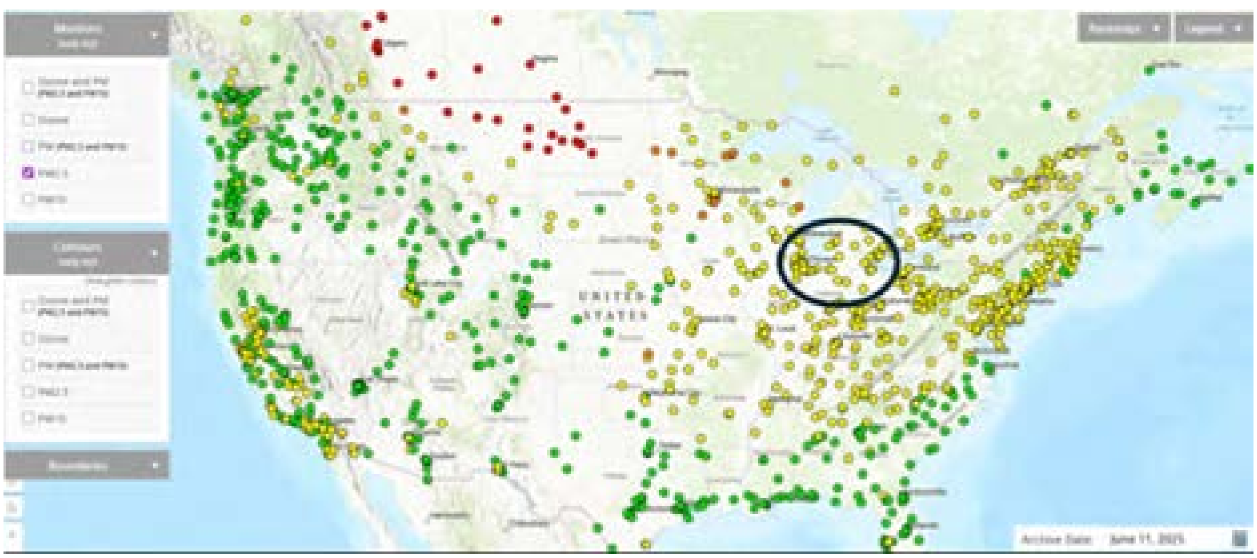


Figure 3.12.24 - AirNow Ozone Map - June 11, 2025

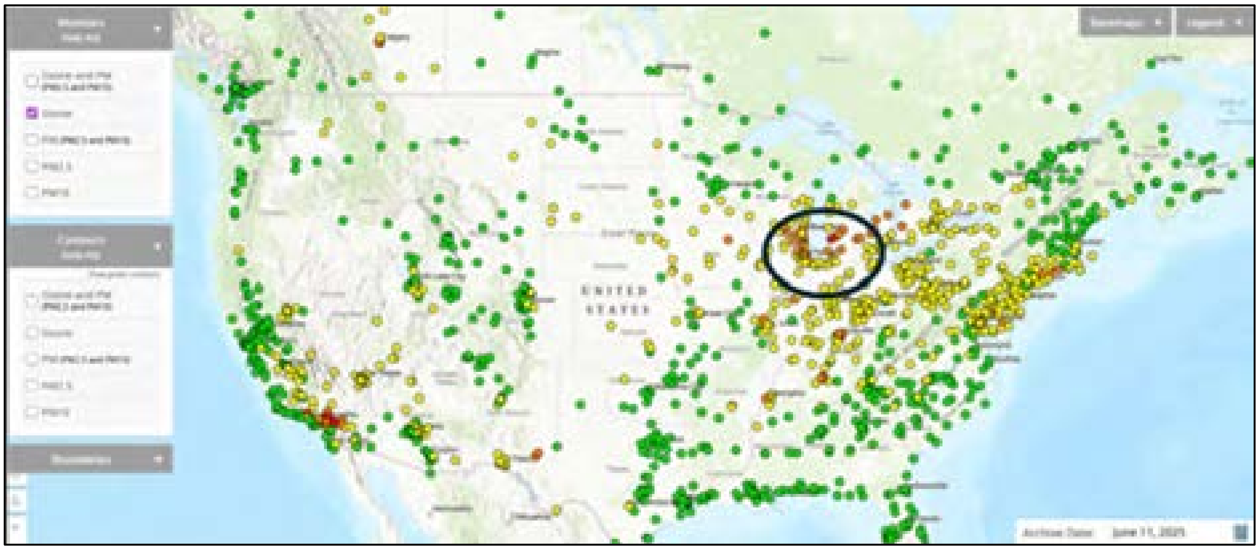


Figure 3.12.25 - AirNow Smoke and Ozone Map - June 11, 2025

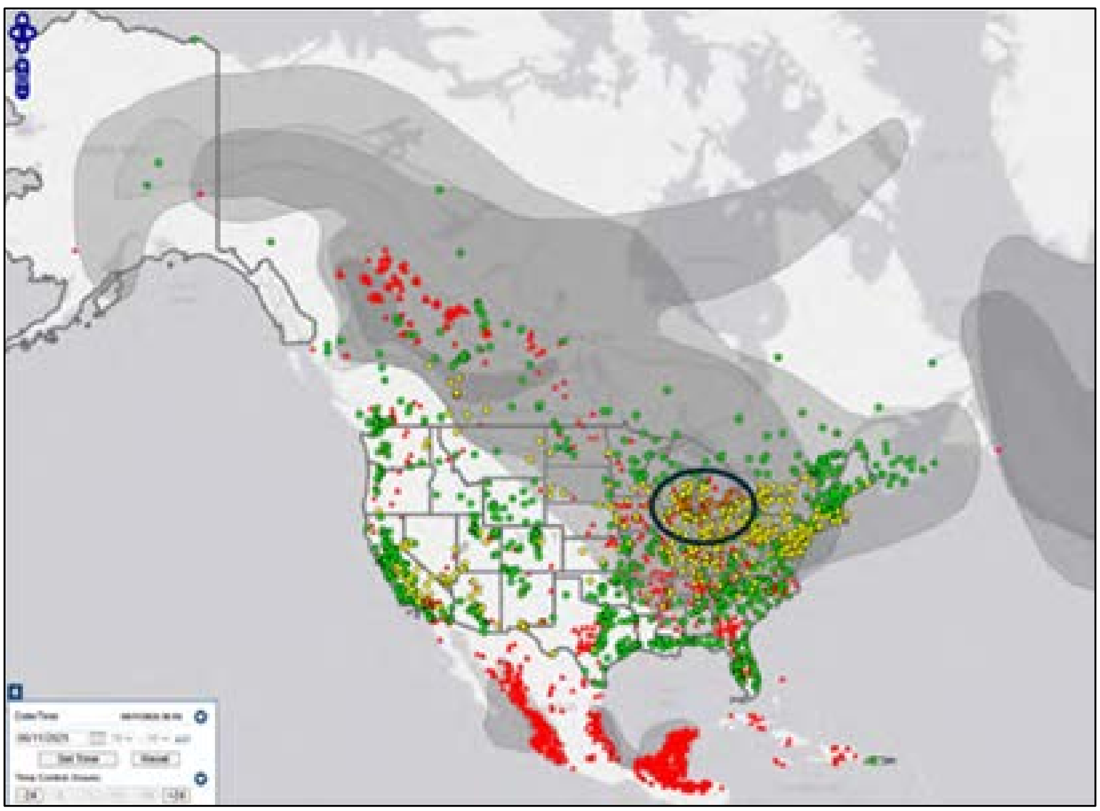


Figure 3.12.26 – AirNow Ozone Map - June 12, 2025

Figure 3.12.27 - AirNow $PM_{2.5}$ Map - June 12, 2025

Figure 3.12.28 - AirNow Ozone Map - June 12, 2025

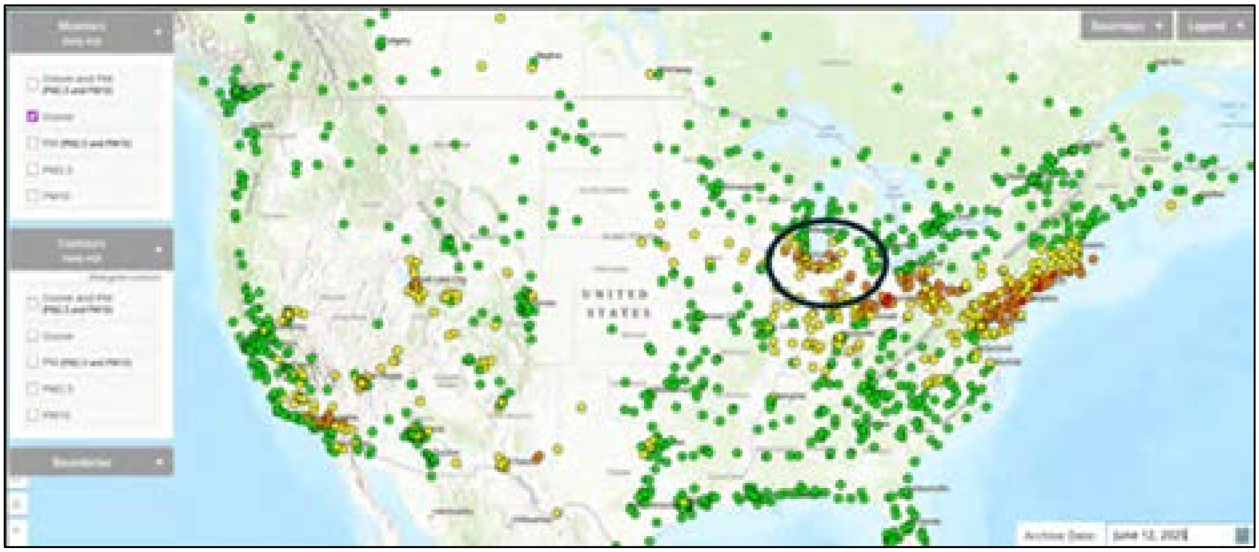
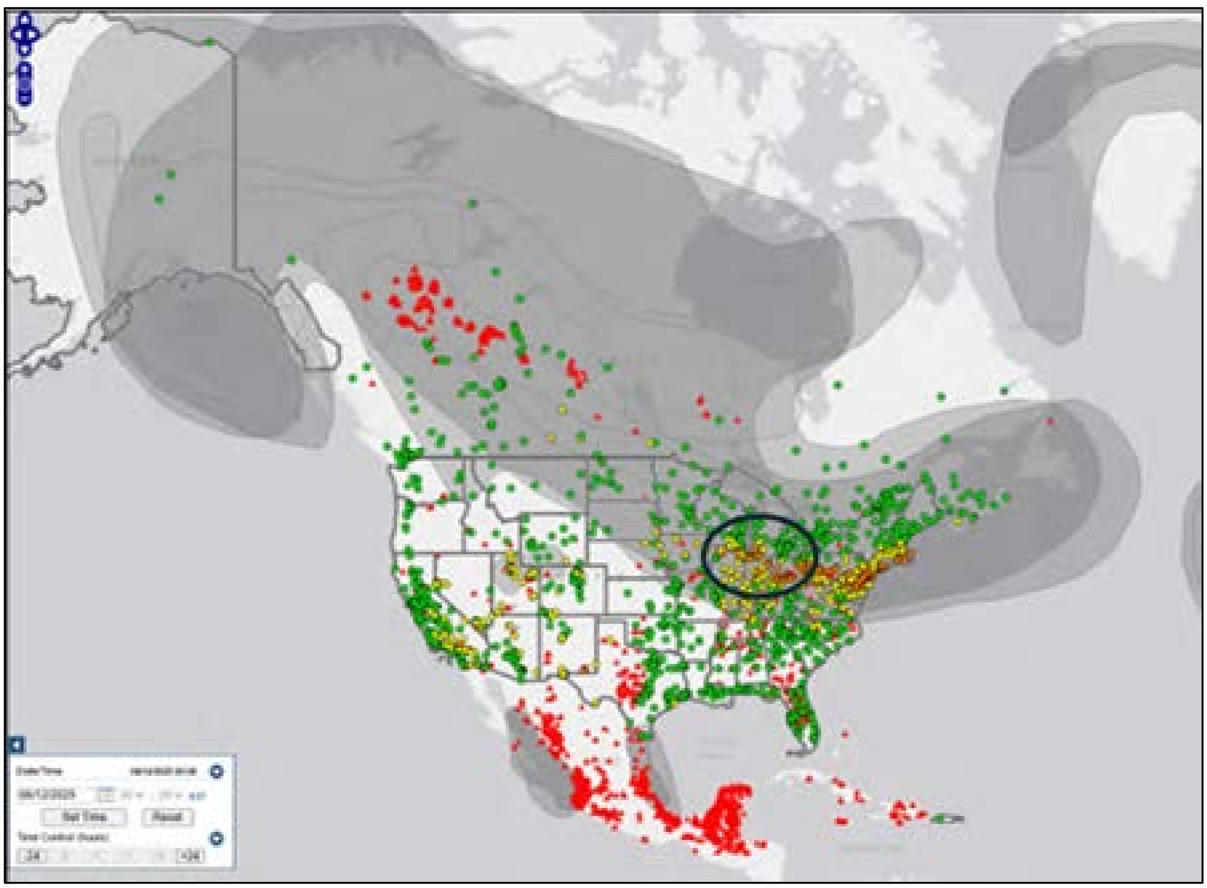


Figure 3.12.29 - AirNow Smoke and Ozone Map - June 12, 2025



3.12.9 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes. EMBER has not been updated to include 2025 days.

Figures 3.12.30 through 3.12.35 show indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER.

Figure 3.12.30 - GAM Smoke Maps Indicating Smoke Days June 11, 2025

Figure 3.12.31 - GAM Observed Ozone with Smoke Days June 11, 2025

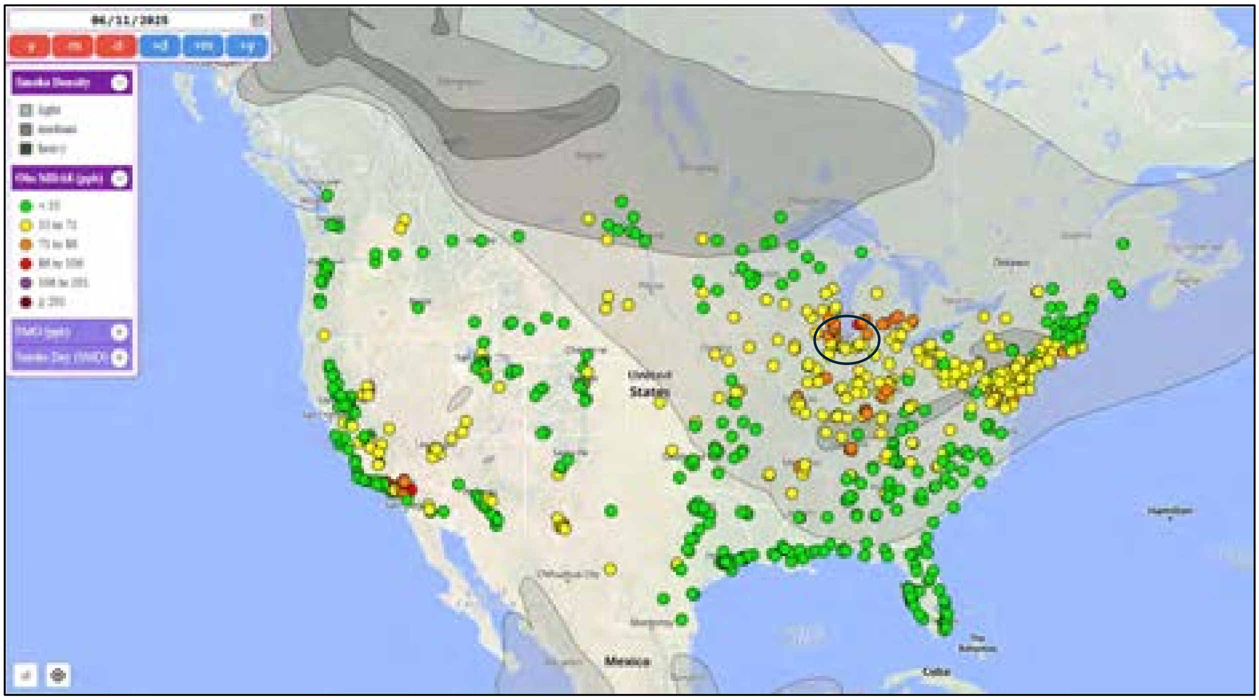


Figure 3.12.32 - GAM Smoke Estimates June 11, 2025

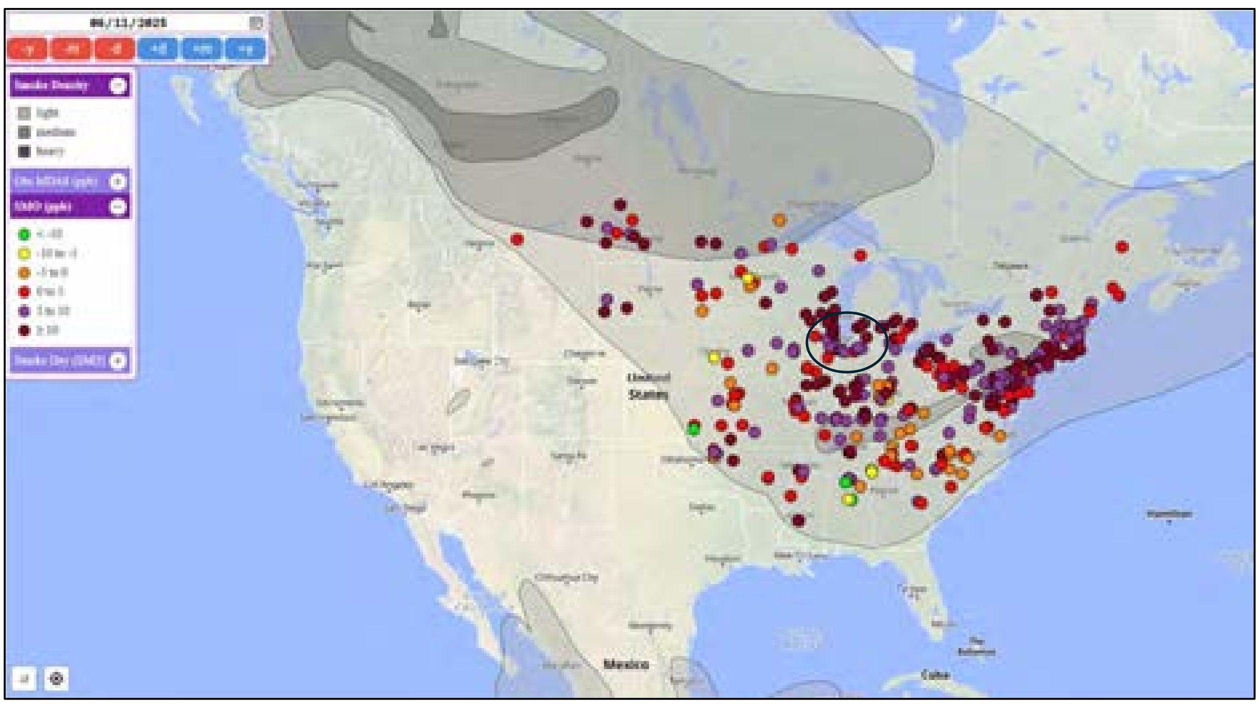


Figure 3.12.33 - GAM Smoke Maps Indicating Smoke Days June 12, 2025

Figure 3.12.34 - GAM Observed Ozone with Smoke days June 12, 2025

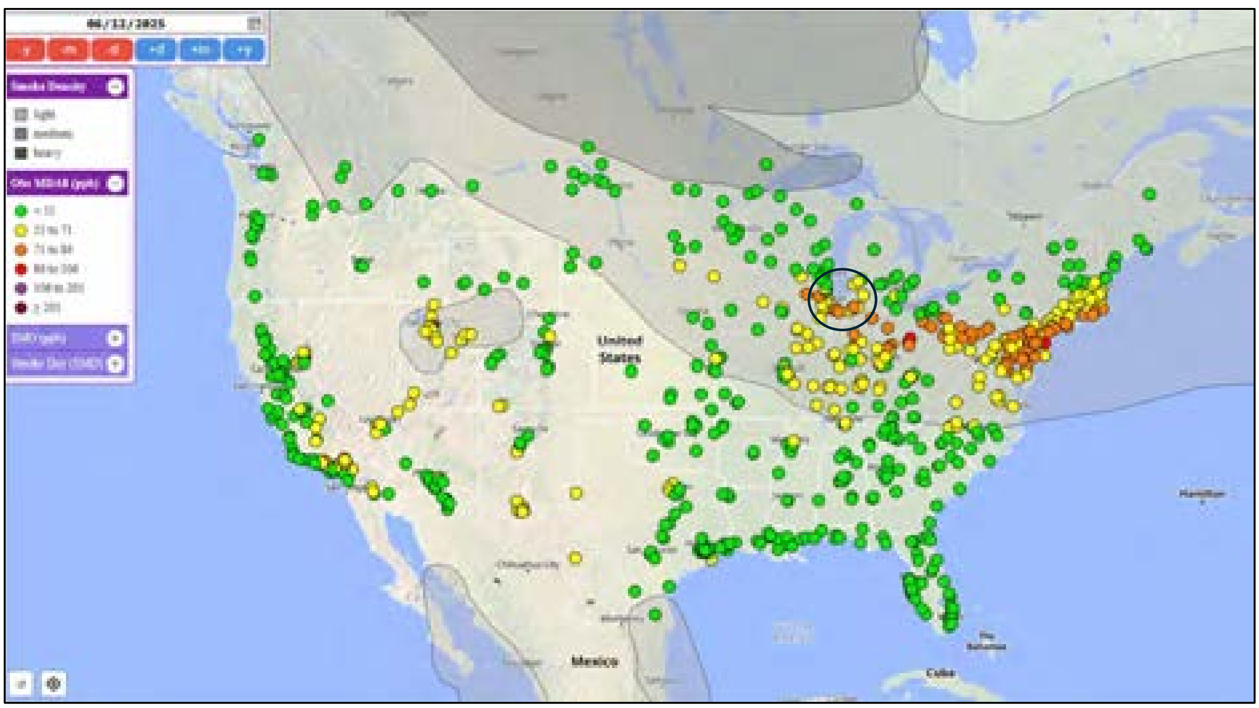
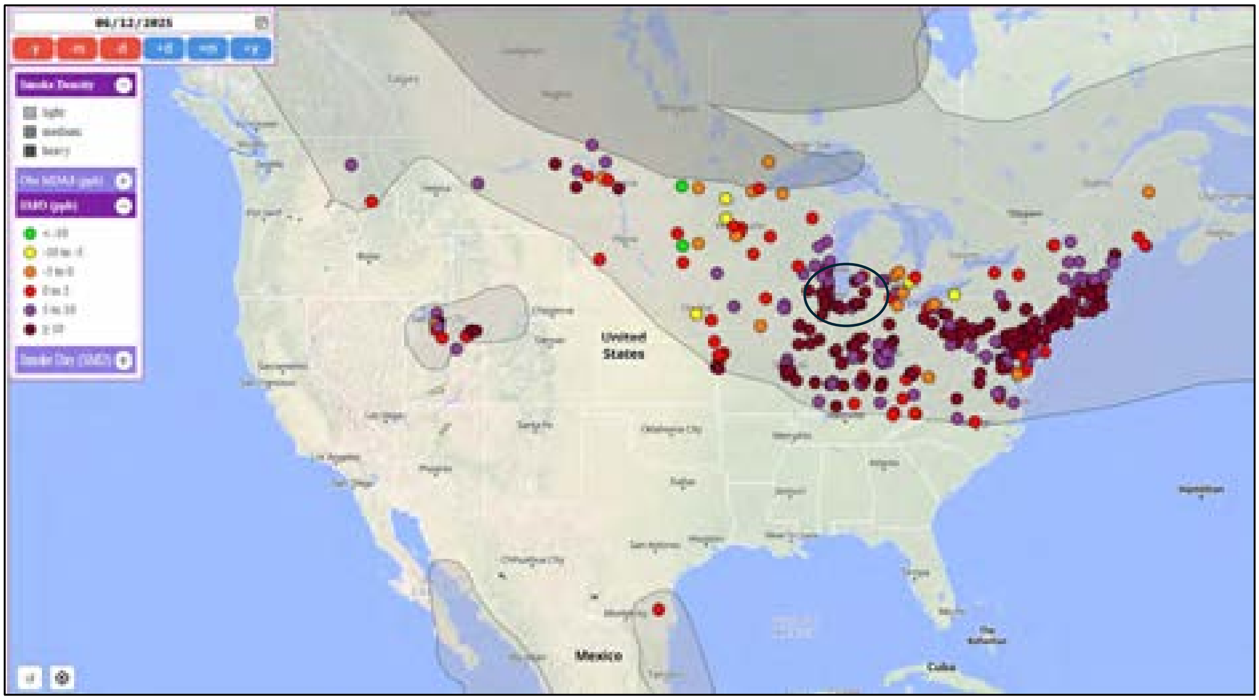


Figure 3.12.35 - GAM Smoke Estimates June 12, 2025



Tables 3.12.4 and 3.12.5 summarize the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.12.4 - Observed versus GAM and EMBER Predicted MDA 8-hour Ozone Values - June 11, 2025

Site ID	Site Name	Observed 8-hour MDA Ozone (PPB)	GAM Predicted 8-hour MDA Ozone (PPB)	GAM Smoke Influenced 8-hour MDA Ozone (PPB)	EMBER Predicted 8-hour MDA Ozone (PPB)	EMBER Smoke Influenced 8-hour MDA Ozone (PPB)
180890022	Gary-IITRI	68	61.1	6.9	NA	NA
180892008	Hammond	77	NA	NA	NA	NA
181270024	Ogden Dunes	69	60.5	8.5	NA	NA
181270026	VALPARAISO	68	58.5	9.5	NA	NA

Table 3.12.5 - Observed versus GAM and EMBER Predicted MDA 8-hour Ozone Values - June 12, 2025

Site ID	Site Name	Observed 8-hour MDA Ozone (PPB)	GAM Predicted 8-hour MDA Ozone (PPB)	GAM Smoke Influenced 8-hour MDA Ozone (PPB)	EMBER Predicted 8-hour MDA Ozone (PPB)	EMBER Smoke Influenced 8-hour MDA Ozone (PPB)
180890022	Gary-IITRI	67	61.2	5.8	NA	NA
180892008	Hammond	68	NA	NA	NA	NA
181270024	Ogden Dunes	76	61	15	NA	NA
181270026	Valparaiso	73	57.8	15.2	NA	NA

3.12.10 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on June 11 and 12, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.10.5 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 12 ppb lower than the MDA8 ozone concentrations observed on June 11 and 36 ppb lower on June 12 with the maximum matching day MDA8 ozone concentration of 66.9 ppb.

Table 3.12.6 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 11, 2025

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	69	66.9	57.4

Table 3.12.7 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 12, 2025

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	76	46.6	39.5

3.12.11 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this $PM_{2.5}$ event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red). And higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. The HMS smoke layers become less opaque as the density of smoke increases. June 11 and 12 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figures 3.12.40 and 3.12.41 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) with higher concentrations found around Northeastern British Columbia and Central-Southern Alberta and Saskatchewan.

Figure 3.12.36 – Back Trajectories June 11 50, 100 and 500 meters (-72 hours)

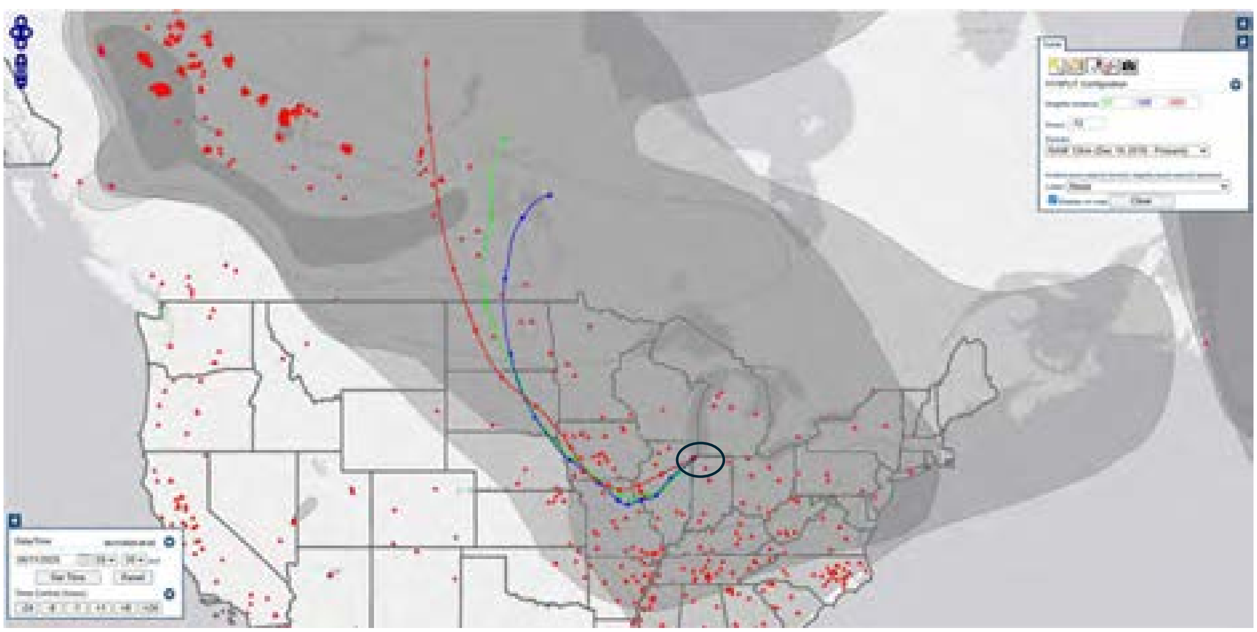


Figure 3.12.37 – Back Trajectories June 12 50, 100 and 500 meters (-72 hours)

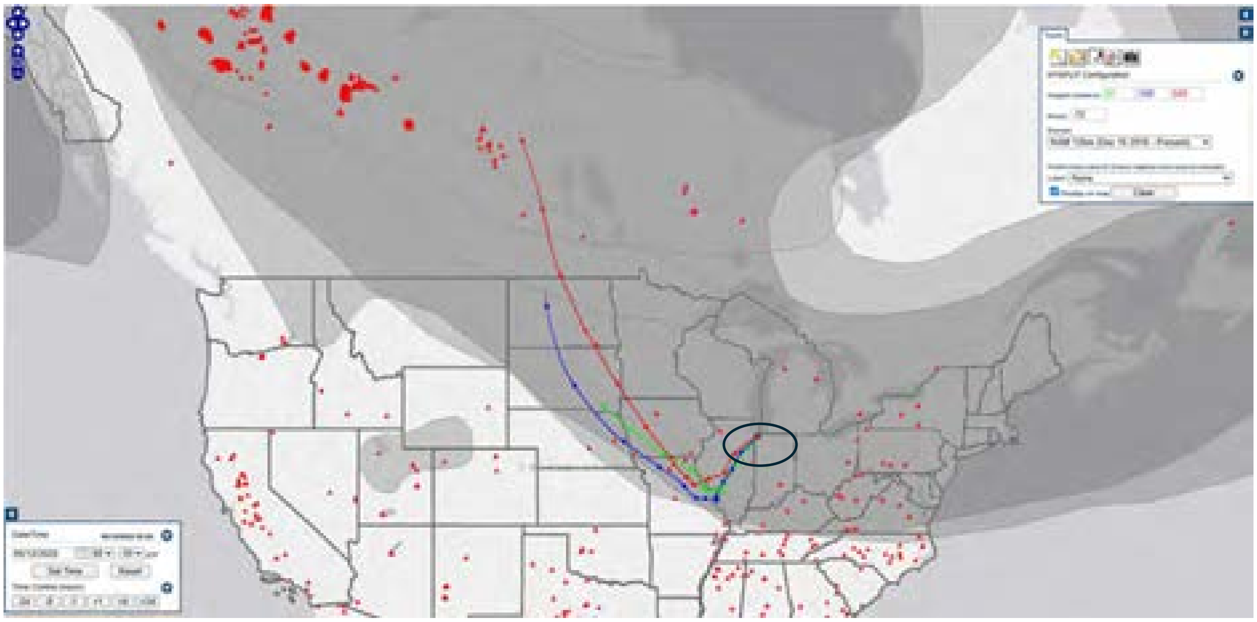


Figure 3.12.38 – Back Trajectories June 11 1000, 2000 and 3000 meters (-72 hours)

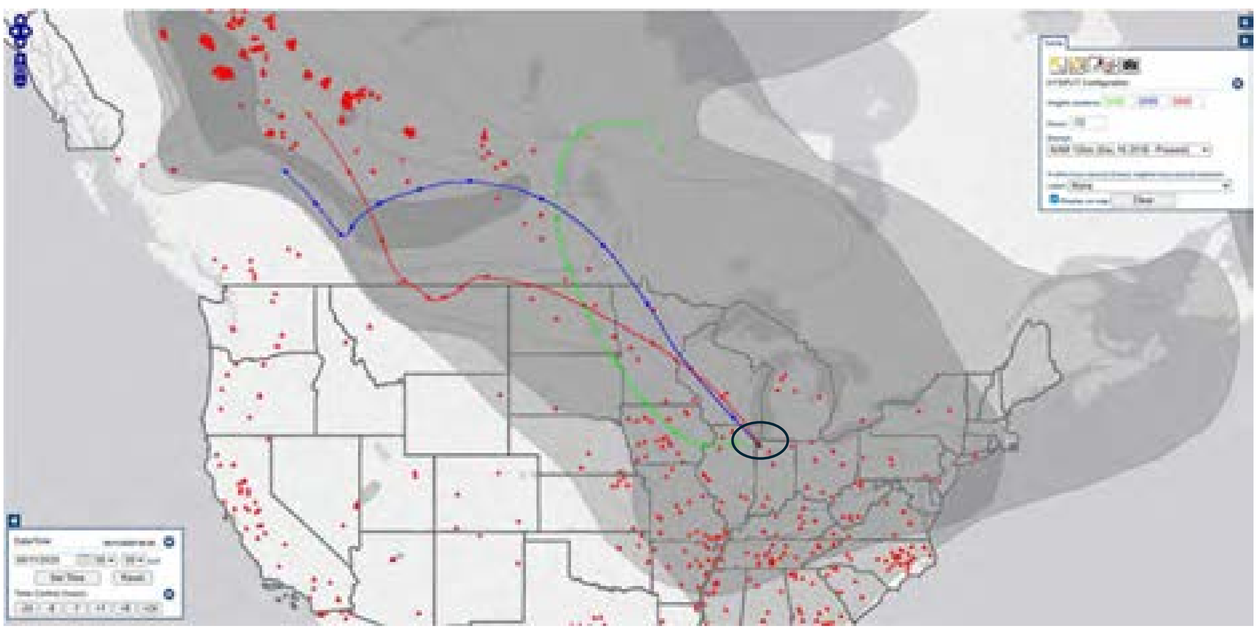


Figure 3.12.39 – Back Trajectories June 12 1000, 2000 and 3000 meters (-72 hours)

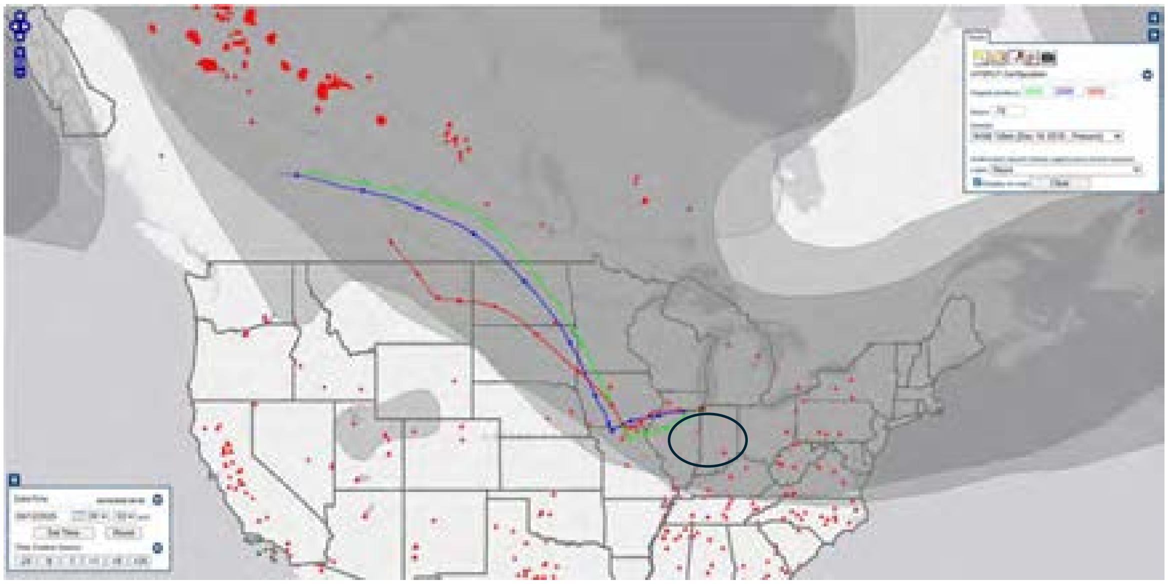


Figure 3.12.40 - Long Range Back Trajectory June 11 100, 500 and 1000 meters (-168 hours)

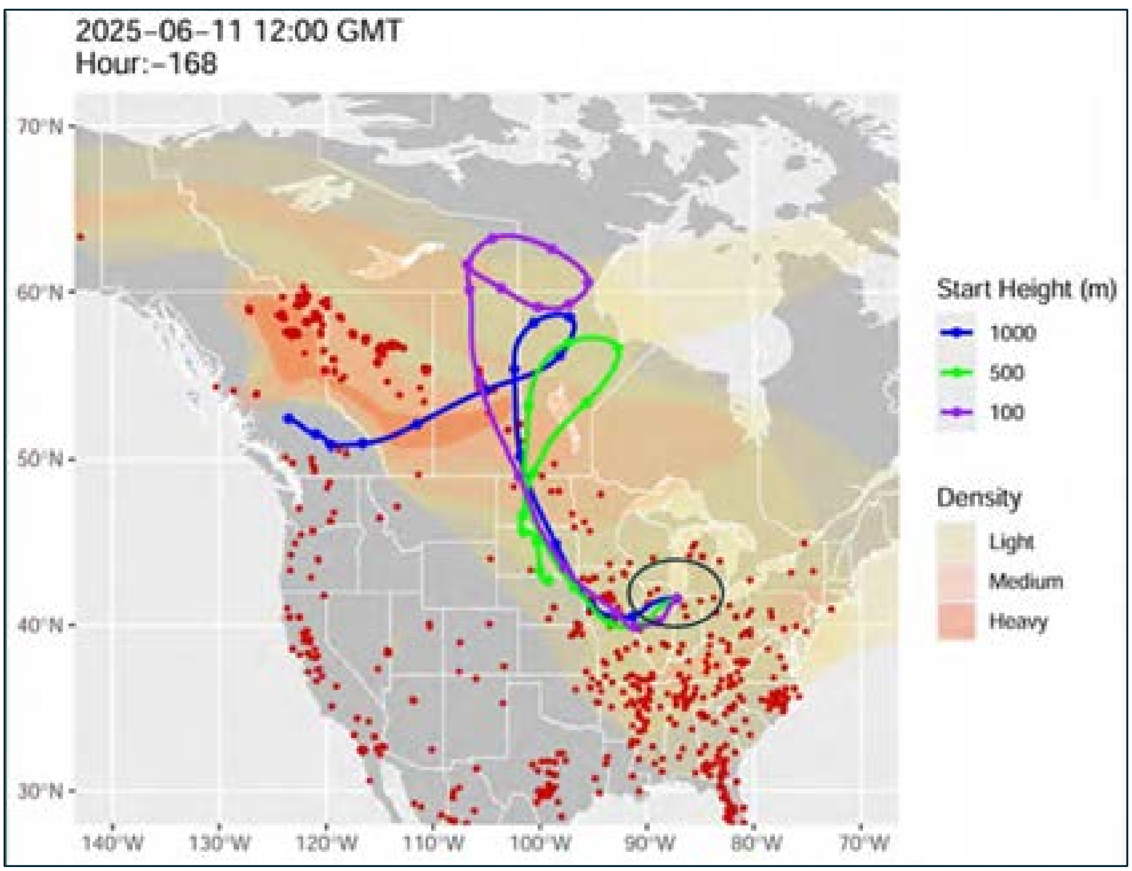
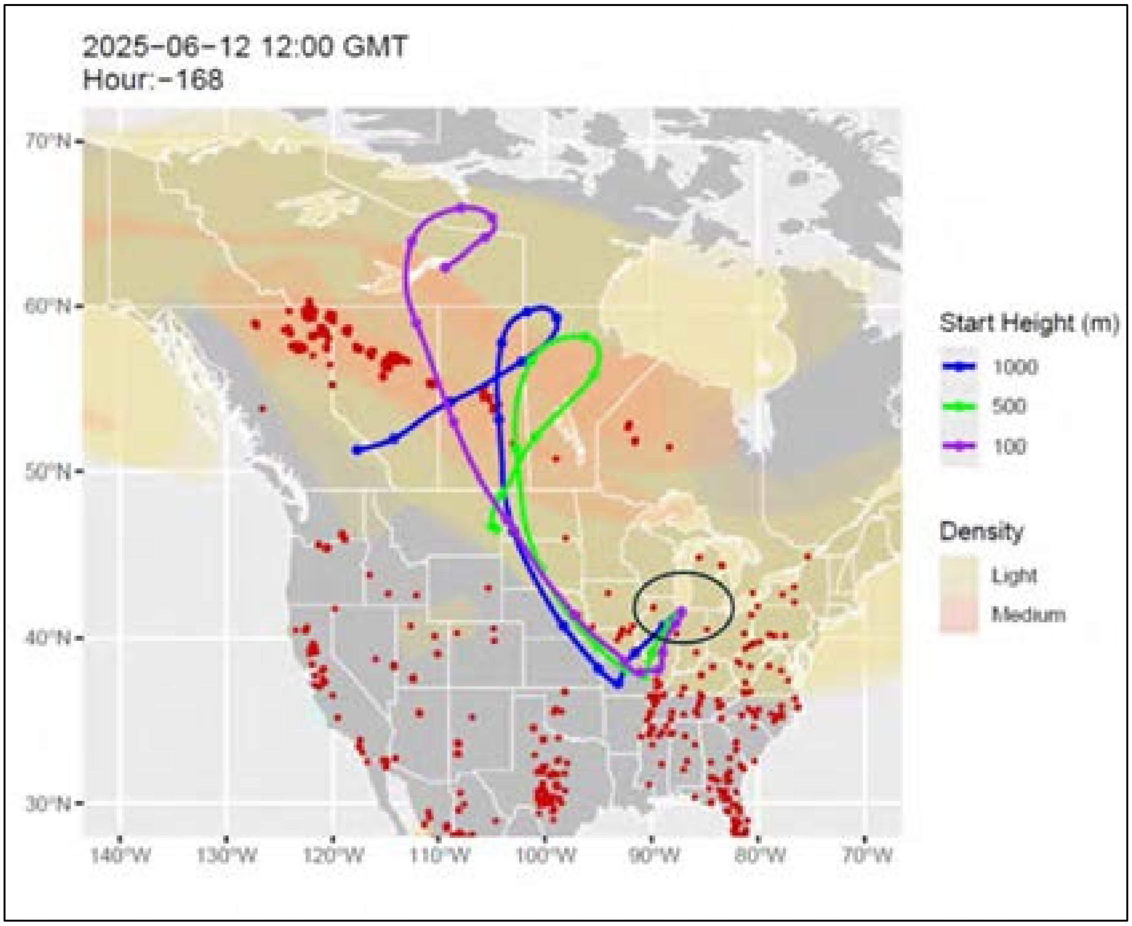


Figure 3.12.41 - Long Range Back Trajectory June 12 100, 500 and 1000 meters (-168 hours)



3.12.12 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.12.42 and 3.12.43 indicate the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.12.42 HRRR Smoke Model

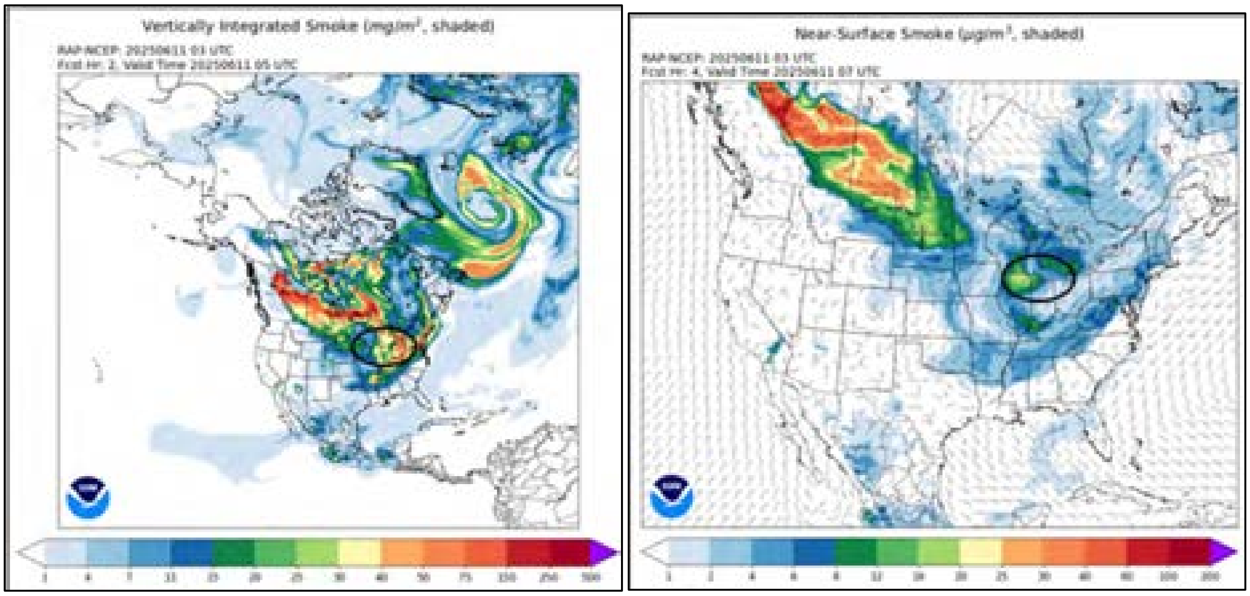
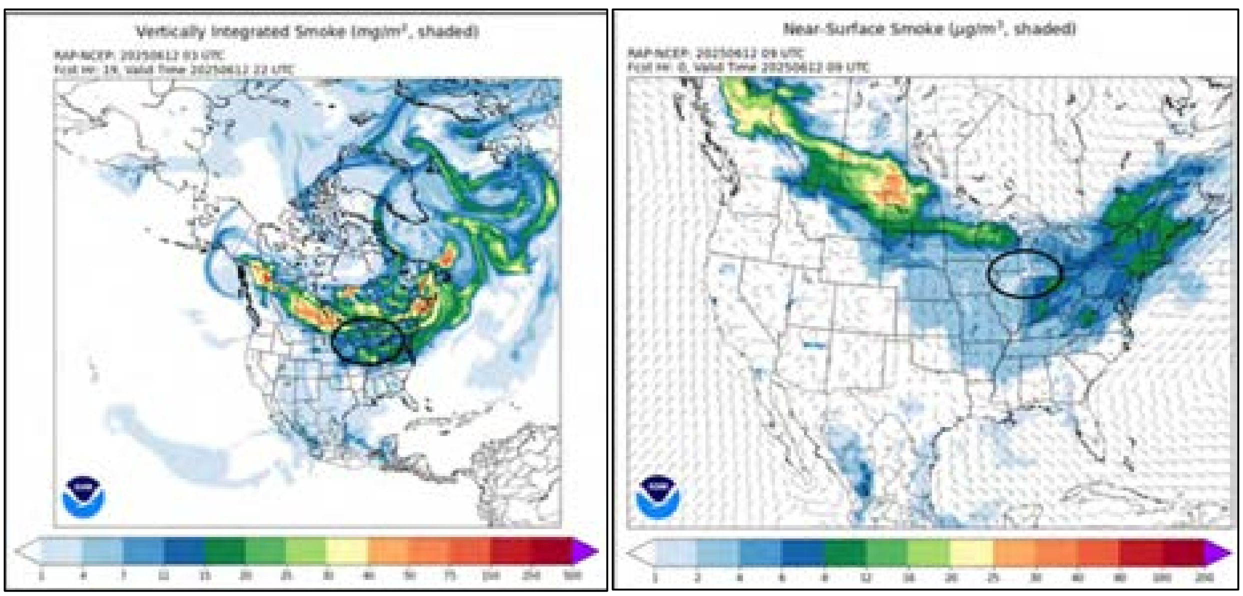


Figure 3.12.43 HRRR Smoke Model



3.12.13 Media Mentions

NOAA Satellites Monitor Canadian Wildfires and Smoke

Air quality concerns in Indiana for June 12, 2025

Premier tours northern Manitoba wildfire zone

Smoke free summers a thing of the past as Alberta gets hit with wildfire smoke from all sides

[Elevated ozone levels, wildfire smoke to impact West Michigan air quality Wednesday]

[Candle Lake prepares for imminent fire threat; restaurant closes to serve firefighters only]

[Fire Bulletin #31]

3.12.14 Summary of Requested Exclusion of June 11 - 12, 2025

Table 3.12.8 - Summary Table - Ogden Dunes

Event Date	June 11, 2025	June 12, 2025
MDA8 Ozone Concentration (PPB)	69	76
Does Ozone Concentration exceed the 95th Percentile?	Yes	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes	Yes
Does TEMPO Satellite imagery show elevated NO2?	Yes	No
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes	Yes
GAM predicted MDA8 ozone (PPB)	60.5	61
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	NA	NA
Matching day MDA8 ozone (max., avg.) (PPB)	62.7, 57.5	46.5, 39.5
HYSPLIT indicated wildfire regions	Shoe/Camp Fire, Saskatchewan, and Flin Flon Fire, Manitoba	
Do HRRR Models indicate smoke?	Yes	Yes
Media Mentions	Yes	Yes
Clear causal relationship established?	Yes	Yes

3.13 June 16, 2025 Ozone Event

3.13.1 Executive Summary

On June 16, 2025, Northwest Indiana experienced ozone exceedances across all Lake and Porter County monitors, with values ranging from 73-76 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM analyses estimate 3-15 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to Red Lake 12, Ontario and Fire EA061, Manitoba.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of June 16 2025, as an exceptional event under U.S. EPA guidelines.

Table 3.13.1 June 16, 2025 Lake and Porter County MDA 8-Hour Ozone Values (PPB)

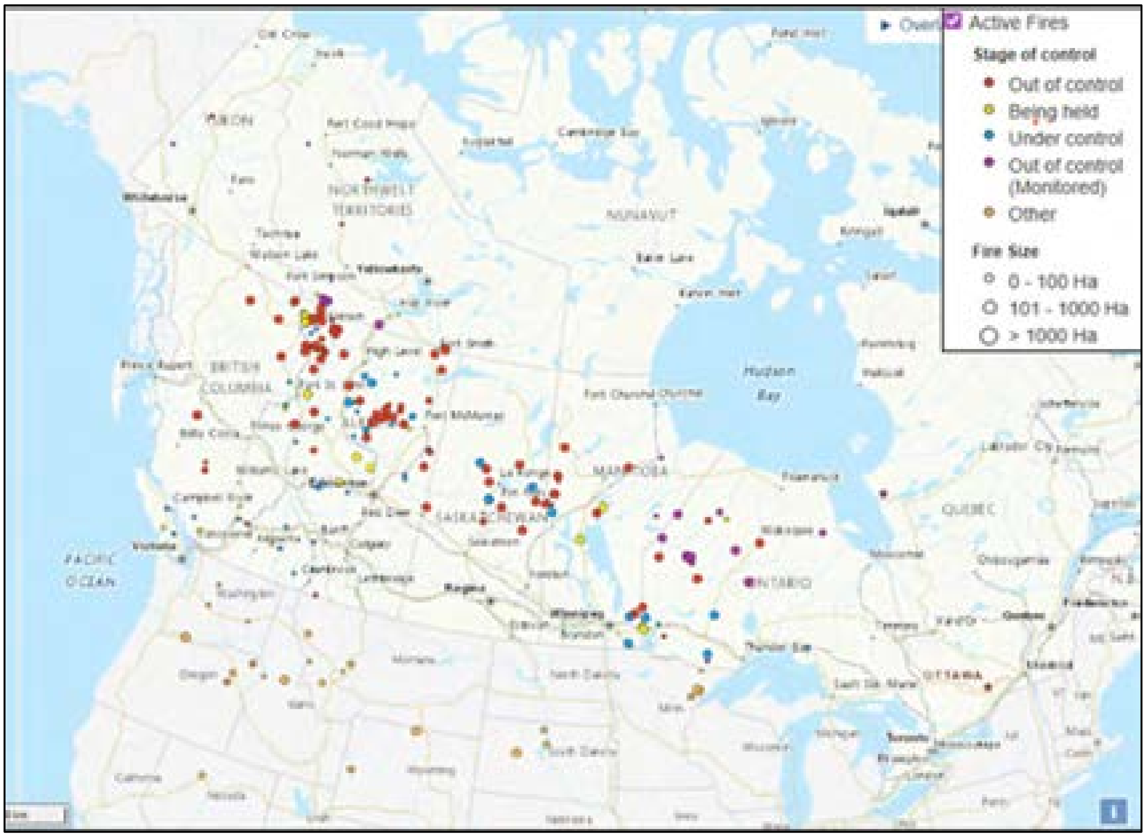
Date	Gary -IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
June 16, 2025	73	76	67	63

On June 16, 2025 multiple Canadian wildfires, as shown in Figure 3.13.1, contributed ground level smoke that caused two of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in June 2025 included the:

- Red Lake 12 Wildfire, which became the largest wildfire in Ontario's history. It peaked at over 196,000 hectares (approximately 484,000 acres), surpassing all previous records for a fire burning entirely within the province.
- Fire EA061, which was a massive, naturally-caused wildfire in eastern Manitoba during the record-breaking 2025 wildfire season. It was first discovered on May

12, 2025, and eventually grew to cover approximately 359,040 hectares (roughly 887,000 acres).

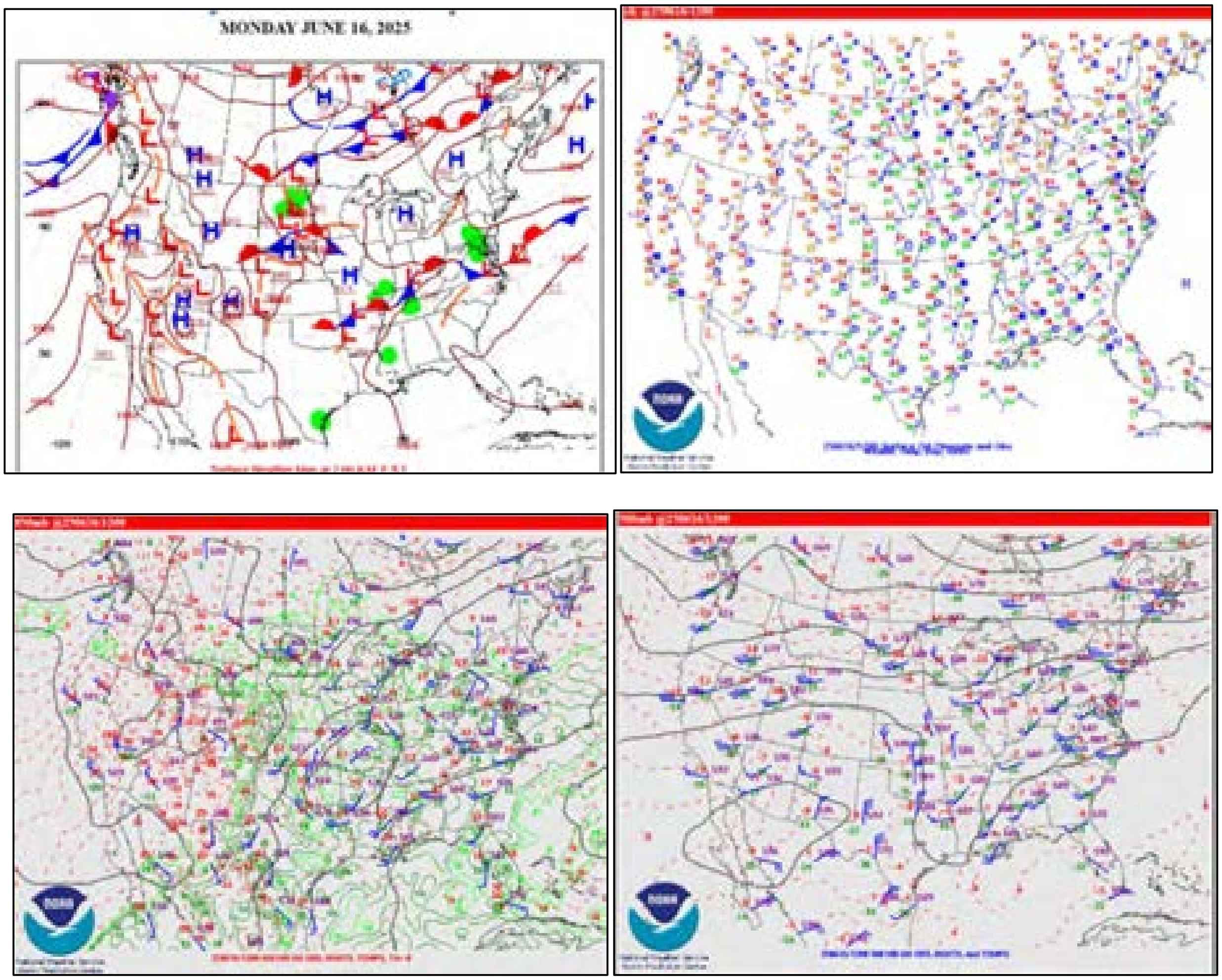
Figure 3.13.1 – Canadian Wildfires June 16, 2025



3.13.2 Meteorological Episode Overview

Zonal flow was evident over the northern portion of the U.S. while an upper air trough was present over the southern U.S. states on June 16. This upper air set up was key in transporting light wildfire smoke from western and central Canadian provinces of British Columbia, Northwest Territories, Alberta, and Ontario. More stagnant conditions were associated with these surface and upper air features. Sunny skies with air temperatures in the mid 80's °F and lower humidity levels in the northern portion of the state helped to maintain conducive ozone conditions. The smoke was persistent throughout the vertically integrated and near surface forecast maps on June 16. The presence of this light to moderate smoke produced elevated levels of ozone throughout the northern portion of Indiana. It is worth noting that the smoke is beginning to exit the state, yet smoke was still present throughout the day. Figure 3.13.2 shows the surface, 850 mb and 500 mb maps of the conditions on June 16.

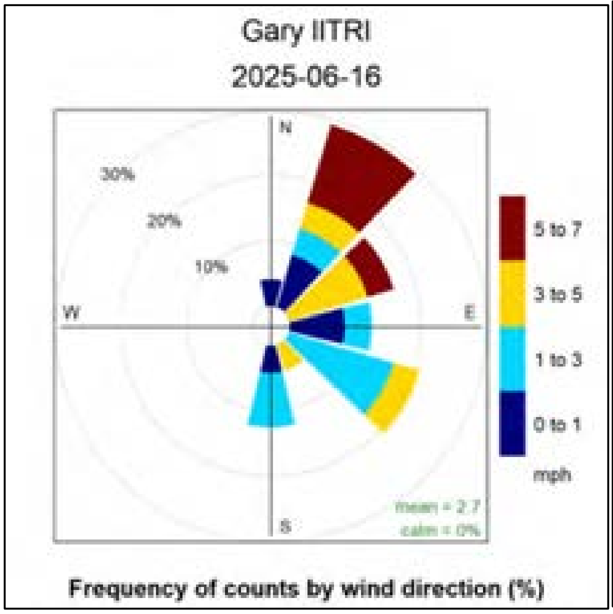
Figure 3.13.2 - Surface, 850 and 500 mb Plots from 12Z on June 16, 2025



Wind rose and pollution rose analyses were taken from the Gary IITRI meteorological station as well as Ogden Dunes. On June 16, winds were light and from the east to northeast due to surface high pressure centered over Michigan and a stationary front to the south over the Ohio River. Conditions remained warm, with wildfire smoke present throughout the vertical column, as confirmed by satellite imagery, GAM analysis, and NASA AOD products. Wind and pollution roses from June 16 also indicate elevated ozone levels. HYSPLIT back trajectories link air masses directly to Canadian fire regions.

These conditions resemble those seen in 2023, when wildfire smoke, known to contain volatile organic compounds (VOCs), intermediate- and semi-volatile organic compounds (IVOCs and SVOCs) likely contributed to enhanced ozone production in the lower troposphere during summer. Reference: [Understanding Volatile Organic Compound Emissions from Wildfires in the Western US with Modeling Comparisons - Climate Program Office]

Figure 3.13.3- Gary IITRI Windrose **Figure 3.13.4 Gary ITRII Pollution Rose**



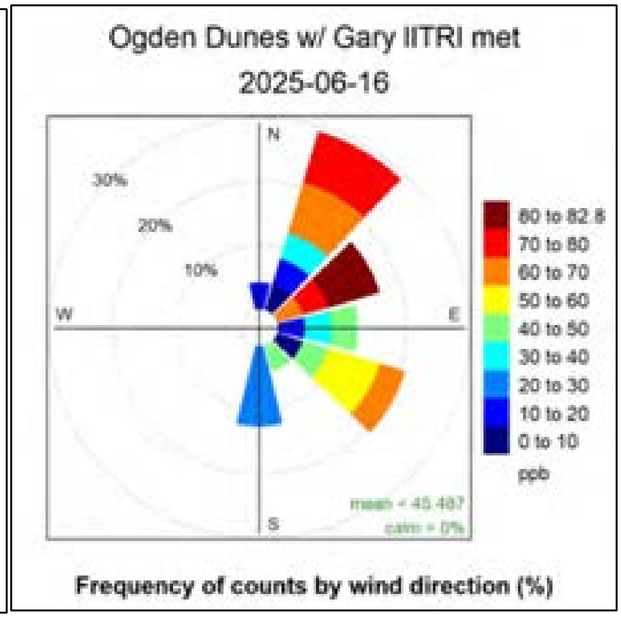
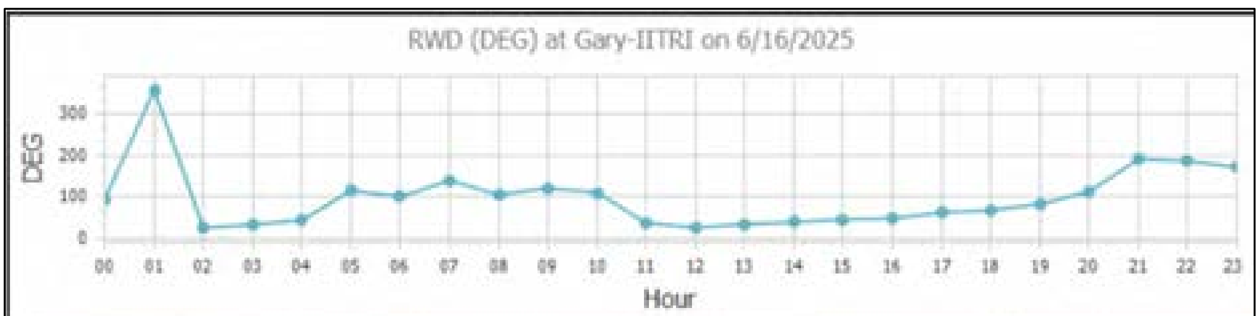


Figure 3.13.5 - Hourly Wind Directions at Gary IITRI for June 16, 2025

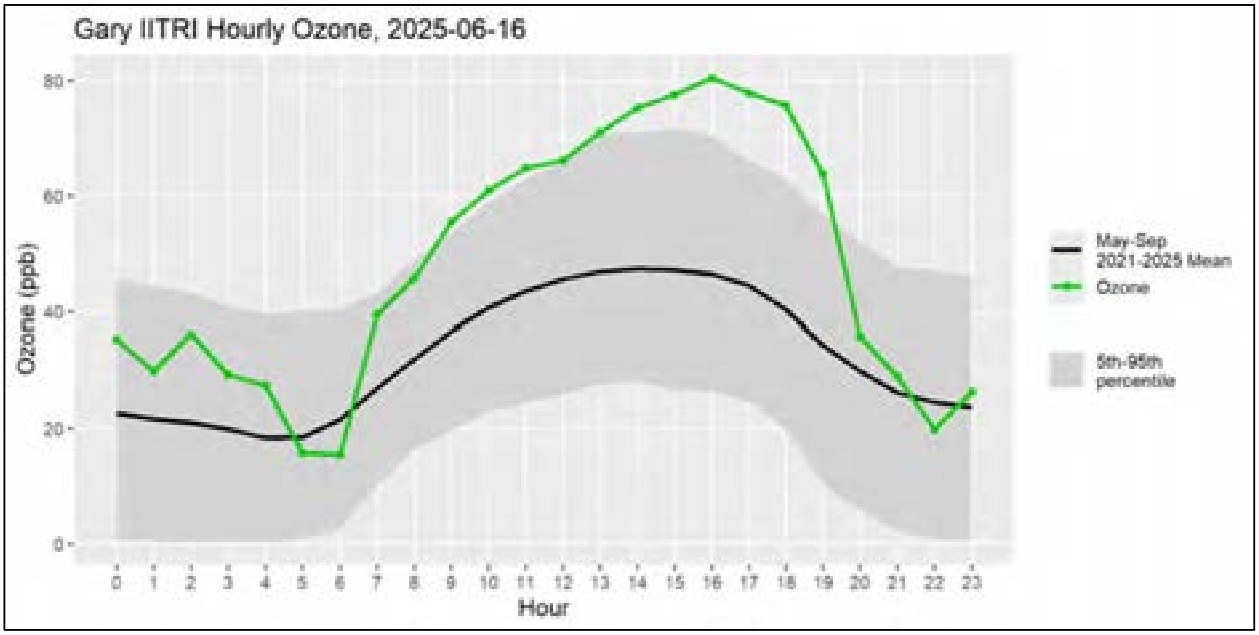


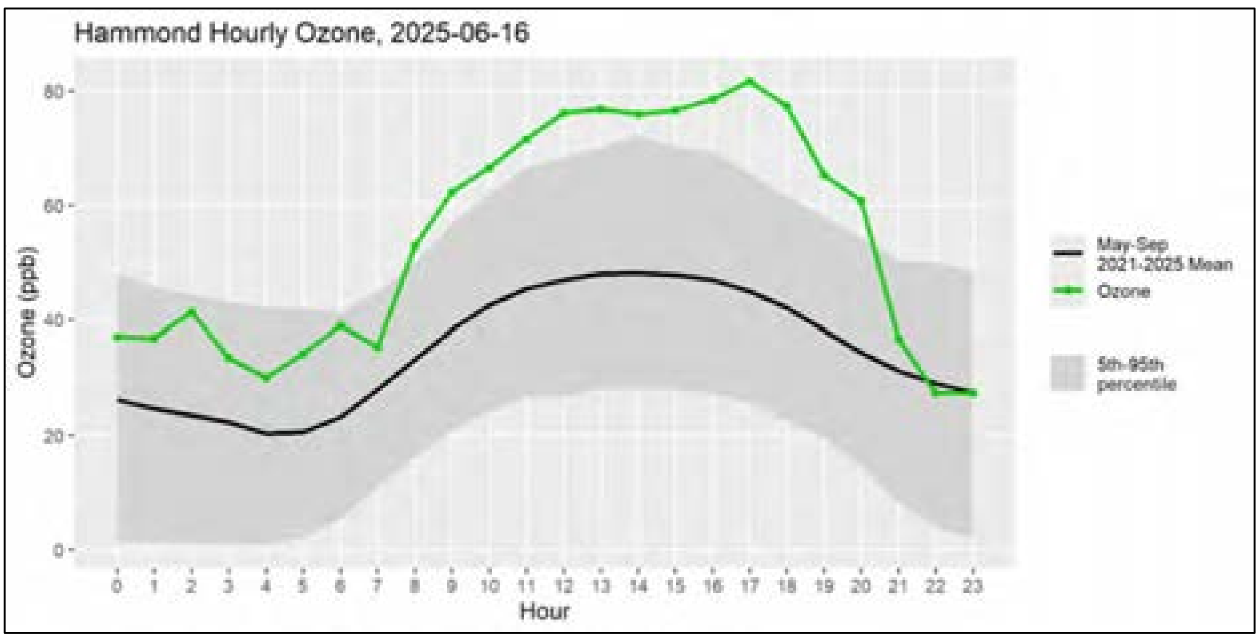
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RWD	95	358	26	34	45	116	101	140	106	122	111	38	27	35	40	47	49	63	69	83	113	192	187	172

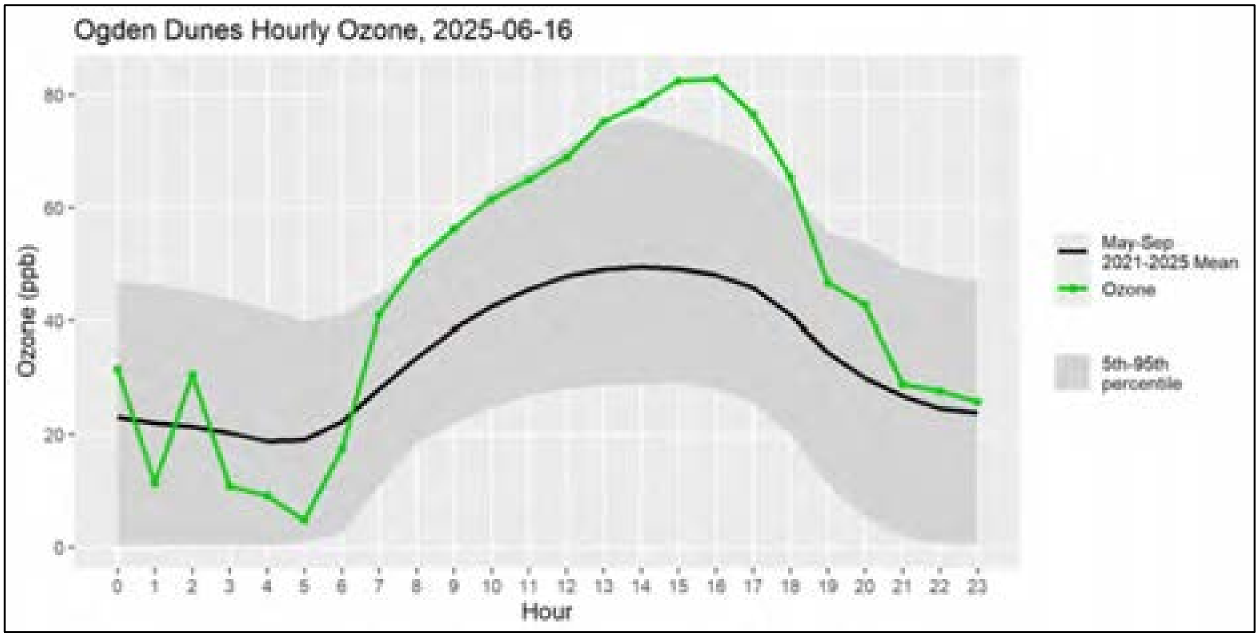
3.13.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for June 16, 2025 for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5^{th} - 95^{th} percentile of those readings, as shown in Figure 3.13.6**.** For most of the day the hourly readings at all three ozone monitors exceeded the 95^{th} percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.13.6 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes June 16, 2025

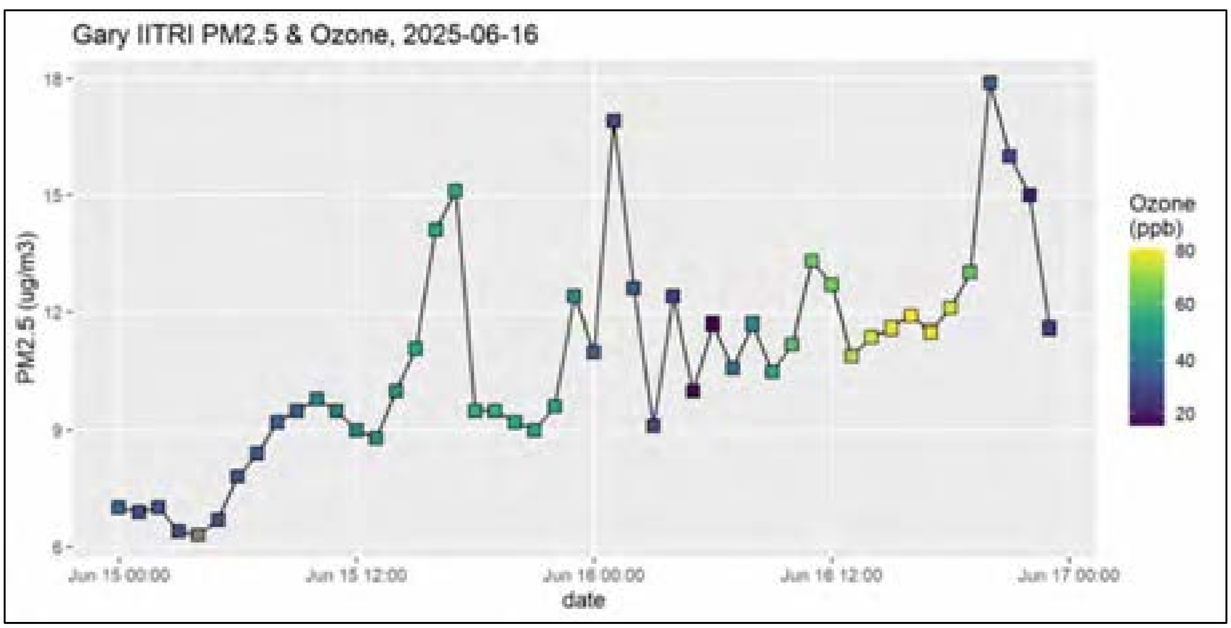






Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for June 16 as shown in Figure 3.11.10. $PM_{2.5}$ concentrations ranged from 9 - 18 ug/m^3

Figure 3.13.7 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data June 16, 2025



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.13.2

shows the percentage above the five-year average. All three pollutants were well above the average.

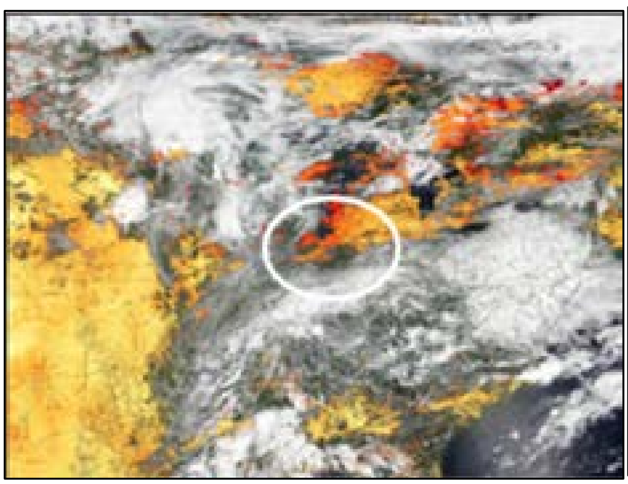
Table 3.13.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
6/16/2025	166%	134%	155%

3.13.4 AOD and Satellite Analyses

Figure 3.13.8 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in Northwest Indiana indicates the presence of smoke.

Figure 3.13.8 - Aerosol Optical Depth (AOD) June 16, 2025



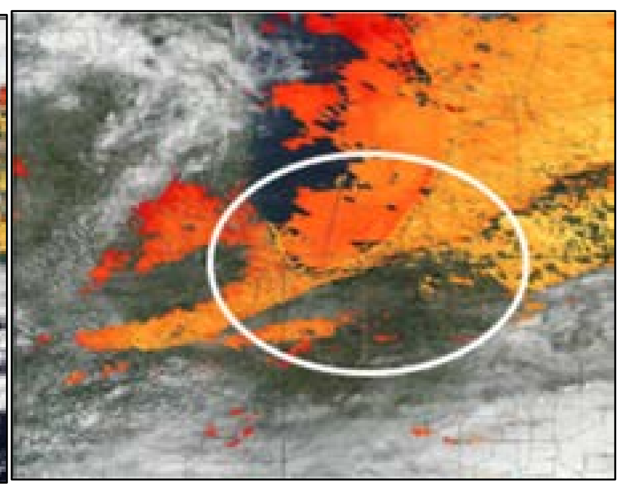
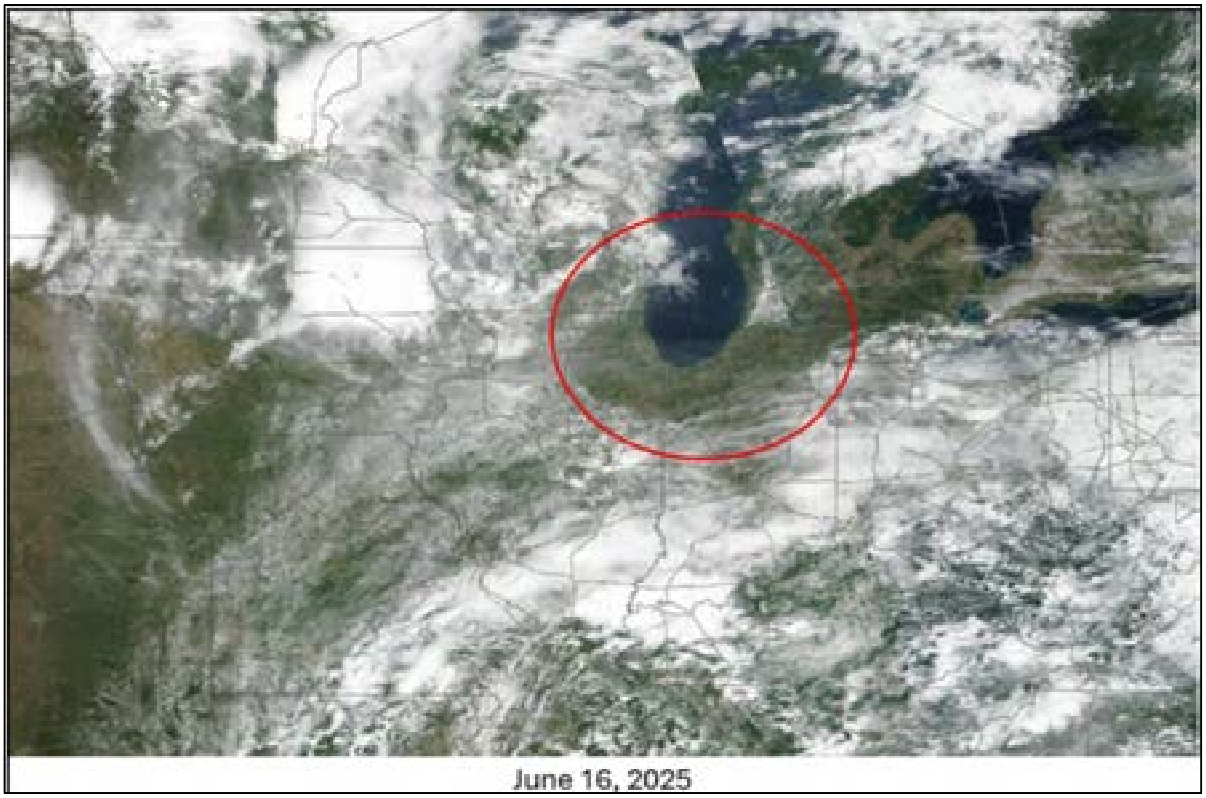
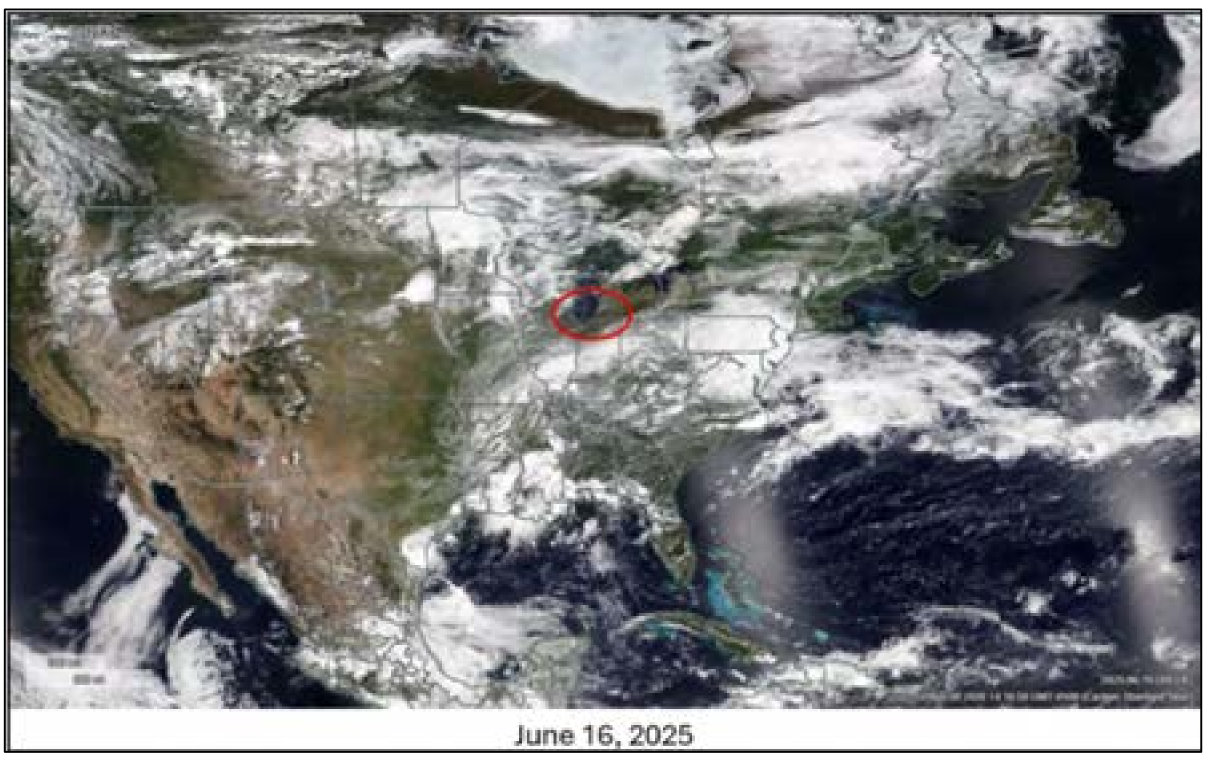


Figure 3.13.9 displays three satellite images indicate Canadian wildfire smoke coming from Manitoba, and Ontario. The image for June 16 shows smoke working into northern Indiana.

Figure 3.13.9 - Satellite Imagery June 16, 2025





The images captured by NOAA's GOES 18 satellite for North America taken June 16, 2025 shows clouds and a plume of gray smoke extending from western Canada to the upper Midwest states. Credit: NOAA NESDIS

3.13.5 NOAA Smoke Narrative

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1652Z June 15, 2025

SMOKE:

Alaska/Pacific Ocean/Canada/Northern and Central United States/Atlantic Ocean... Wildfire activity across northeastern British Columbia, southwestern Northwest Territories, northwestern Alberta, and western Ontario continued to generate moderate to thick smoke, which spread from Alaska, northeastern British Columbia, and Yukon to Quebec and into the North Atlantic Ocean. **Lighter-density smoke blanketed portions of Alaska and the Pacific Ocean off the western coastline; northwestern, central, and eastern Canada; the Midwestern U.S.; and the Upper Great Lakes, moving eastward over the Atlantic toward Europe.** Cloud cover over parts of northwestern and central Canada limited smoke detection in those areas in satellite imagery.

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1500Z June 16, 2025

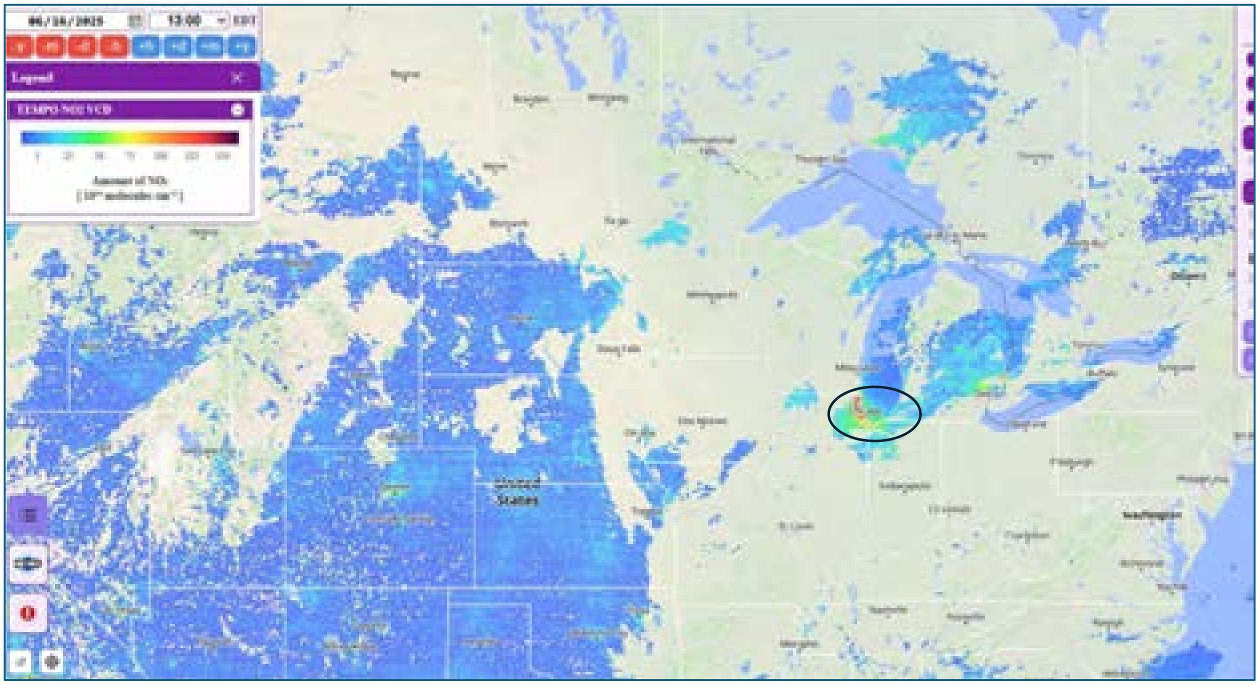
SMOKE:

Alaska/Pacific Ocean/Canada/Northern and Central United States/Atlantic Ocean... Alaska/Pacific Ocean/Canada/Northern and Central United States/Atlantic Ocean... Wildfire activity across northeastern British Columbia, southwestern Northwest Territories, northwestern Alberta, and western Ontario continued to generate light to moderate density smoke, which spread from Alaska, northeastern British Columbia, and Yukon to Quebec and into the North Atlantic Ocean.

3.13.6 TEMPO Satellite Nitrogen Dioxide

The Tropospheric Emissions: Monitoring of Pollutants (TEMPO) mission is part of a constellation of instruments measuring air quality over the Northern Hemisphere. Its measurements from geostationary orbit of ozone, aerosols, and clouds will create a revolutionary dataset that provides understanding and improves prediction of air quality and physical effects on climate. TEMPO sensors use NO_2 as one indicator to identify and track wildfire plumes.

Figure 3.13.10 TEMPO Hourly NO2 Concentrations

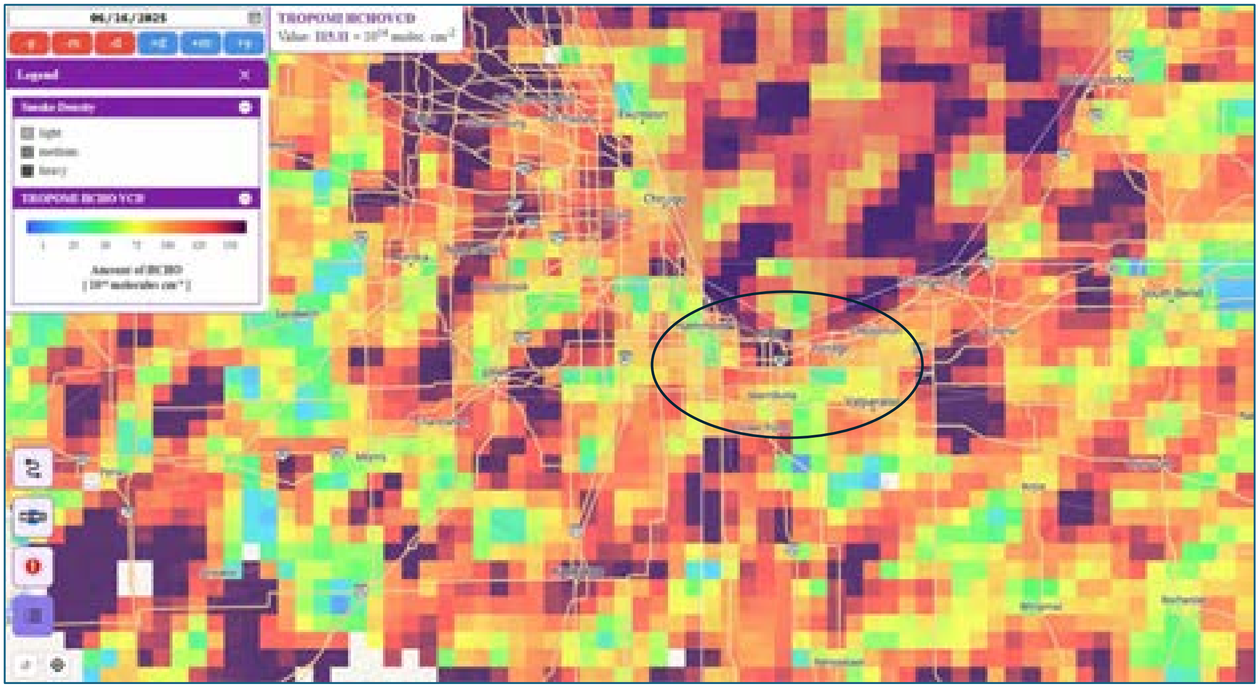


Despite the lack of local fires, North Bay and much of Southern Ontario were frequently impacted by heavy smoke drifting from massive out-of-control blazes in Northwestern Ontario (such as Red Lake 12) and the Prairies. This smoke triggered several Special Air Quality Statements across the province in early to mid-June. Back trajectories for June 16 track air from the North Bay Ontario area.

3.13.7 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.13.11 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 4-16 × 10^{15} molecules/cm^2 indicate moderate to extreme wildfire smoke influence.

Figure 3.13.11- TROPOMI Satellite Daily Formaldehyde Monitoring



3.13.8 AirNow Smoke Maps

AirNow shows in Figures 3.13.12 through 3.13.15 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.13.12 - AirNow Ozone Map - June 16, 2025

Figure 3.13.13 - AirNow $PM_{2.5}$ Map - June 16, 2025

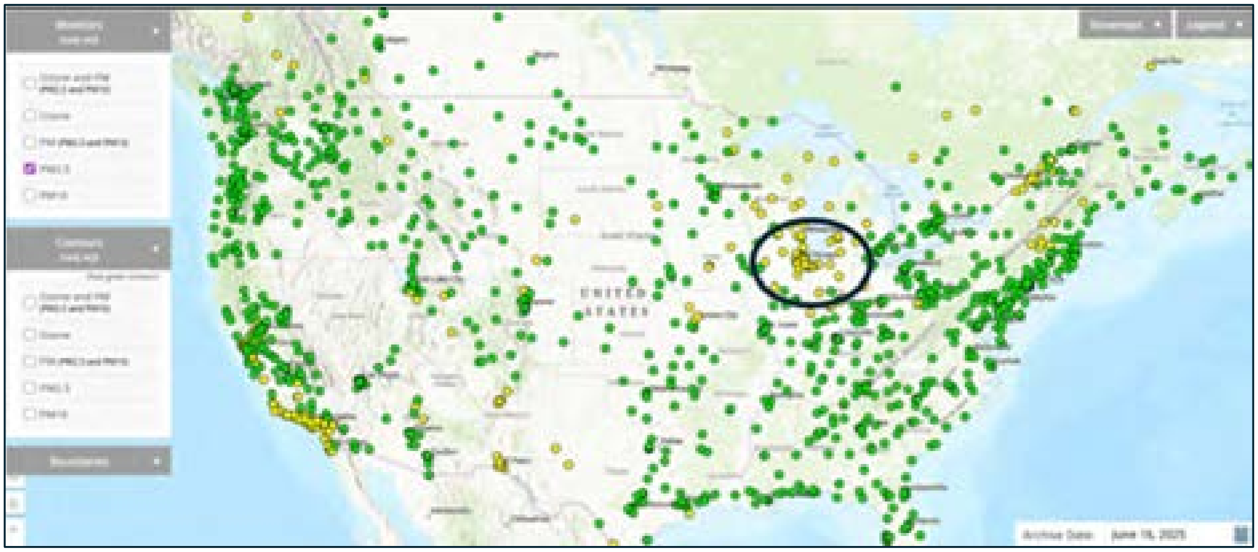


Figure 3.13.14 - AirNow Ozone Map - June 16, 2025

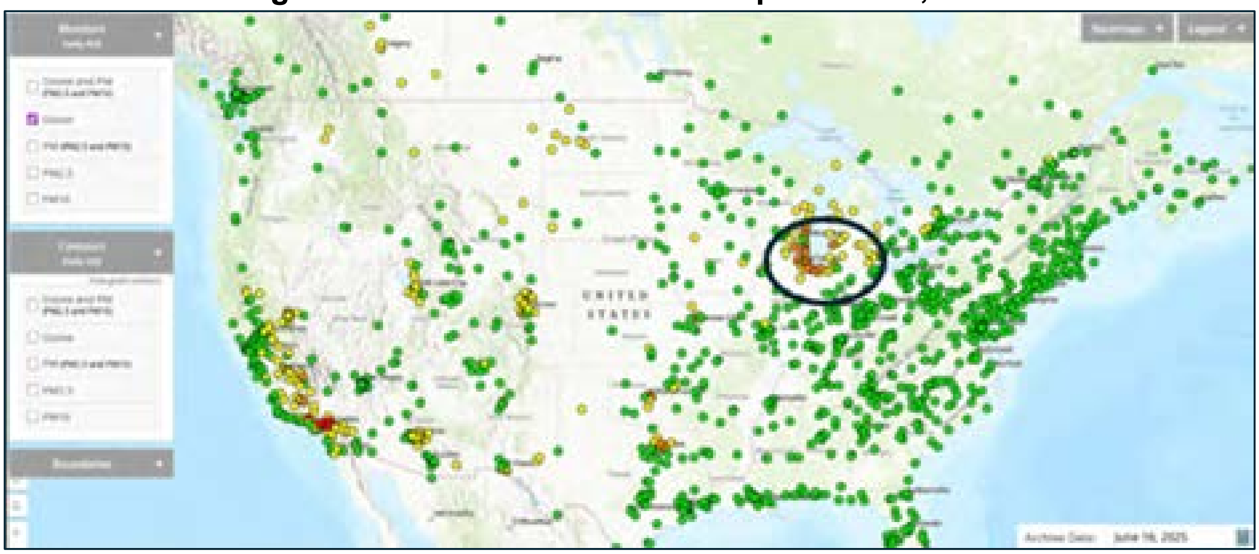
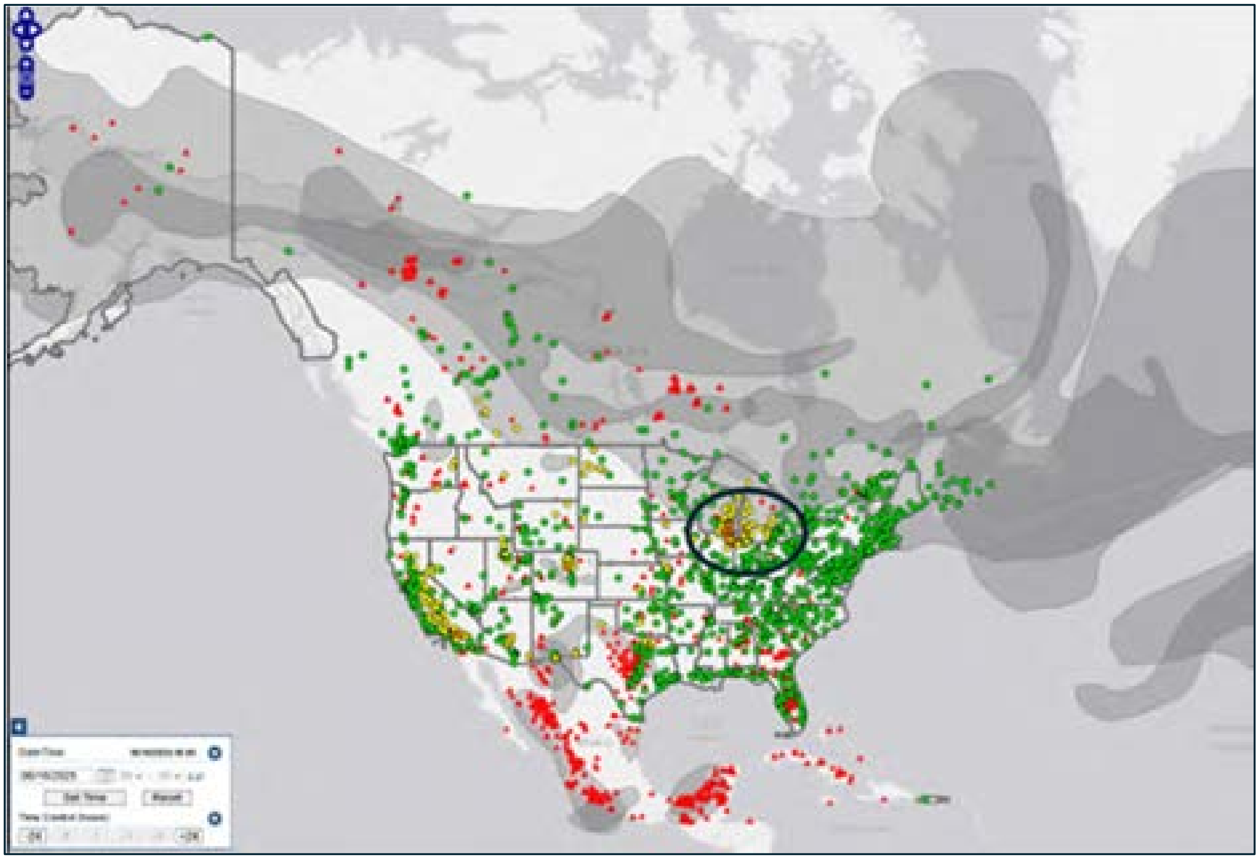


Figure 3.13.15 - AirNow Smoke and Ozone Map - June 16, 2025



3.13.9 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes. EMBER has not been updated to include 2025 data.

Figures 3.13.16 through 3.13.18 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM.

Figure 3.13.16 - GAM Smoke Maps Indicating Smoke Days - June 16, 2025

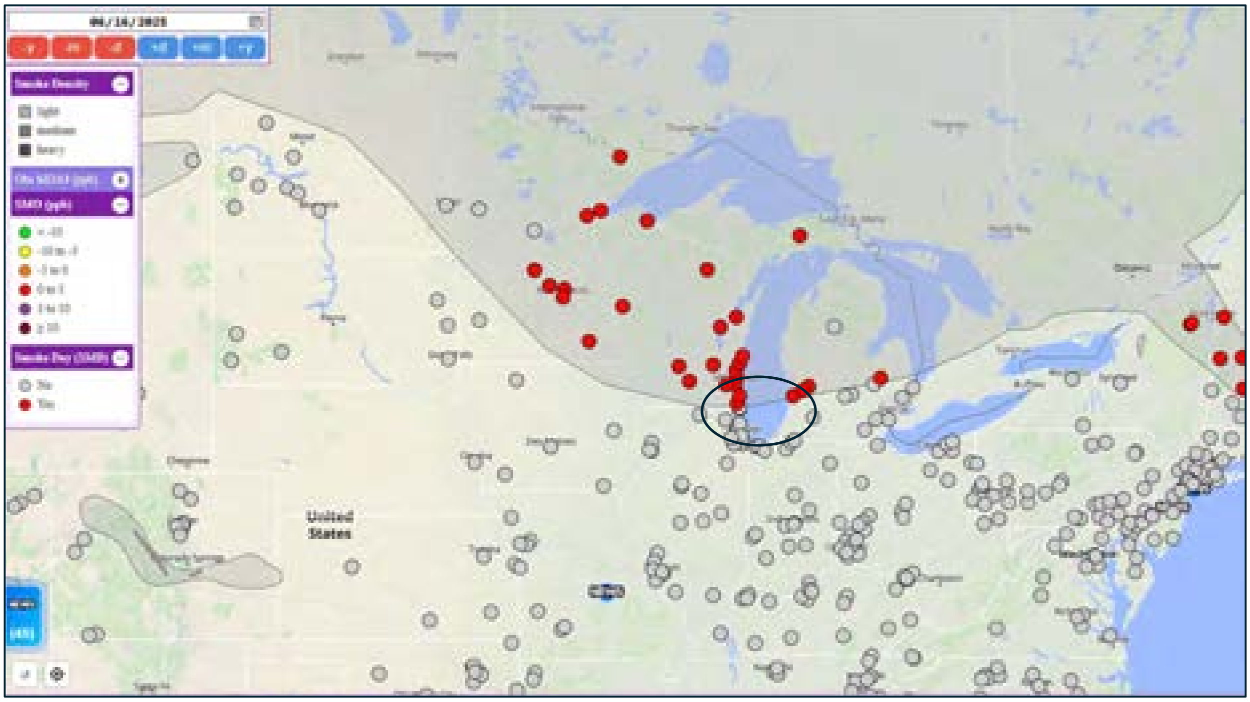


Figure 3.13.17 - GAM Smoke Maps Indicating Smoke Days - June 16, 2025

Figure 3.13.18 - GAM Smoke Maps Indicating Smoke Days - June 16, 2025

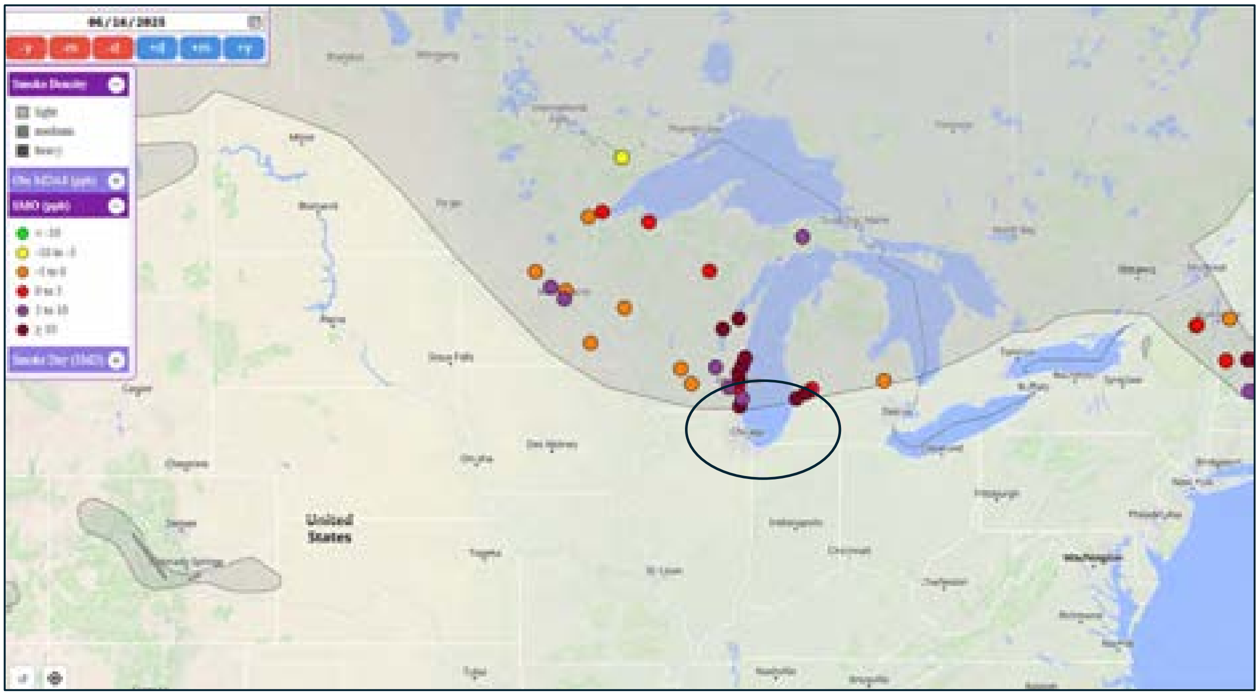


Table 3.13.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.13.3 - Observed versus GAM and EMBER Predicted MDA 8-hour Ozone Values

Site ID	Site Name	Observed 8-hour MDA Ozone (PPB)	GAM Predicted 8-hour MDA Ozone (PPB)	GAM Smoke Influenced 8-hour MDA Ozone (PPB)	EMBER Predicted 8-hour MDA Ozone (PPB)	EMBER Smoke Influenced 8-hour MDA Ozone (PPB)
180890022	Gary-IITRI	73	58.3	14.7	NA	NA
180892008	Hammond	76	NA	NA	NA	NA
181270024	Ogden Dunes	67	62.2	4.8	NA	NA
181270026	Valparaiso	63	60	3	NA	NA

3.13.10 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on June 16, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.13.3 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 11 ppb lower than the MDA8 ozone concentrations observed on May 30 with the maximum matching day MDA8 ozone concentration of 77.2 ppb.

Table 3.13.3 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values June 16, 2025

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	67	77.2*	56.1

* Indicates Matching days were influenced by wildfire smoke

3.13.11 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red). And higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. The HMS smoke layers become less opaque as the density of smoke increases. June 16 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure 3.13.21 increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) with higher concentrations found around Ontario.

Figure 3.13.19 – Back Trajectories - June 16 50, 100 and 500 meters (-72 hours)

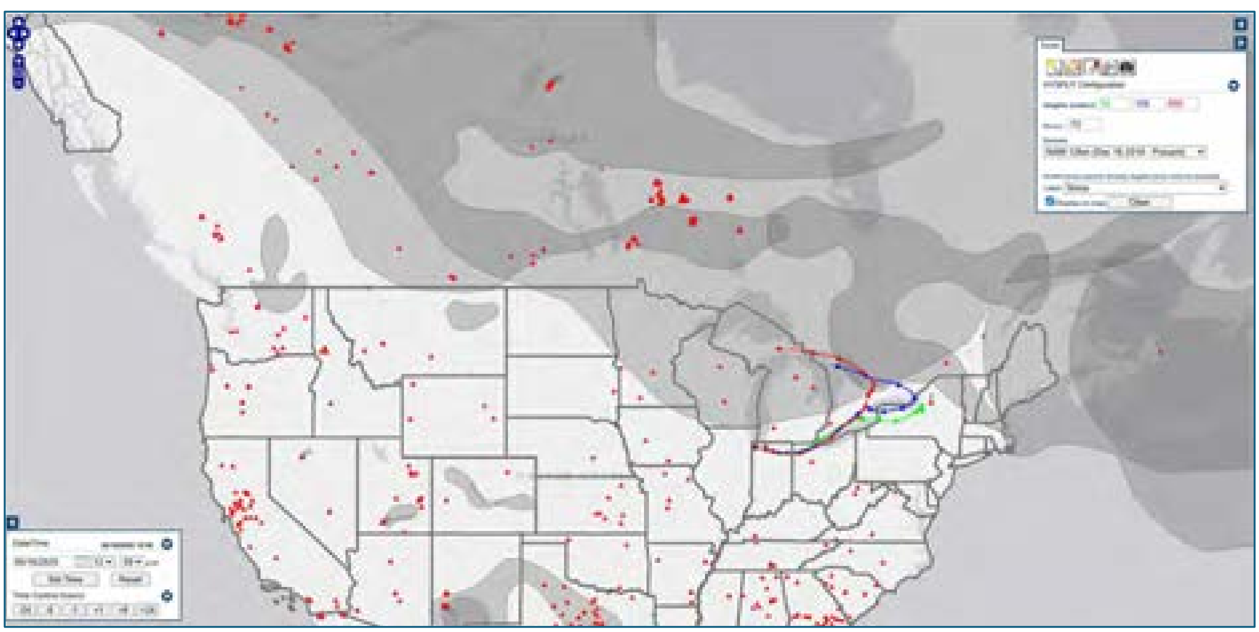


Figure 3.13.20 – Back Trajectories - June 16 1000, 2000 and 3000 meters (-72 hours)

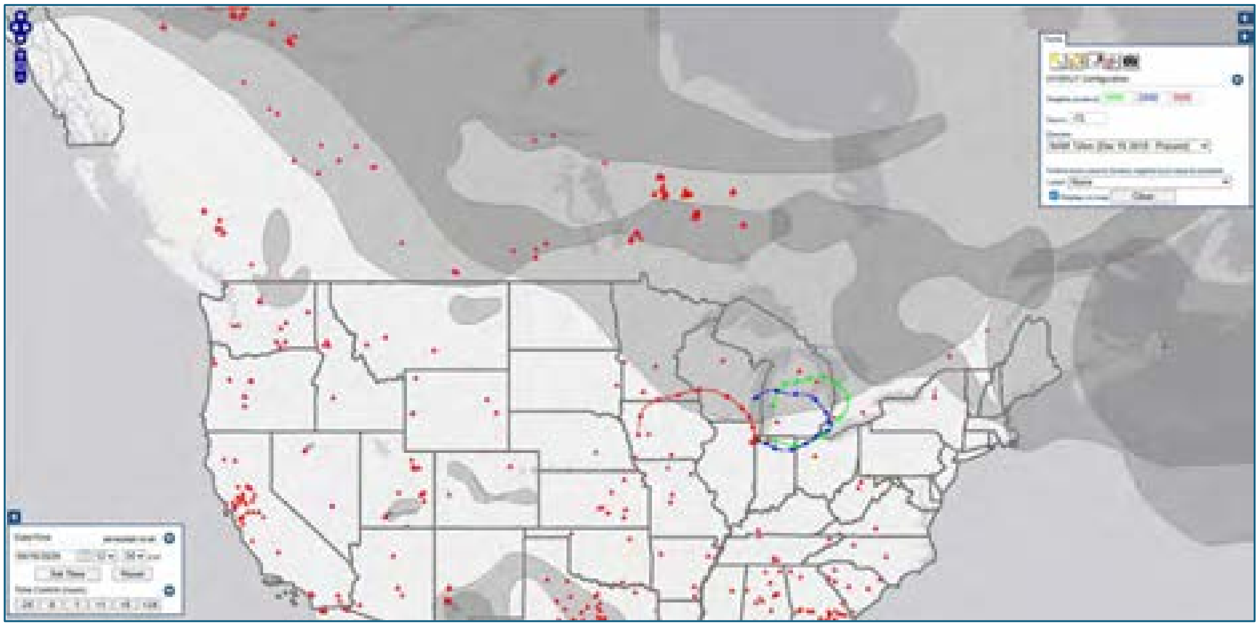
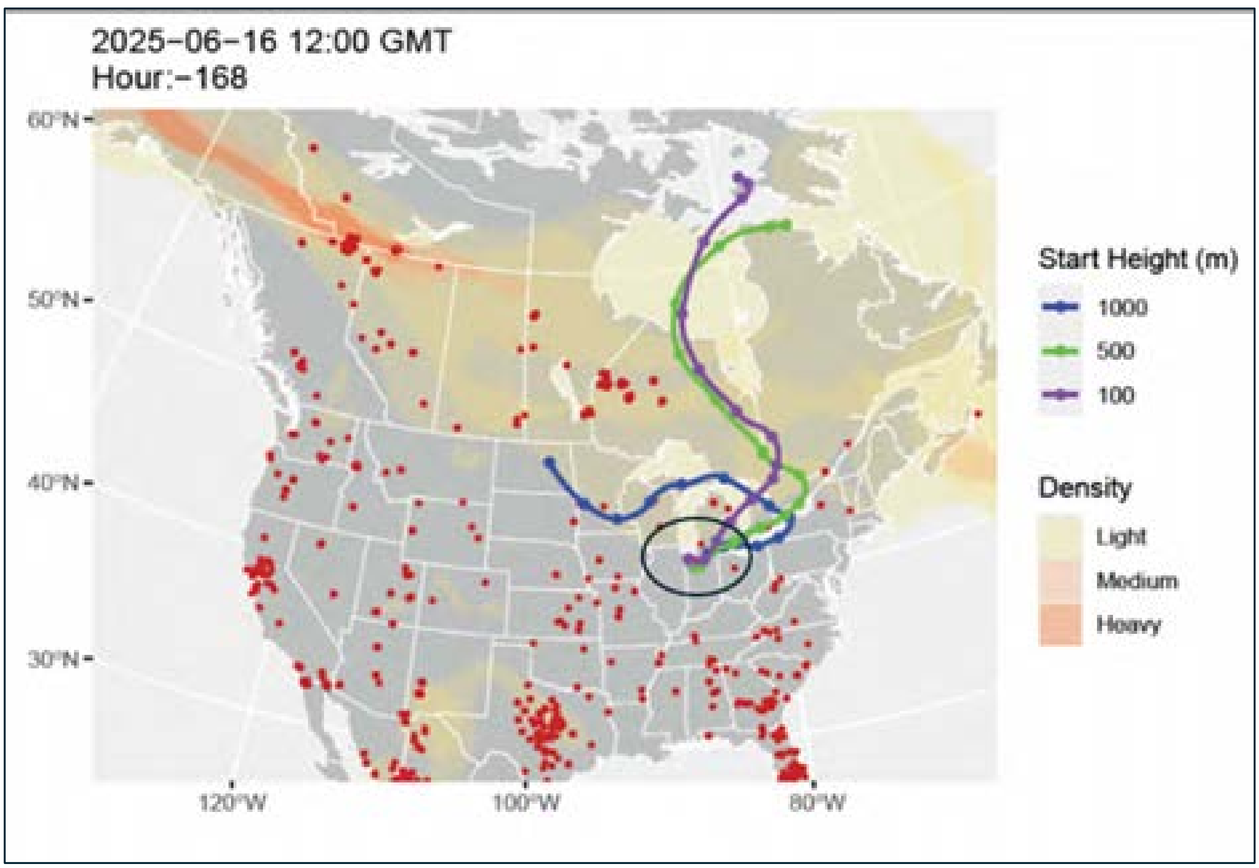


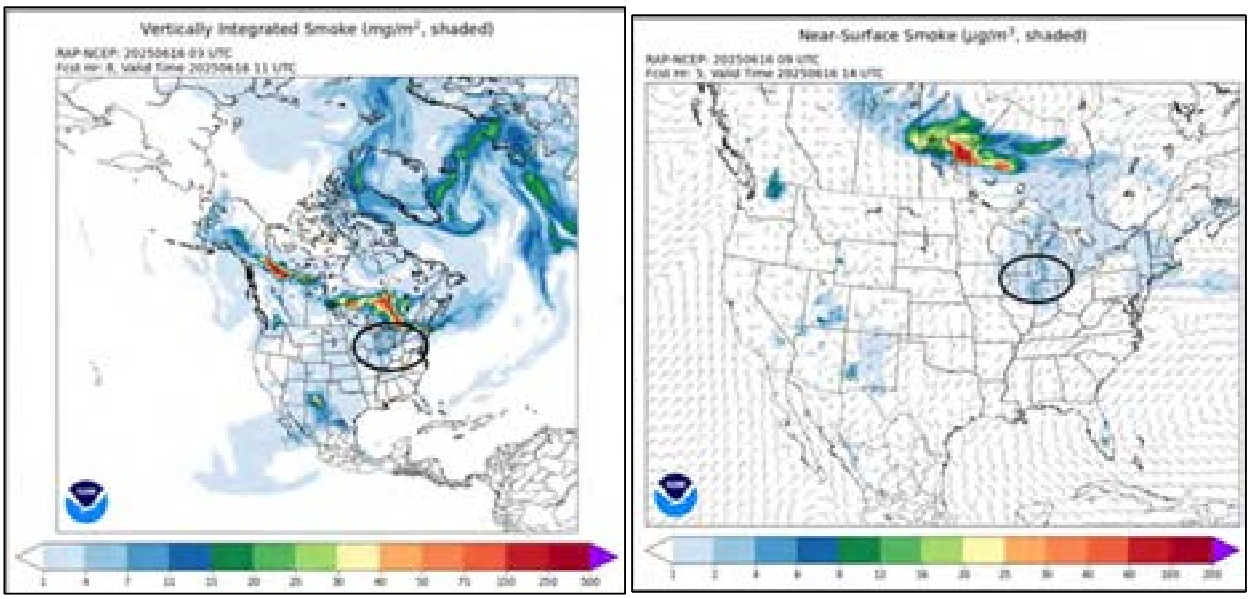
Figure 3.13.21 – Back Trajectories - June 16, 100, 500 and 1000 meters (-168 hours)



3.13.12 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.13.22 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.13.22 HRRR Smoke Model



3.13.13 Media Mentions

FIRE BULLETIN #61

WILDFIRE NEAR TWO ONTARIO FIRST NATIONS ‘LIKE A SLEEPING GIANT’ FOR NOW, MPP SAYS

MASSIVE NORTHWESTERN FOREST FIRE THE BIGGEST EVER MEASURED IN THE PROVINCE

NASA’S TEMPO INSTRUMENT AIR QUALITY DATA NOW PUBLICLY AVAILABLE

3.13.14 Summary of Requested Exclusion of Jun 16, 2023

Table 3.13.4 - Summary Table Ogden Dunes

Event Date	**June 16, 2025**
MDA8 Ozone Concentration (PPB)	73
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	No
Does TEMPO Satellite imagery show elevated NO2?	Yes
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	No
GAM predicted MDA8 ozone (PPB)	66.2
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	NA
Matching day MDA8 ozone (max., avg.) (PPB)	77.2*, 56.1
HYSPLIT indicated wildfire regions	EA061 Fire, Manitoba and Red Lake 12 fire, Ontario
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

3.14 July 2, 2025

3.14.1 Executive Summary

On July 2, 2025, Northwest Indiana experienced ozone exceedances across all Lake and Porter County monitors, with values ranging from 70-75 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM analyses estimate 11-12 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to Shoe/Camp Fire and Muskeg Fire, Saskatchewan.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of July 2, 2025, as an exceptional event under U.S. EPA guidelines.

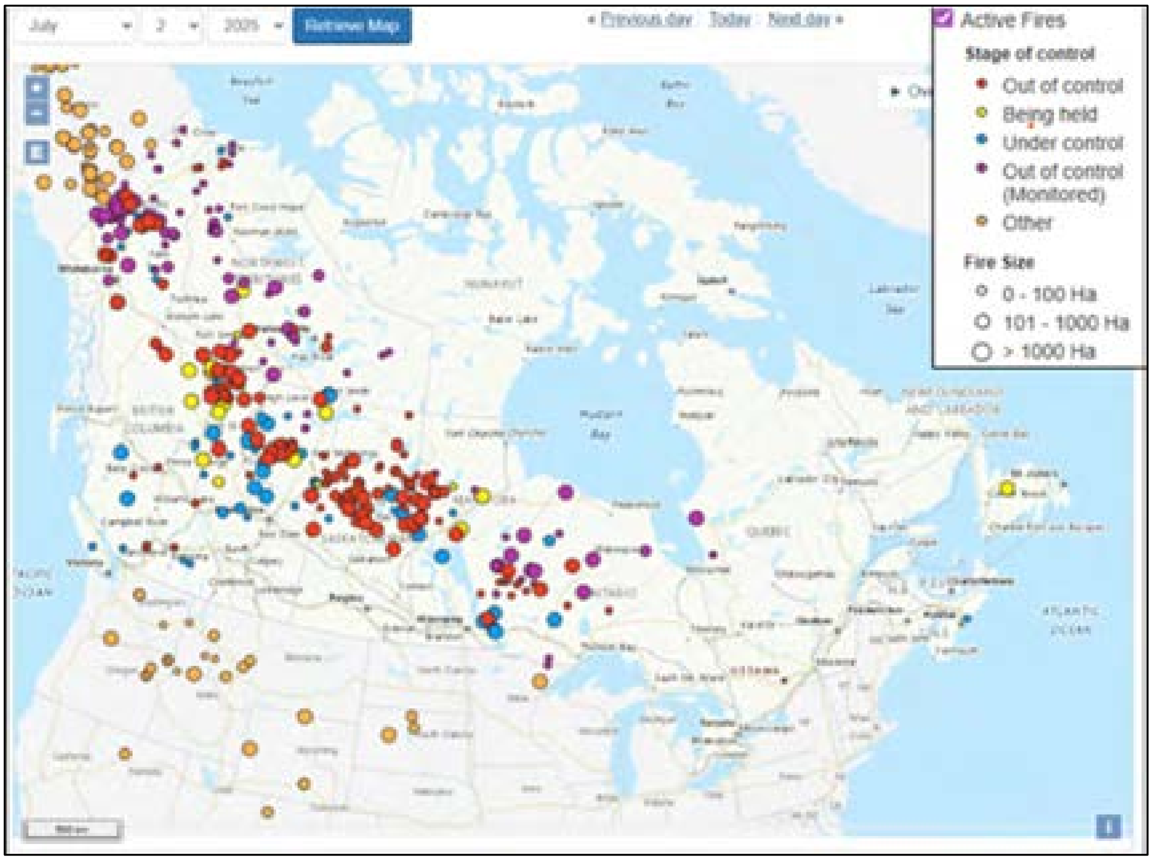
Table 3.14.1 July 2, 2025 Lake and Porter County MDA 8-Hour Ozone Values (PPB)

Date	Gary -IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
July 2, 2025	73	70	75	64

On July 2, 2025 multiple Canadian wildfires, as shown in Figure 3.14.1, contributed ground level smoke that caused three of the four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter counties in July 2025 included the:

- Shoe Fire and the Camp Fire, which were among the largest in Canada in 2025. These fires burned from early-May through mid-August, burning over 565,000 hectares (approximately 1.4 million acres) at their peak.
- Muskeg Fire, which was a massive, uncontrolled blaze in northern Saskatchewan that reached over 192,850 hectares by mid-July. It directly threatened the communities of Beauval, La Plonge, and Jans Bay.

Figure 3.14.1 – Canadian Wildfires July 2, 2025



3.14.2 Meteorological Episode Overview

Deep upper air trough existed over the Midwest while upper air ridging was evident of the western ½ of the U.S. on July 1. This upper air set allowed transport of light wildfire smoke from Saskatchewan province as well as southeastern Nevada wildfires, as noted by NOAA Smoke Narrative. As these systems moved east, more stagnant conditions were associated with these surface and upper air features on July 2. Sunny skies with air temperatures in the mid to upper 80's ^{o}F and dewpoints in the 60's ^{o}F in the northern portion of the state helped to maintain conducive ozone conditions. The light smoke was persistent throughout the vertically integrated and near surface forecast maps on July 2. The presence of this light smoke helped to produce elevated levels of ozone throughout state. Figure 3.14.2 shows the surface, 850 mb and 500 mb maps of the conditions on July 1 while Figure 3.14.3 shows those maps on July 2

Figure 3.14.2 - Surface, 850 and 500 mb Plots from 12Z on July 1, 2025

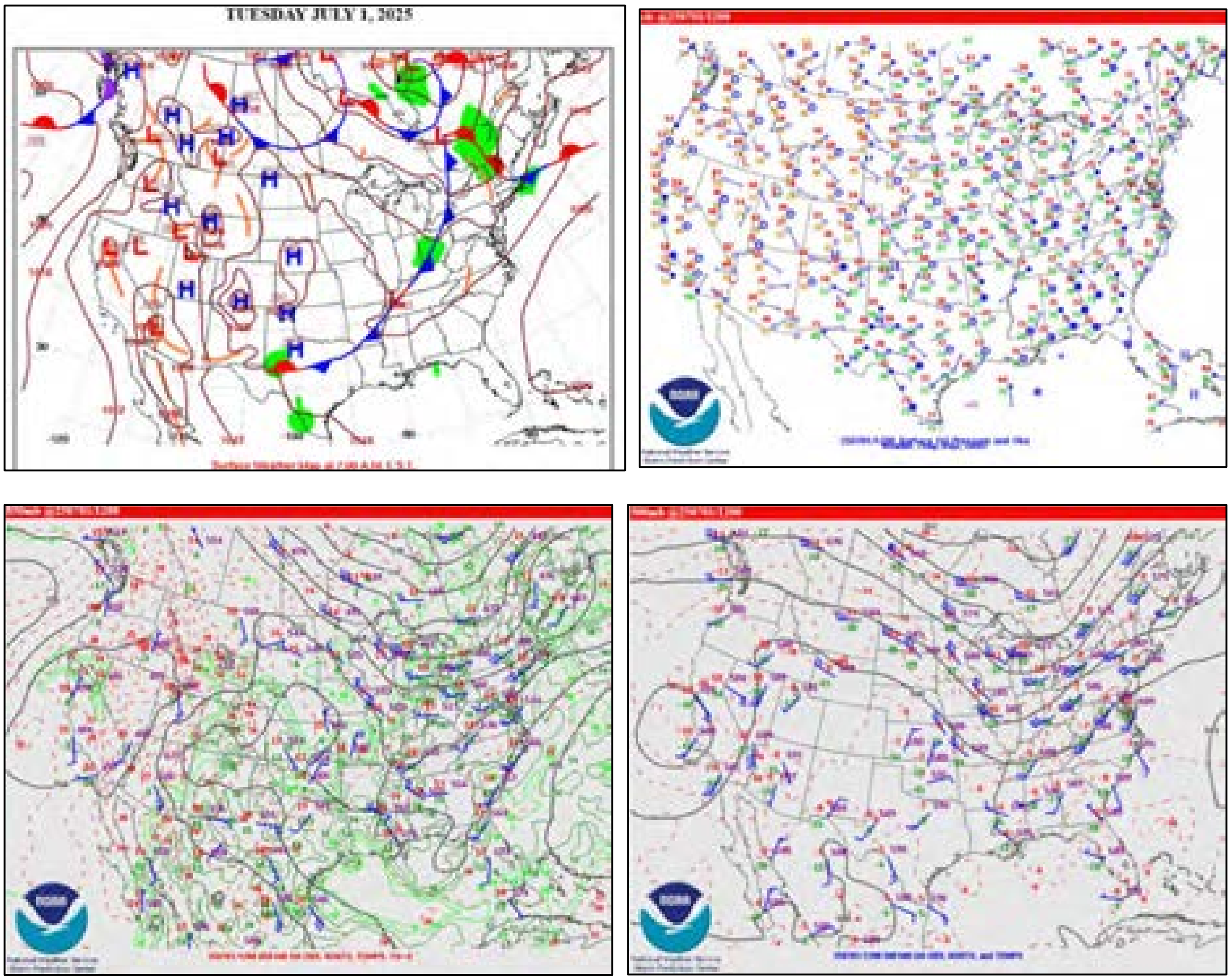
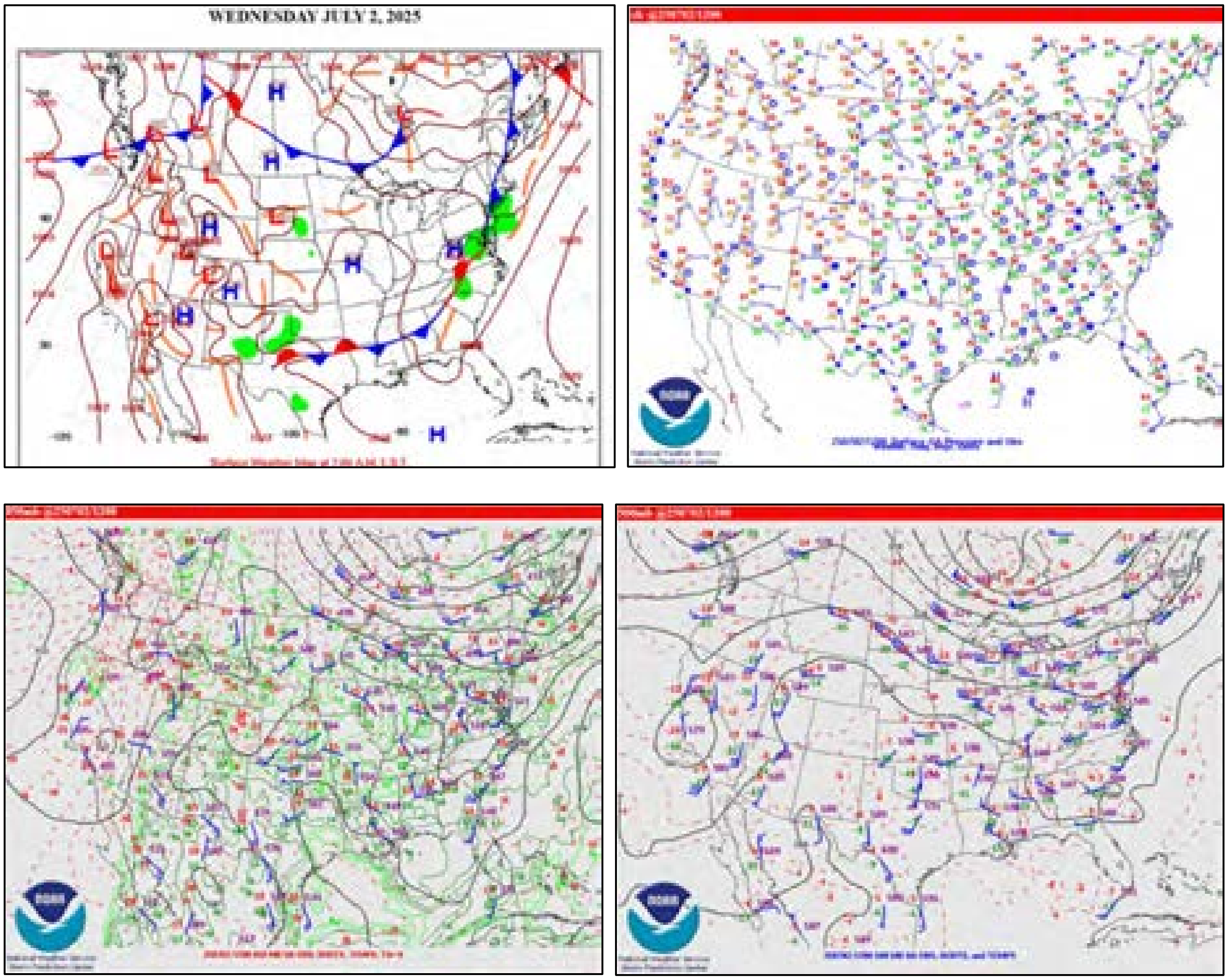


Figure 3.14.3 Surface, 850 and 500 mb Plots from 12Z on July 2, 2025



Light Canadian wildfire smoke drifted southward under northwesterly flow, with the heaviest plumes remaining well north of Indiana during July 1–2. Wind rose and pollution rose analyses from the Gary IITRI and Ogden Dunes stations were reviewed. On June 2, a cold front moved southeast in the early morning hours, shifting winds to a northerly component and allowing Canadian wildfire smoke to move back into the region. Conditions remained warm with lower humidity, but wildfire smoke was present throughout the vertical column, as confirmed by satellite imagery, GAM analysis, and NASA AOD products. Wind and pollution roses from June 2 also indicate elevated ozone levels. HYSPLIT back trajectories link the air masses directly to Canadian fire regions.

These conditions resemble those seen in 2023, when wildfire smoke, known to contain volatile organic compounds (VOCs), intermediate- and semi-volatile organic compounds (IVOCs and SVOCs) likely contributed to enhanced ozone production in the lower troposphere during summer. Reference: Understanding Volatile Organic Compound

[Emissions from Wildfires in the Western US with Modeling Comparisons - Climate Program Office]

Figure 3.14.4- Gary IITRI Windrose

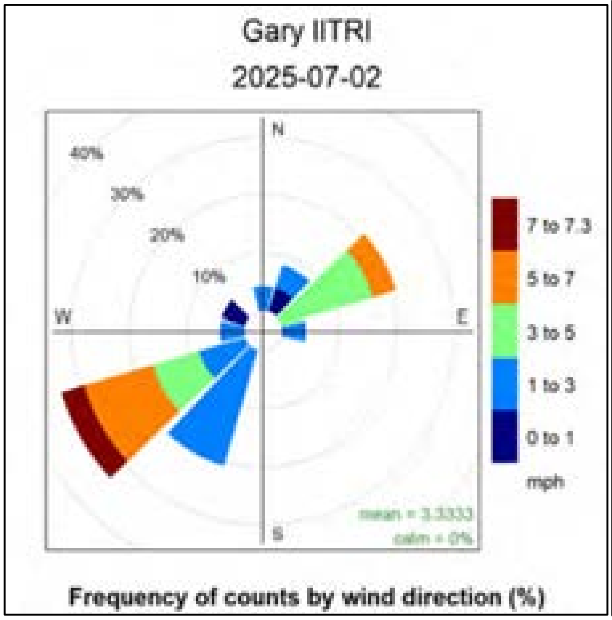


Figure 3.14.5 Gary ITRII Pollution Rose

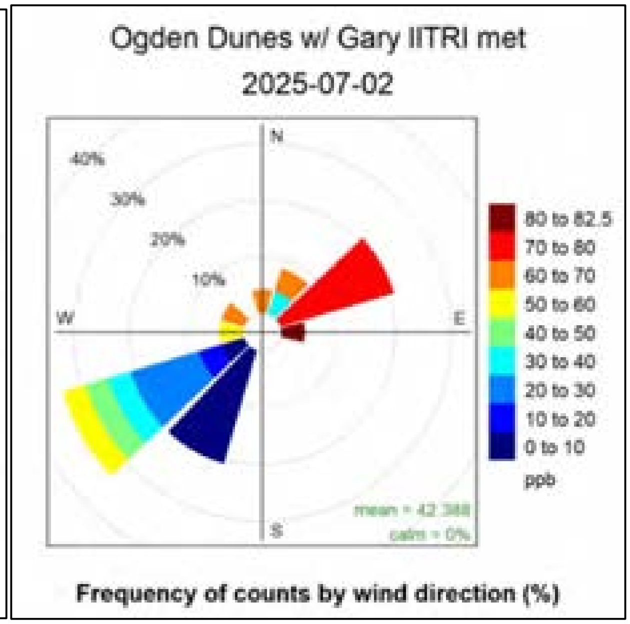


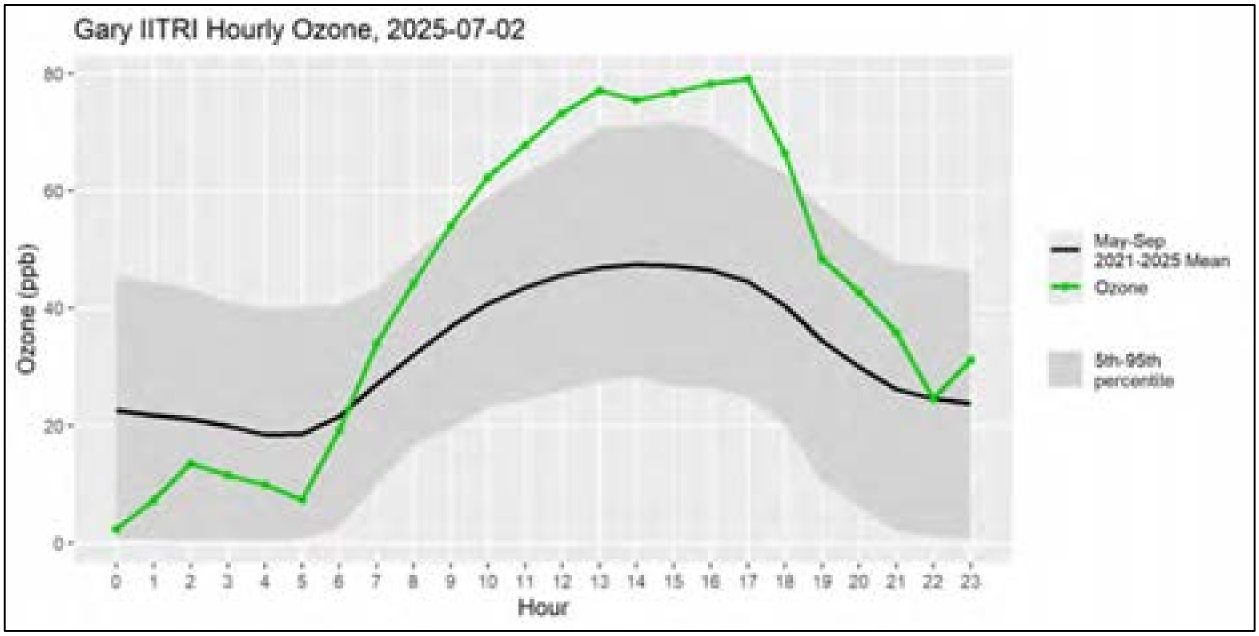
Figure 3.14.6 - Hourly Wind Directions at Gary IITRI for July 2, 2025

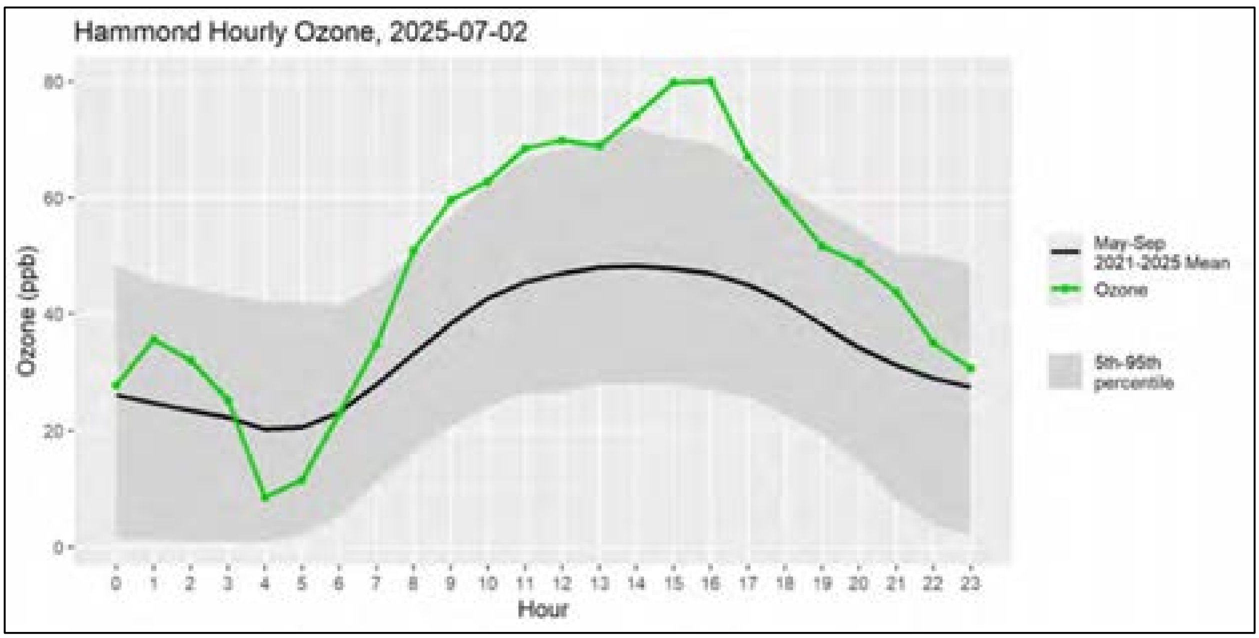
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RWD	203	209	217	198	200	230	250	253	248	274	7	35	46	59	52	53	51	76	295	255	249	232	233	26

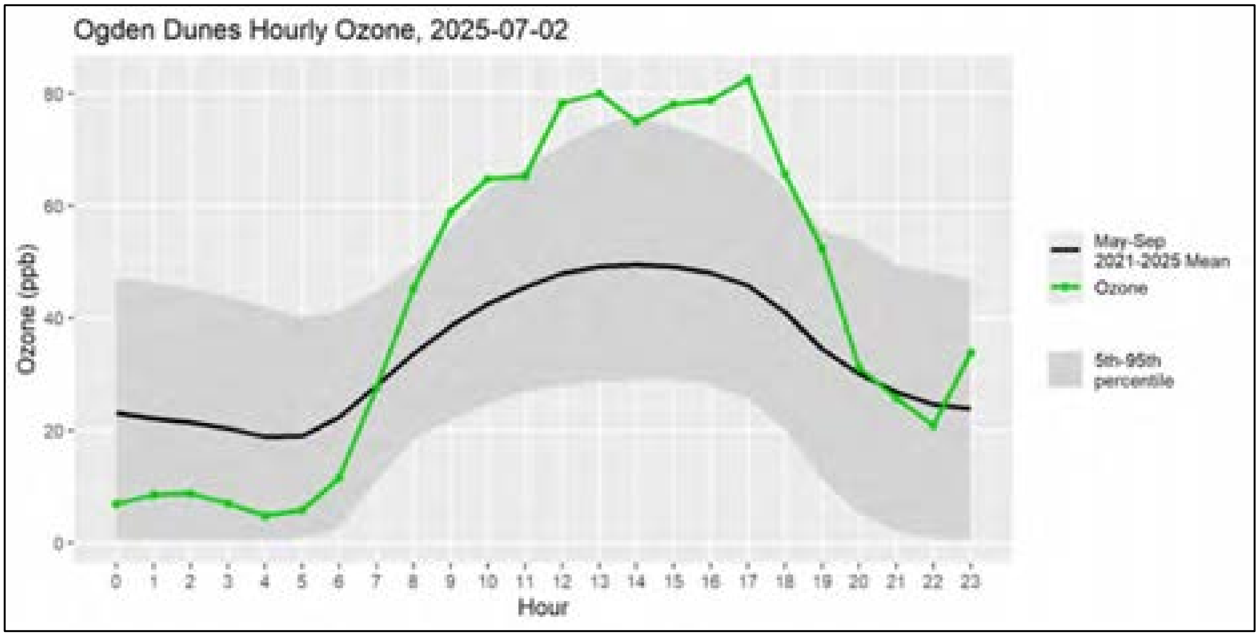
3.14.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for July 2, 2025, for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5^{th} - 95^{th} percentile of those readings, as shown in Figure 3.14.7. For most of the day the hourly readings at all three ozone monitors exceeded the 95^{th} percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.14.7 - Ozone Diurnal Pattern for Gary IITRI, Hammond and Ogden Dunes July 2, 2025

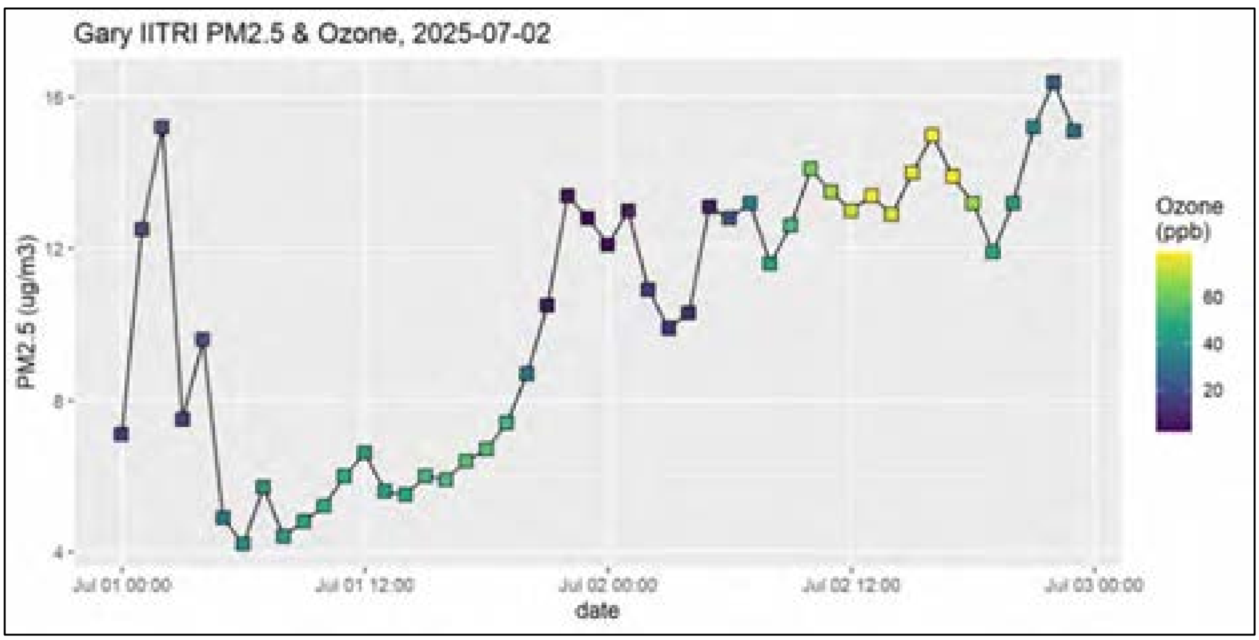






Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for May 22 - 23 as shown in Figure 3.14.8. $PM_{2.5}$ concentrations ranged from 10 - 17 ug/m^3.

Figure 3.14.8 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data July 2, 2025



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.14.2

shows the percentage above the five-year average. NO_2 was well above the average, CO and BC were below the average.

Table 3.14.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
7/2/2025	95%	129%	41%

3.14.4 AOD and Satellite Analyses

Figure 3.14.9 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of smoke.

Figure 3.14.9 - Aerosol Optical Depth (AOD) July 2, 2025

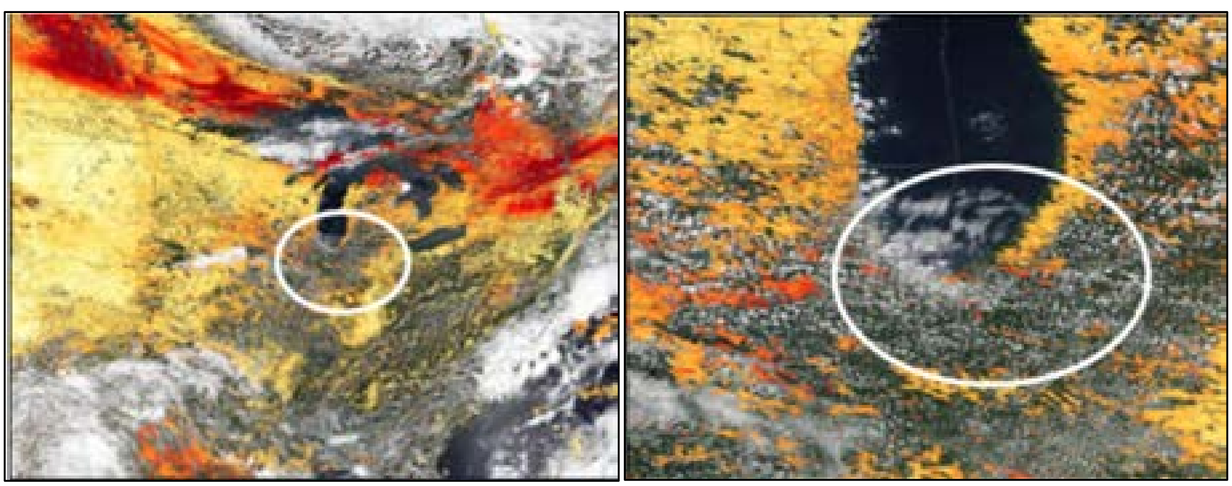


Figure 3.14.10 displays three satellite images indicate Canadian wildfire smoke coming from Manitoba, Saskatchewan and Alberta. The image for July 2 shows smoke working into northern Indiana.

Figure 3.14.10 - Satellite Imagery July 2, 2025

July 2, 2025

July 2, 2025

The images captured by NOAA's GOES 18 satellite for North America taken July 2, 2025 shows clouds and a plume of gray smoke extending from western Canada to the upper Midwest states. Credit: NOAA NESDIS

3.14.5 NOAA Smoke Narrative

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1500Z July 2, 2025

SMOKE:

Alaska/Yukon/Canada…

Extensive wildfire activity central and southern Yukon, eastern British Columbia, southwestern Northwest Territories, and much of Alberta and Saskatchewan continued to produce a widespread area of light to moderate density smoke. This smoke extended from northwestern Alaska eastward across central Canada into western Quebec. The highest smoke concentrations were centered over northern Alberta and northern Saskatchewan, with embedded pockets of moderate to locally dense smoke linked directly to active fire clusters.

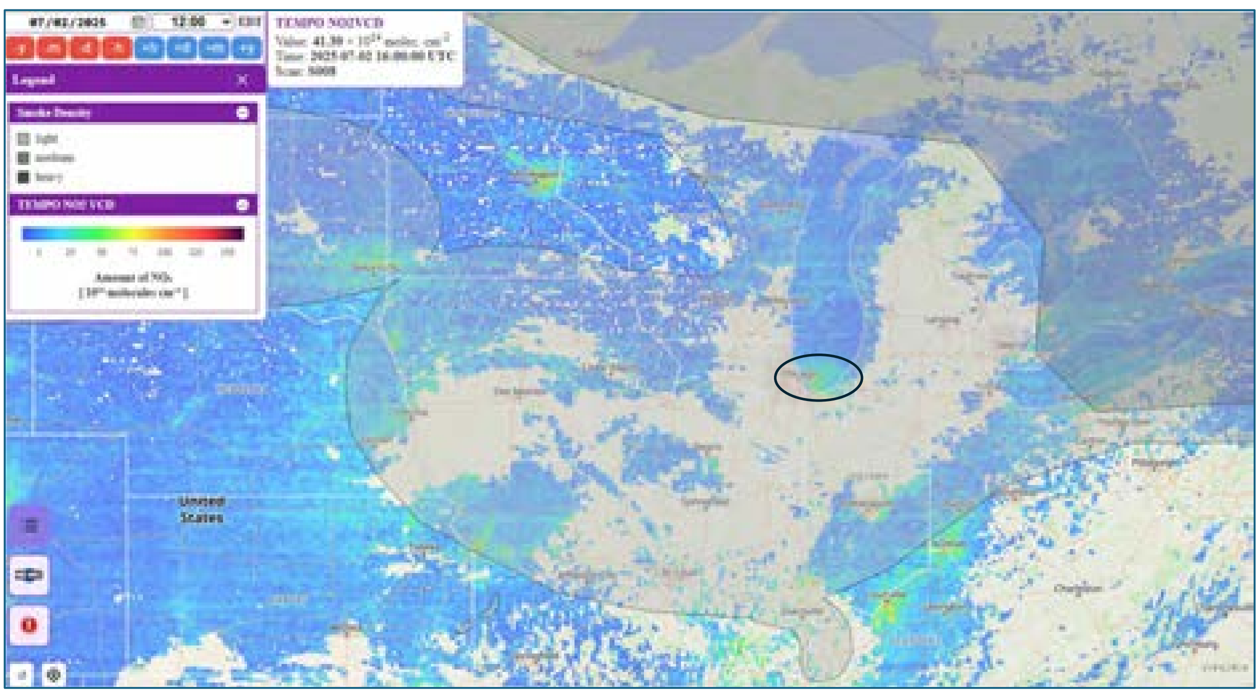
Central and Eastern United States…

As a result of the fires in Southeastern Nevada, a large patch of light smoke was present across the central Plains, drifting eastward into parts of the Midwest and Ohio Valley.

3.14.6 TEMPO Satellite Nitrogen Dioxide

TEMPO sensors use NO_2 as one indicator to identify and track wildfire plumes.

Figure 3.14.11 TEMPO Hourly NO_2 Concentrations July 2, 2025



3.14.7 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.14.12 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 8-16 × 10^{15} molecules/cm^2 indicate strong to extreme wildfire smoke influence.

Figure 3.14.12- TROPOMI Satellite Daily Formaldehyde Monitoring

3.14.8 AirNow Smoke Maps

AirNow shows in Figures 3.14.13 through 3.14.16 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.14.13 - AirNow Ozone Map - July 2, 2025

Figure 3.14.14 - AirNow $PM_{2.5}$ MAP - July 2, 2025

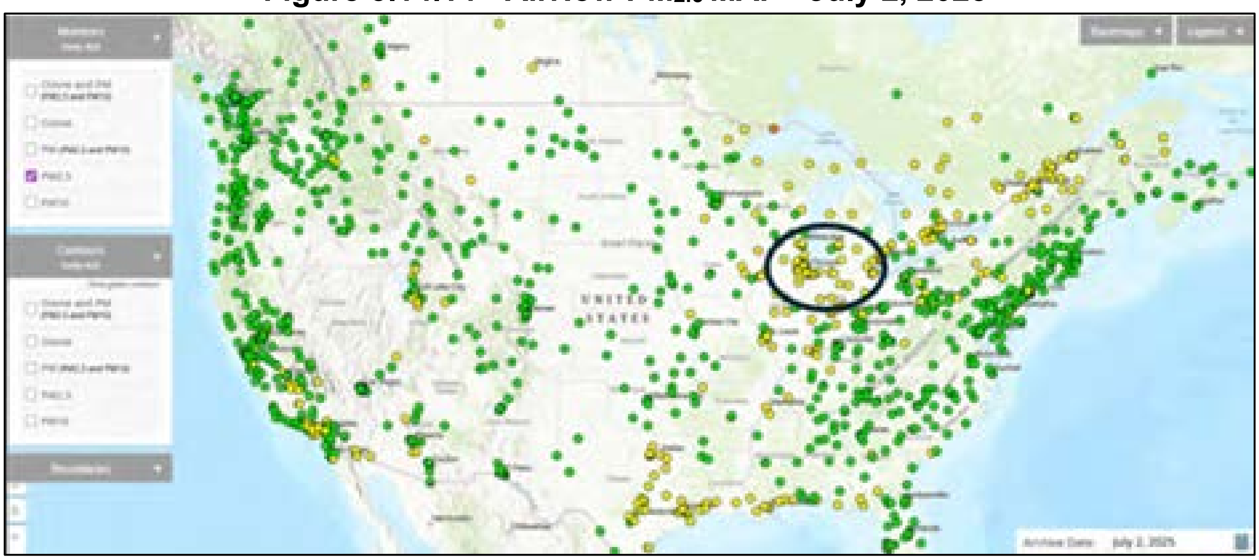


Figure 3.14.15 - AirNow Ozone Map - July 2, 2025

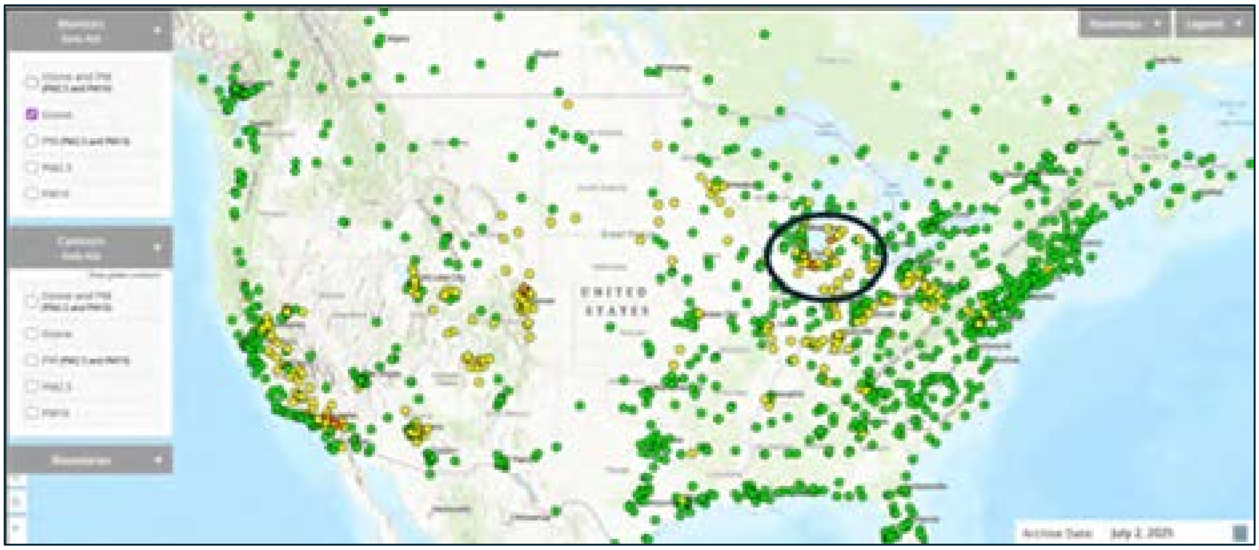
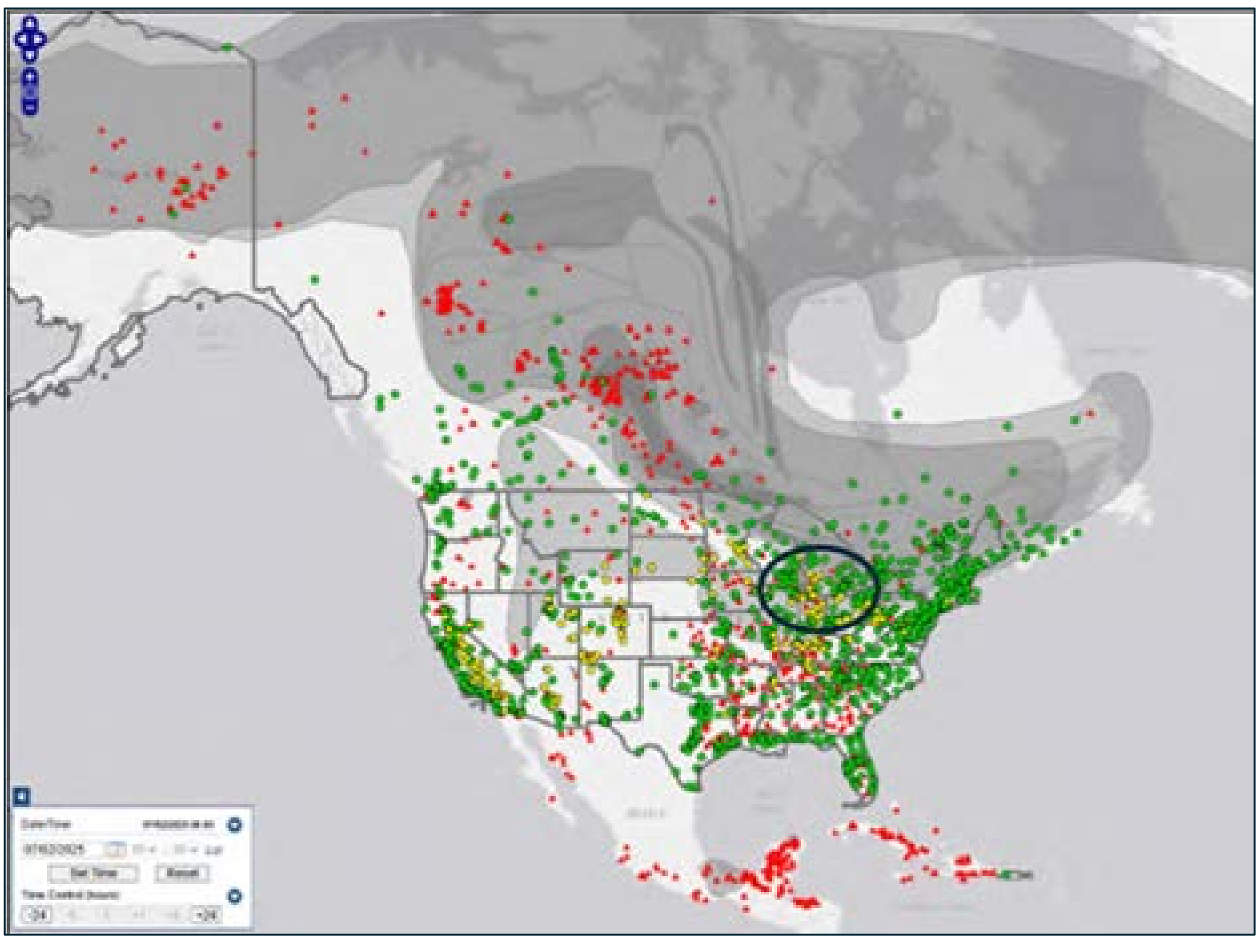


Figure 3.14.16 - AirNow Smoke Ozone Map - July 2, 2025



3.14.9 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes. EMBER has not been updated to include 2025 data.

Figures 3.14.17 through 3.14.19 indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER.

Figure 3.14.17 - GAM Smoke Maps Indicating Smoke Days July 2, 2025

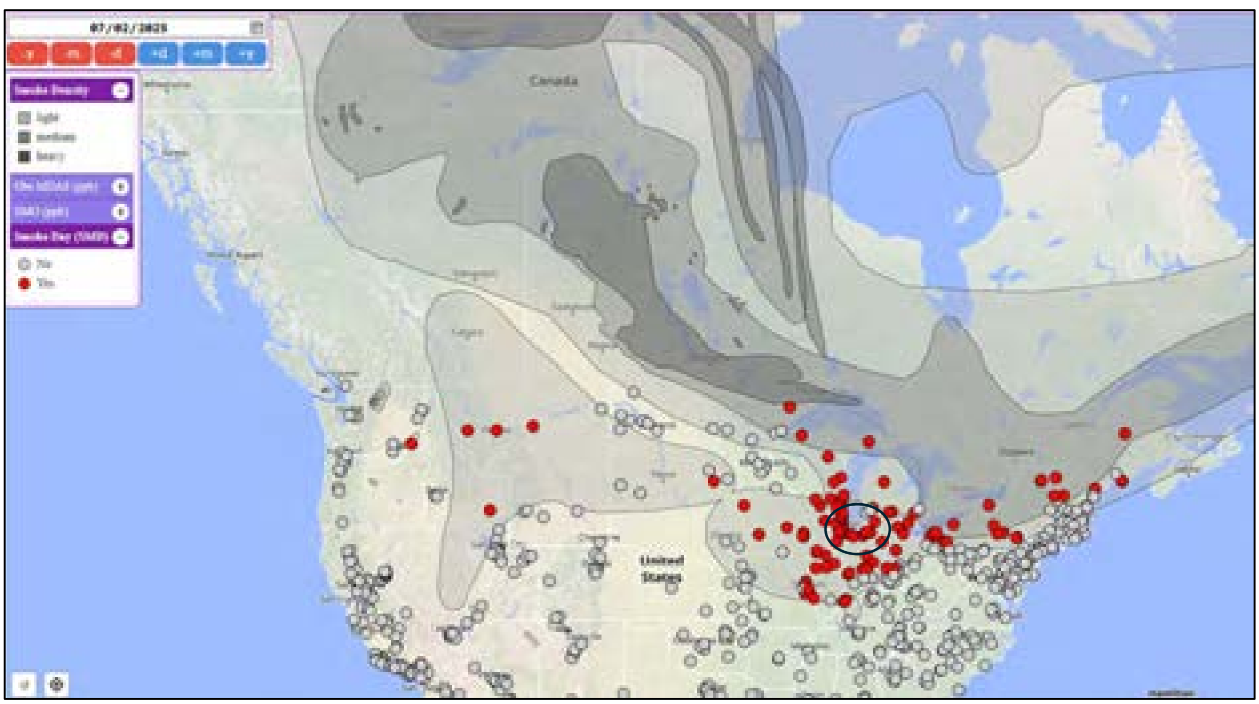


Figure 3.14.18 - GAM Smoke Map and PM2.5 Values July 2, 2025

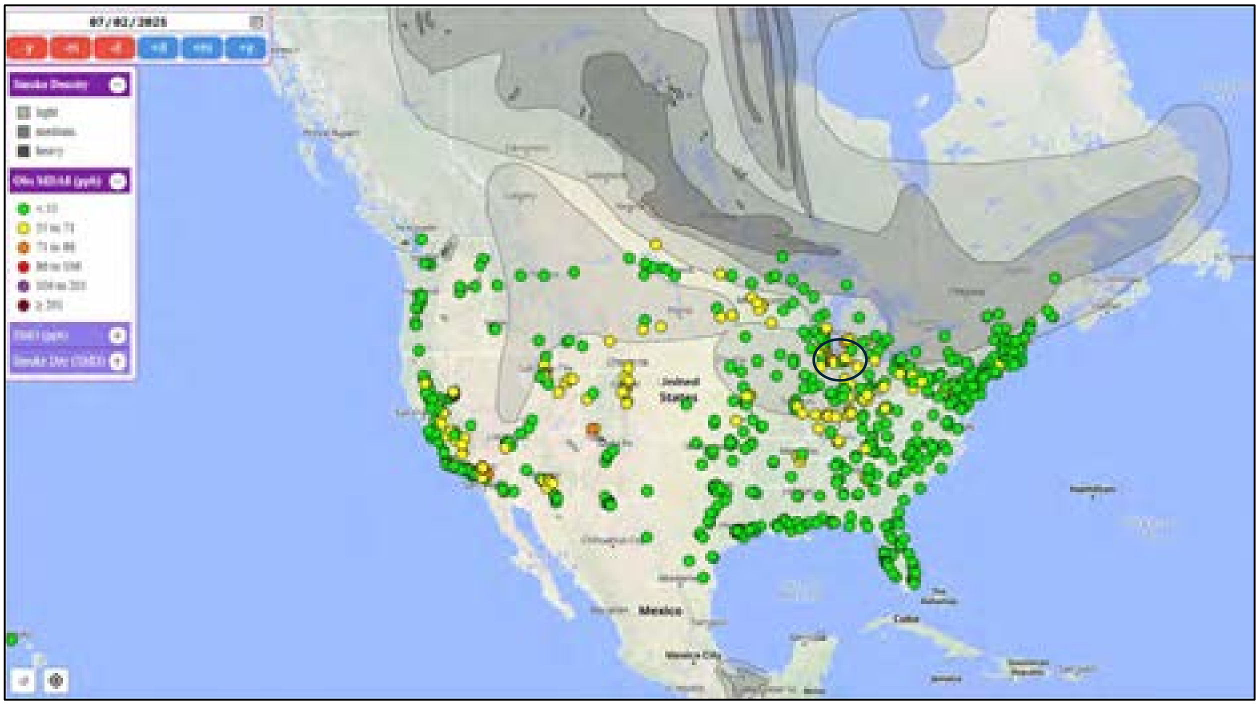


Figure 3.14.19 - GAM Smoke Maps Indicating Smoke Days July 2, 2025

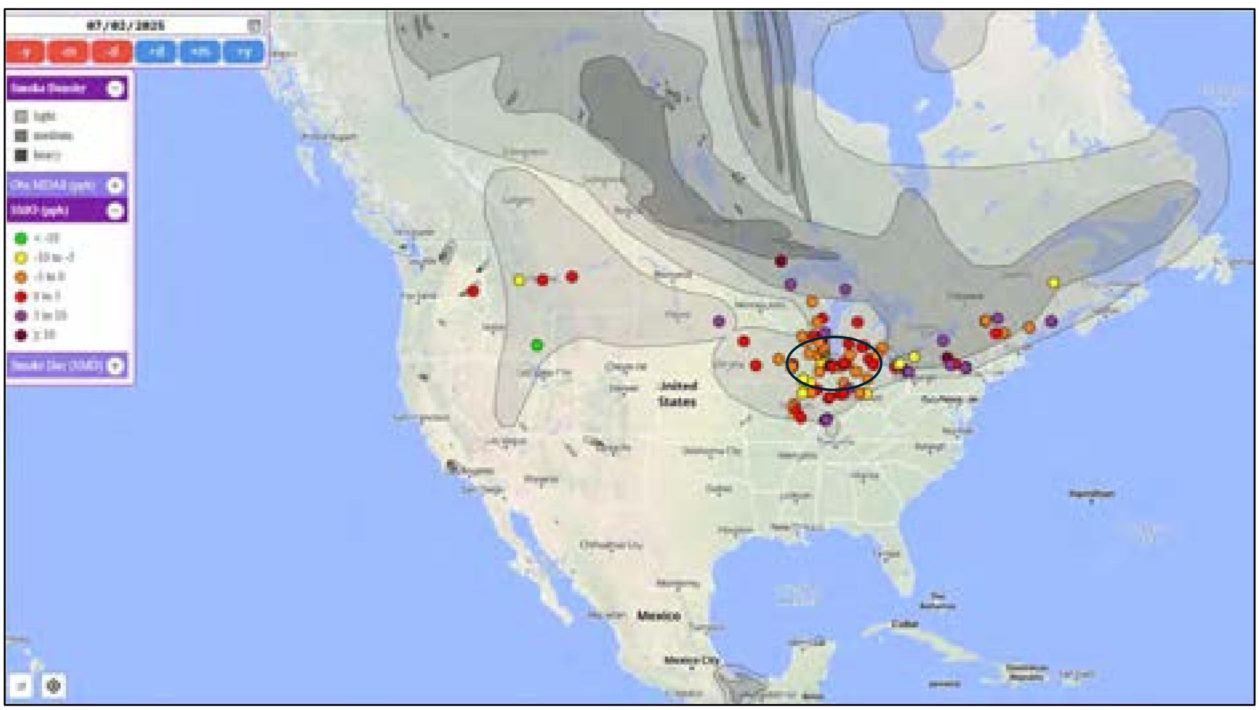


Table 3.14.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.14.3 - Observed versus GAM and EMBER Predicted MDA 8-hour Ozone Values

Site ID	Site Name	Observed 8-hour MDA Ozone (PPB)	GAM Predicted 8-hour MDA Ozone (PPB)	GAM Smoke Influenced 8-hour MDA Ozone (PPB)	EMBER Predicted 8-hour MDA Ozone (PPB)	EMBER Smoke Influenced 8-hour MDA Ozone (PPB)
180890022	Gary-IITRI	73	61.1	11.9	NA	NA
180892008	Hammond	70	NA	NA	NA	NA
181270024	Ogden Dunes	75	64.1	10.9	NA	NA
181270026	Valparaiso	64	63.9	0.1	NA	NA

3.14.10 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on July 2 as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.14.4 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 24 ppb lower than the MDA8 ozone concentrations observed on July 2 with the maximum matching day MDA8 ozone concentration of 56 ppb.

Table 3.14.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values July 2, 2025

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	75	56	51.2

3.14.11 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red). And higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. The HMS smoke layers become less opaque as the density of smoke increases. June 11 and 12 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure

3.14.22 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) with higher concentrations found around Northeastern British Columbia and Central-Southern Alberta and Saskatchewan.

Figure 3.14.20 – Back Trajectories July 2 50, 100 and 500 meters (-72 hours)

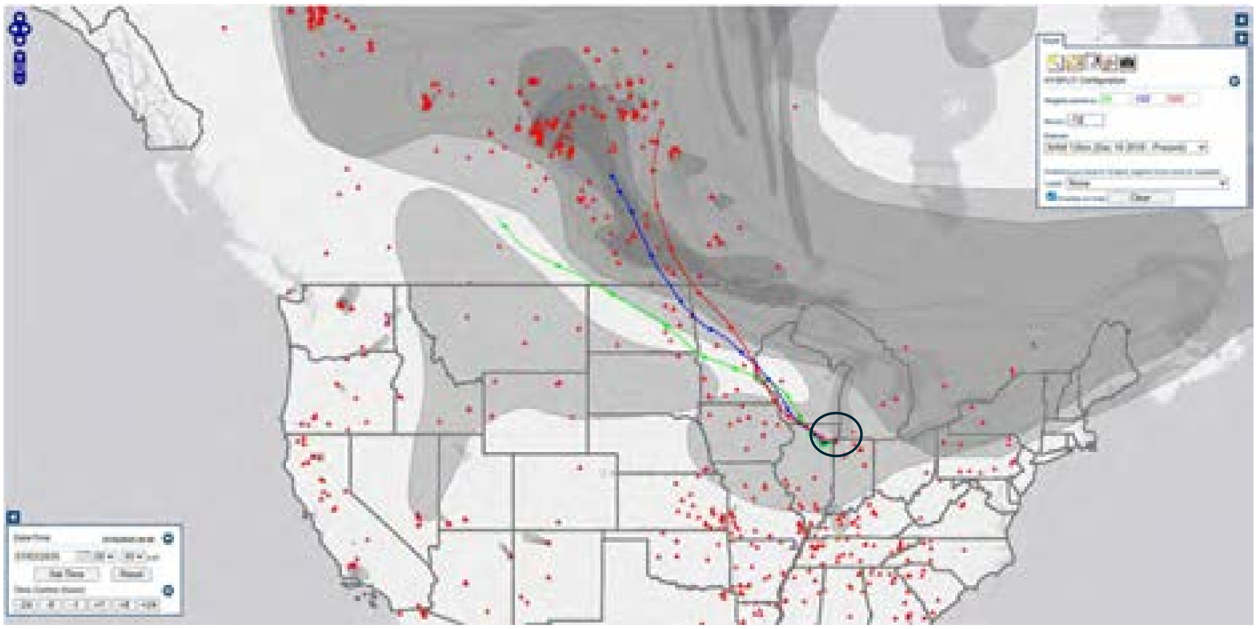


Figure 3.14.21 – Back Trajectories July 2 1000, 2000 and 3000 meters (-72 hours)

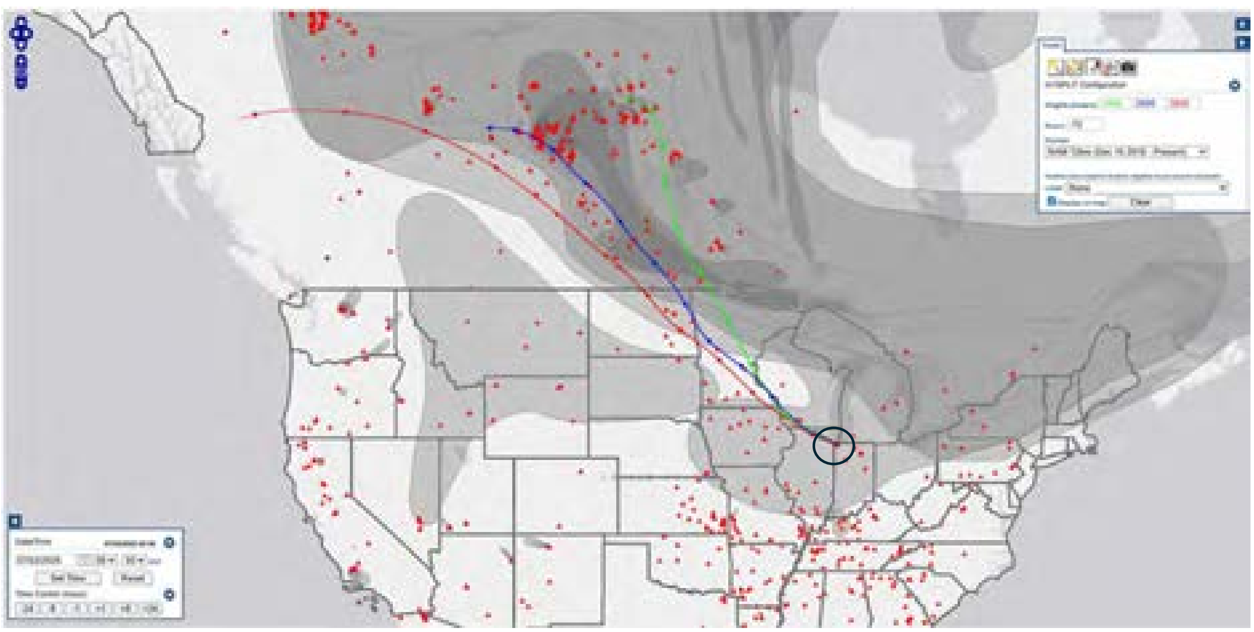
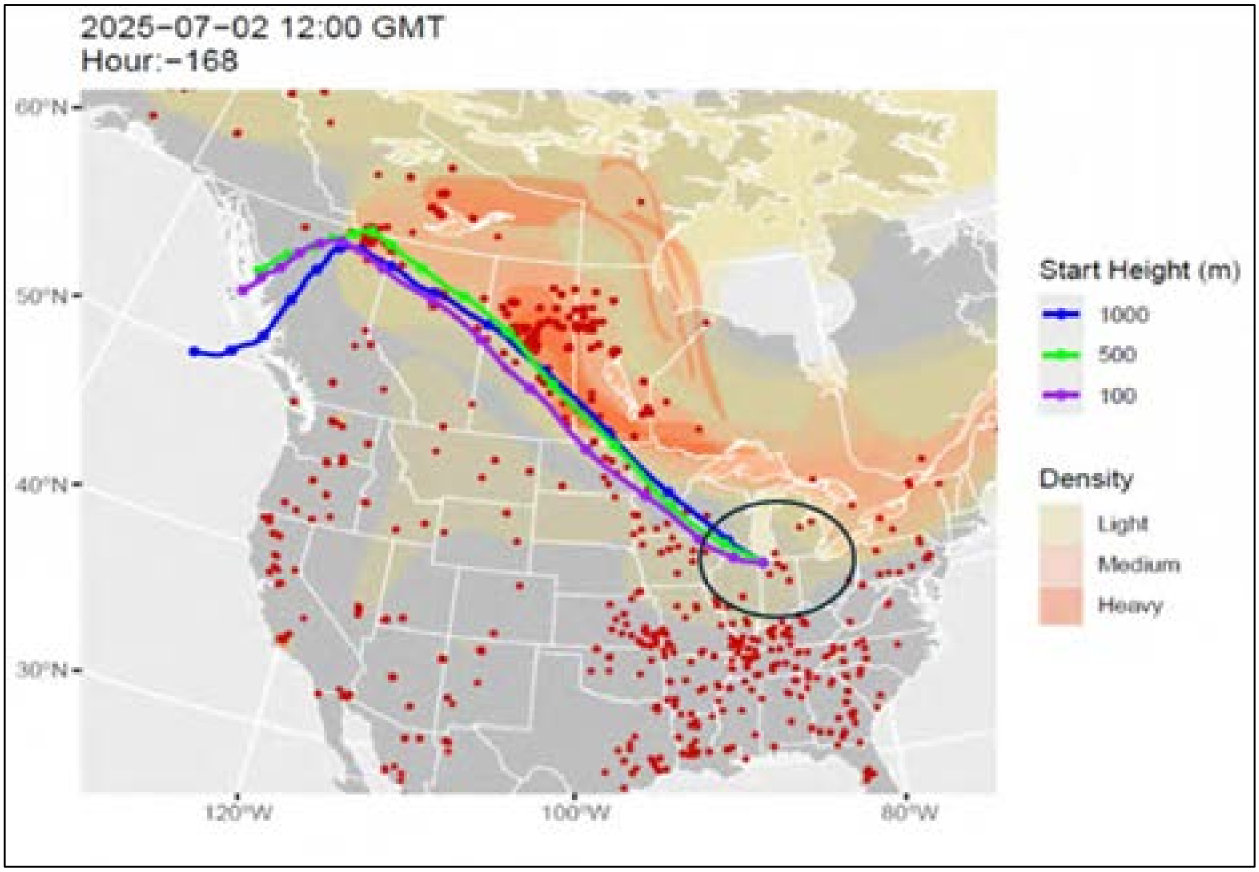


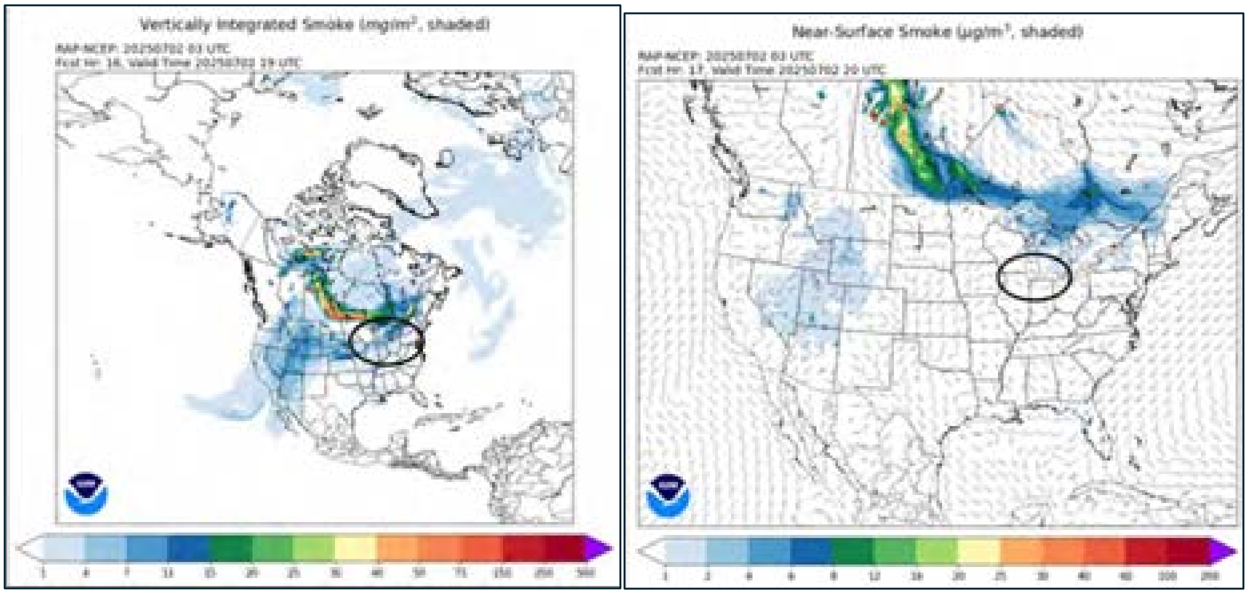
Figure 3.14.22 – Long Range Back Trajectories - July 2 100, 500 and 1000 meters (-168 hours)



3.14.12 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.14.23 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.14.23 HRRR Smoke Model



3.14.13 Media Mentions

[Massive Shoe Fire remains uncontained as 84 blazes burn in Saskatchewan]

[Wildfire Map Spotlight: Muskeg Wildfire, Saskatchewan, Canada]

[Nine northern communities under evacuation]

3.14.14 Summary of Requested Exclusion of July 2, 2025

Table 3.14.4 - Summary Table - Ogden Dunes

Event Date	**July 2, 2025**
MDA8 Ozone Concentration (PPB)	75
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	No
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	Yes
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone (PPB)	64.1
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	NA
Matching day MDA8 ozone (max., avg.) (PPB)	56, 51.1
HYSPLIT indicated wildfire regions	Shoe/Camp Fire and Muskeg Fire. Saskatchewan
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

3.15 July 14, 2025 Ozone Event

3.15.1 Executive Summary

On July 14, 2025, Northwest Indiana experienced ozone exceedances across all Lake and Porter County monitors, with values ranging from 70-87 ppb, surpassing the 70 ppb NAAQS. While meteorological conditions were conducive to ozone formation, they alone cannot explain these elevated levels. Multiple lines of evidence confirm that Canadian wildfire smoke was a key contributor:

- Satellite Imagery & AOD Analysis: Dense smoke plumes from Canadian wildfires were observed over the region.
- Air Quality Indicators: AirNow maps showed elevated ozone and $PM_{2.5}$ concentrations coinciding with smoke presence.
- Modeling Support: GAM analyses estimate 13-25 ppb of ozone attributable to wildfire smoke.
- Trajectory Analysis: HYSPLIT back trajectories link air masses directly to Shoe/Camp Fire and Muskeg fire, Saskatchewan regions.

This convergence of observational data, satellite imagery, and modeling establishes a clear causal relationship between wildfire smoke and ozone exceedances. These findings support classification of July 14, 2025, as an exceptional event under U.S. EPA guidelines.

Table 3.15.1 July 14, 2025 Lake and Porter County MDA 8-Hour Ozone Values (PPB)

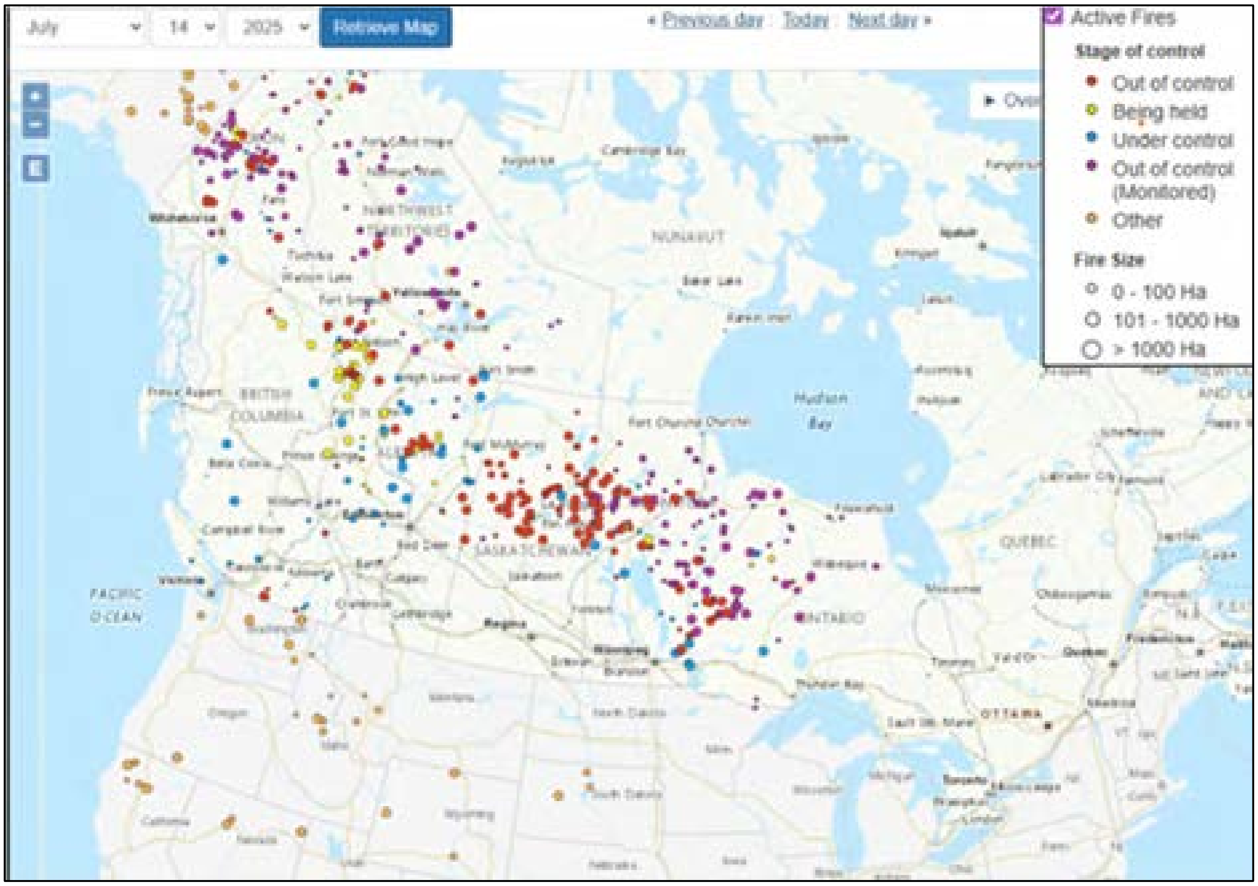
Date	Gary -IITRI	Hammond	Ogden Dunes	Valparaiso
Monitor ID	180890022	180892008	181270024	181270026
July 14, 2025	80	87	81	70

On July 14, 2025 multiple Canadian wildfires, as shown in Figure 3.15.1, contributed ground level smoke that caused all four Lake and Porter County monitors to exceed the 70 parts per billion (ppb) NAAQS. Major contributors to the smoke plumes that reached Lake and Porter Counties in July 2025 included the:

- Shoe Fire and Camp Fire, which were among the largest in Canada in 2025. These fires burned from early-May through mid-August, burning over 565,000 hectares (approximately 1.4 million acres) at their peak.

- Muskeg Fire, which was a massive, uncontrolled blaze in northern Saskatchewan that reached over 192,850 hectares by mid-July. It directly threatened the communities of Beauval, La Plonge, and Jans Bay.

Figure 3.15.1 – Canadian Wildfires July 14, 2025



3.15.2 Meteorological Episode Overview

Sweeping, broad upper air trough existed over the upper northern U.S. with a cold front located in the northern Indiana area on July 13th. This upper air set allowed transport of light wildfire smoke from Saskatchewan province as well as other areas of western Canada, as noted by NOAA Smoke Narrative. As the cold front moved slowly south, more stagnant conditions over northern Indiana were evident on July 14 with air temperatures in the mid 80's ^{o}F and dewpoints increasing into the upper 60's ^{o}F to help to maintain conducive ozone conditions. The light smoke was persistent throughout the vertically integrated and near surface forecast maps over Lake and Porter counties throughout the day. The presence of this light smoke helped to produce elevated levels of ozone throughout state. Figure 3.15.2 shows the surface, 850 mb and 500 mb maps of the conditions on July 13 while Figure 3.15.3 shows those maps on July 14.

Figure 3.15.2 - Surface, 850 and 500 mb Plots from 12Z on July 13, 2025

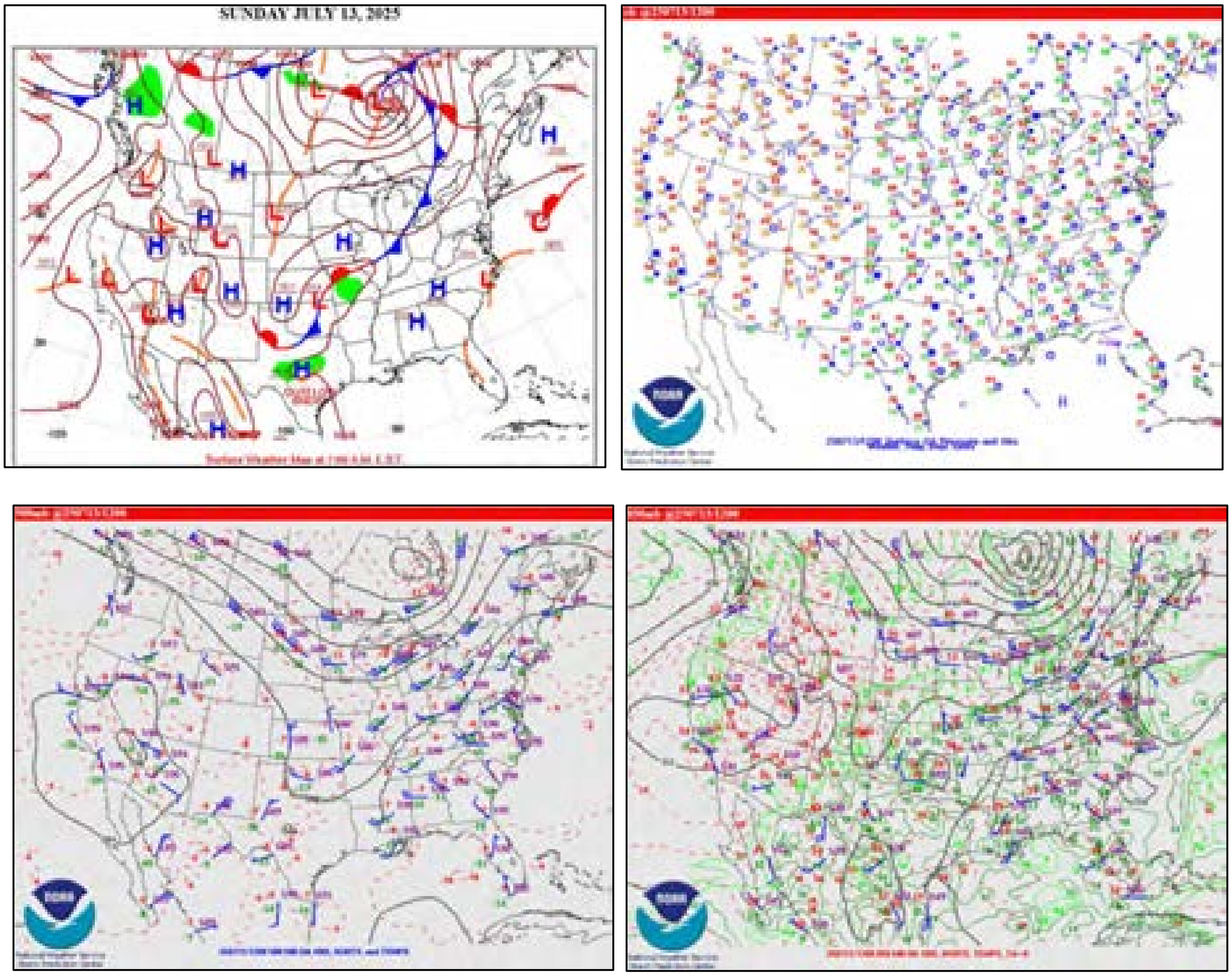
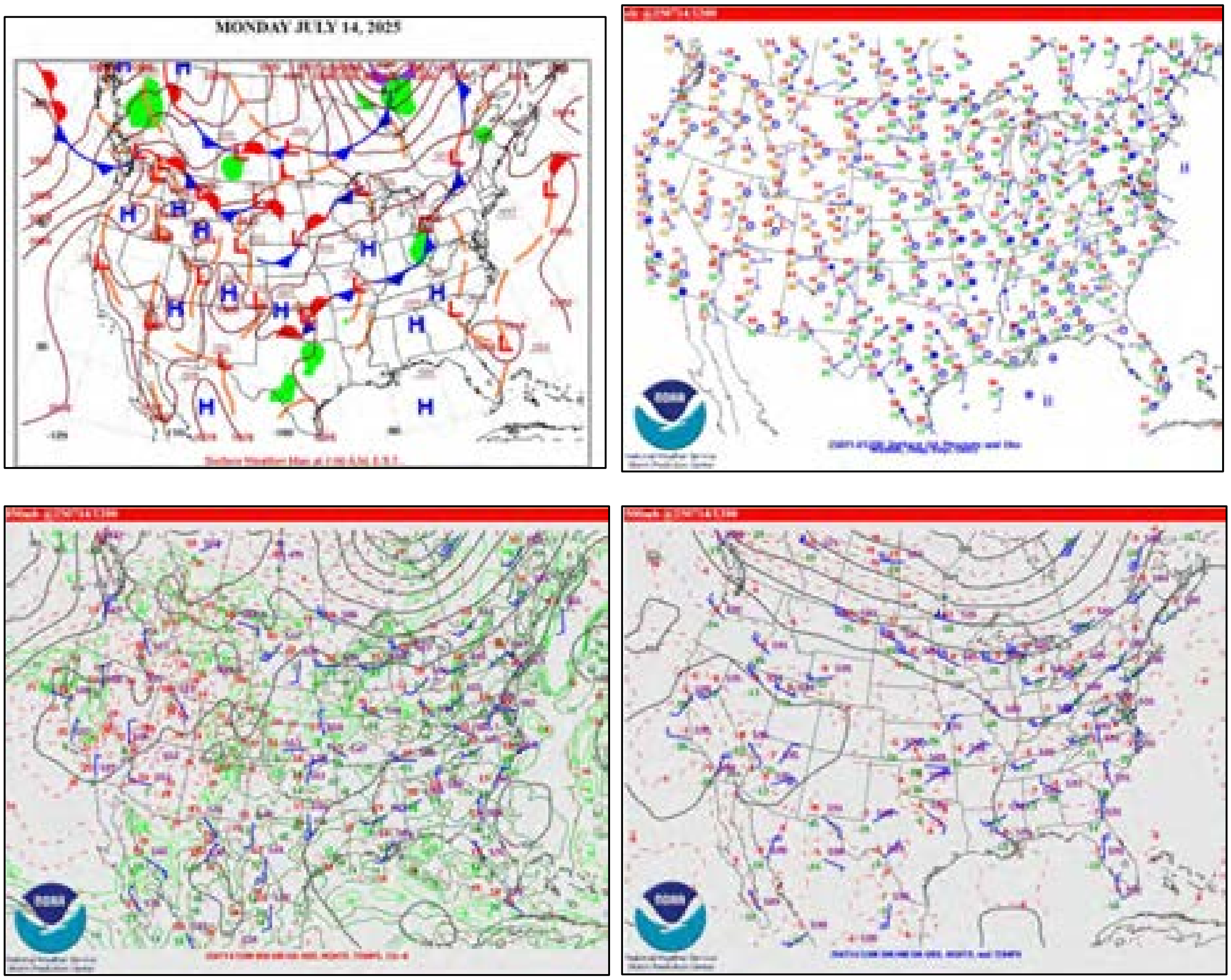


Figure 3.15.3 - Surface, 850 and 500 mb Plots from 12Z on July 14, 2025

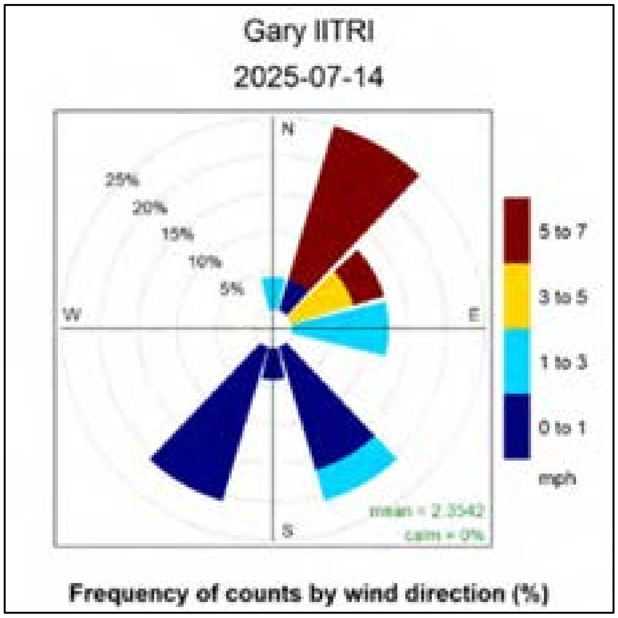


The period featured a transition from a warm, humid regime under southwest flow initially to a stalled frontal boundary and light and variable winds with weak surface high pressure over the region later in the day, creating conditions conducive to ozone buildup near Lake Michigan and sustained $PM_{2.5}$ impacts from Canadian wildfire smoke as the boundary drifted into southern Indiana. Wind rose and pollution rose analyses from the Gary IITRI and Ogden Dunes stations were reviewed. Conditions remained warm with higher humidity, but wildfire smoke was present throughout the vertical column, as confirmed by satellite imagery, GAM analysis, and NASA AOD products. Wind and pollution roses from the 14 also indicate elevated ozone levels. HYSPLIT back trajectories link the air masses directly to Canadian fire regions.

These conditions resemble those seen in 2023, when wildfire smoke, known to contain volatile organic compounds (VOCs), intermediate- and semi-volatile organic compounds (IVOCs and SVOCs) likely contributed to enhanced ozone production in the lower troposphere during summer. Reference: Understanding Volatile Organic Compound

[Emissions from Wildfires in the Western US with Modeling Comparisons - Climate Program Office](#)

Figure 3.15.4- Gary IITRI Windrose **Figure 3.15.6 Gary ITRII Pollution Rose**



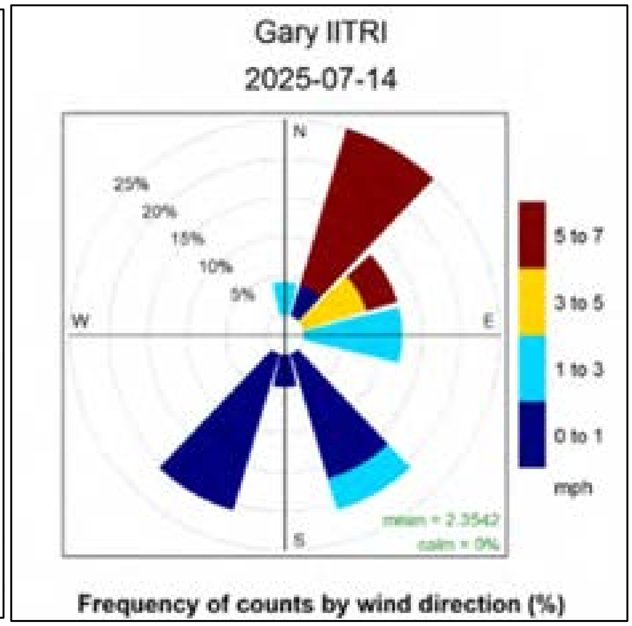
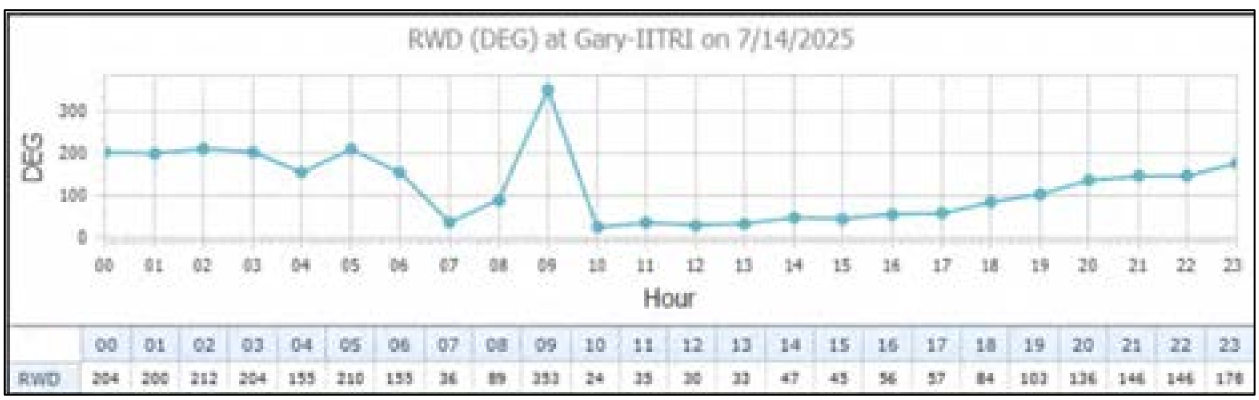


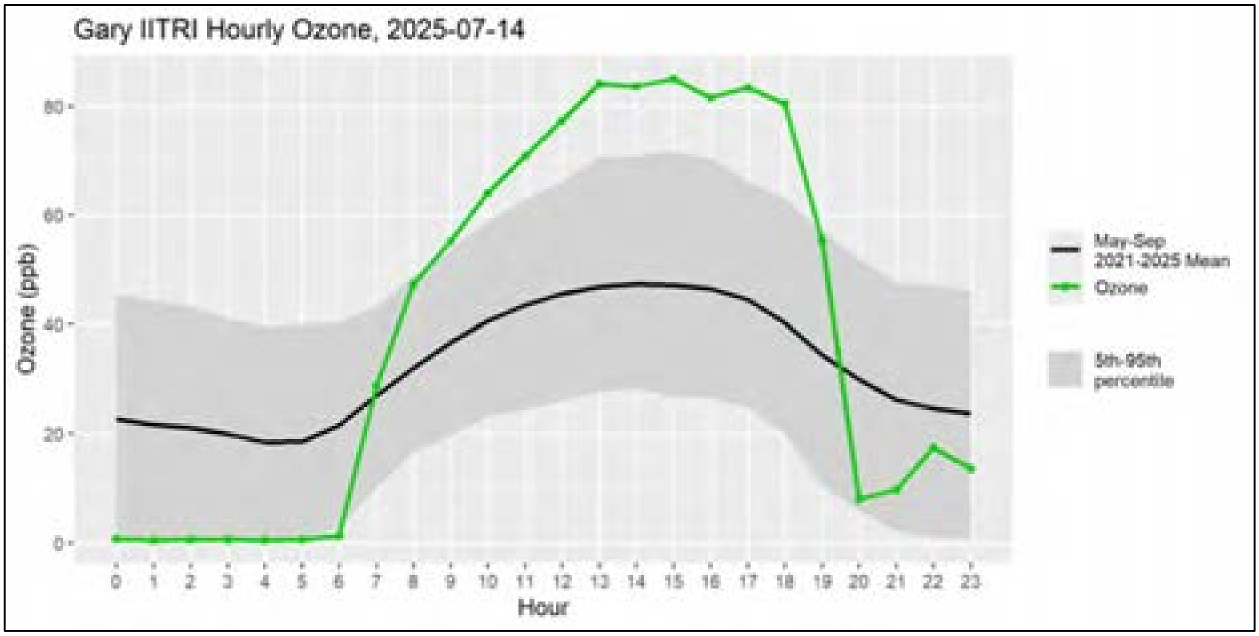
Figure 3.15.6 - Hourly Wind Directions at Gary IITRI for July 14, 2025

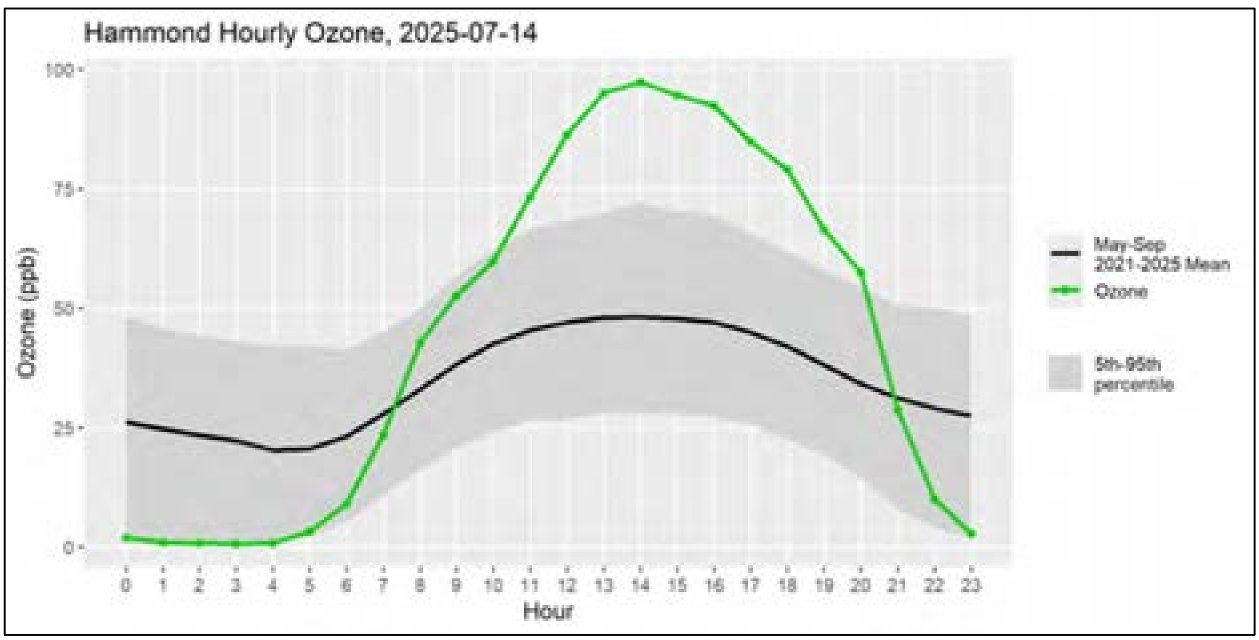


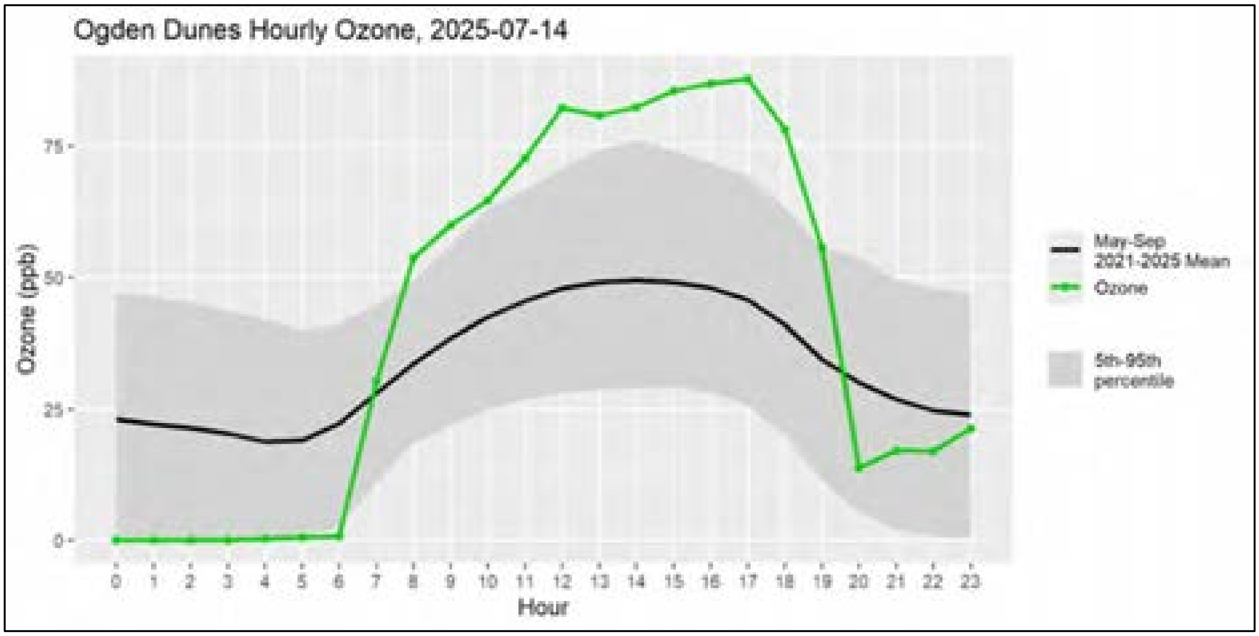
3.15.3 Hourly Pollutant Analyses and Comparison

The hourly ozone readings (green line) for July 14, 2025, for Gary-IITRI, Hammond and Ogden Dunes were compared to the five-year ozone season mean (black line) and the 5th - 95th percentile of those readings, as shown in Figure 3.15.7. For most of the day the hourly readings at all three ozone monitors exceeded the 95th percentile only returning to below that upper percentile threshold after the sun set.

Figure 3.15.7 - Ozone Diurnal Pattern for Gary IITRI, Hammond, and Ogden Dunes July 14, 2025

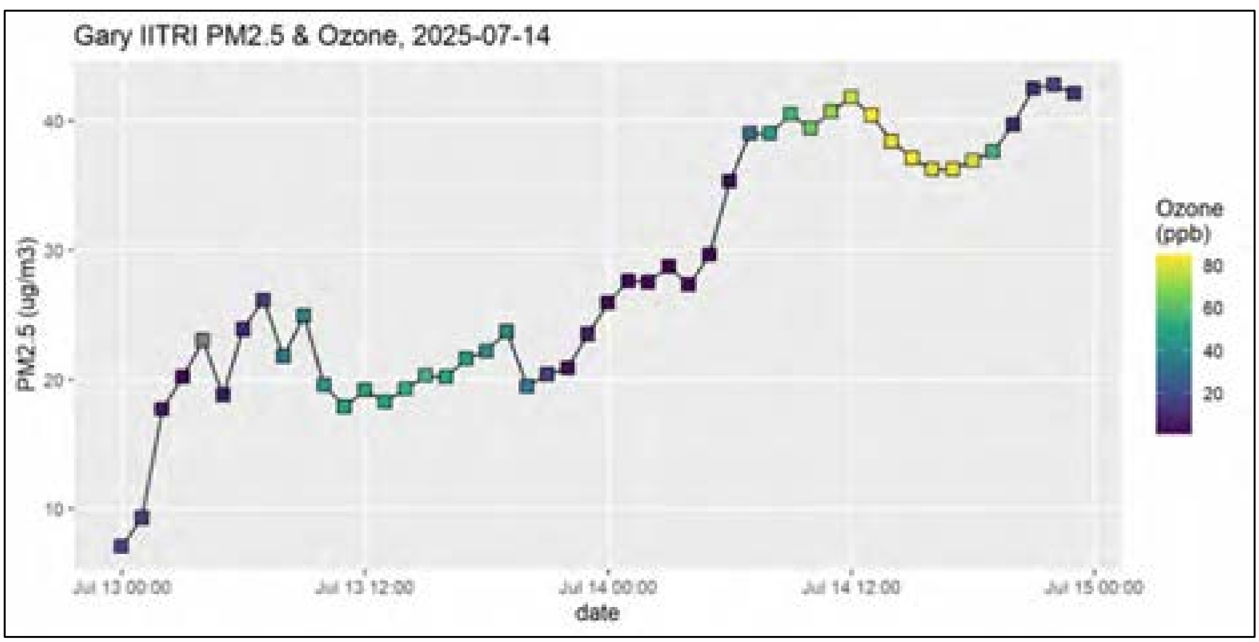






Hourly comparisons were completed for $PM_{2.5}$ with ozone values included for each hour from the nearest $PM_{2.5}$ monitor available for July 14 as shown in Figure 3.15.8. $PM_{2.5}$ concentrations ranged from 25 - 42 ug/m^3.

Figure 3.15.8 - Gary IITRI $PM_{2.5}$ and Ozone Comparison with Hourly Data July 14, 2025



IDEM compared the daily average concentration with the five-year daily average for carbon monoxide (CO), nitrogen dioxide (NO_2) and black carbon (BC). Table 3.15.2 shows the percentage above the five-year average. All three pollutants were well above the average.

Table 3.15.2 Carbon Monoxide, Nitrogen Dioxide and Black Carbon Percentage above the Five-Year Average

Date	Percentage CO Above 5-Year Average	Percentage NO_2 Above 5-Year Average	Percentage Black Carbon Above 5-Year Average
7/14/2025	135%	181%	413%

3.15.4 AOD and Satellite Analyses

Figure 3.15.9 displays satellite imagery from Aerosol Optical Depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) combined Terra and Aqua Multi-Angle Implementation of Atmospheric Correction (MAIAC) Land Aerosol Optical Depth level 2 product. An optical thickness of less than 0.1 (palest yellow) indicates a crystal-clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions. The dark red color in northwest Indiana indicates the presence of smoke.

Figure 3.15.9 - Aerosol Optical Depth (AOD) July 14, 2025

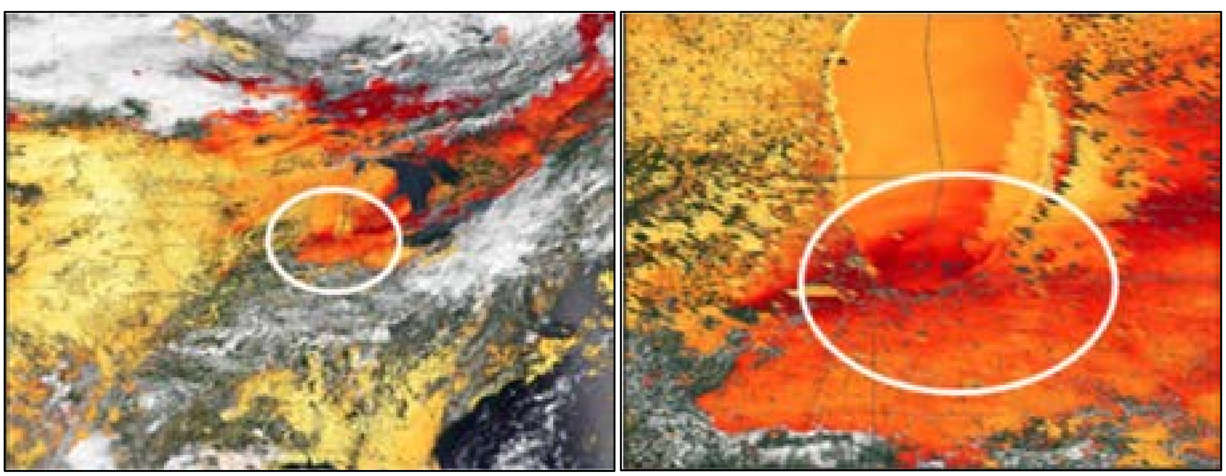
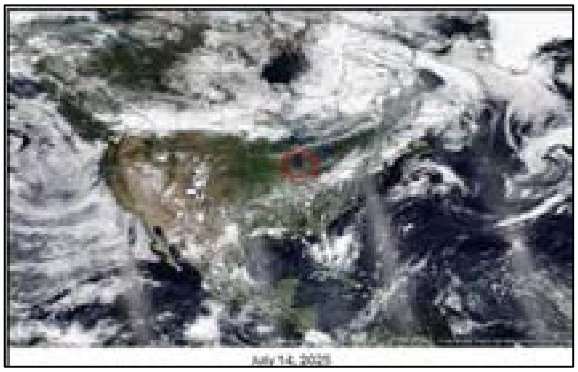
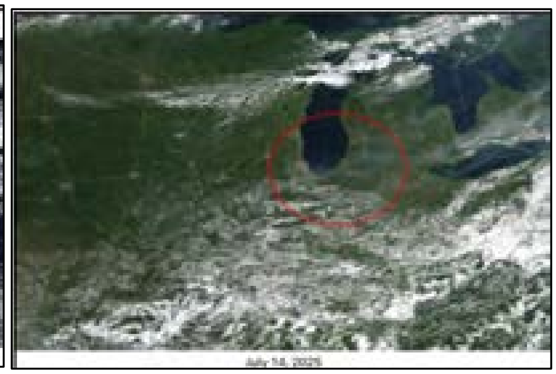


Figure 3.15.10 displays three satellite images indicate Canadian wildfire smoke coming from Manitoba and Saskatchewan. The image for July 14 shows smoke working into northern Indiana.

Figure 3.15.10 - Satellite Imagery July 14, 2025





The right and left images captured by NOAA's GOES 18 satellite images of North America taken July 14, 2025 shows clouds and a plume of gray smoke extending from western Canada to the upper Midwest states. Credit: NOAA NESDIS.

3.15.5 NOAA Smoke Narrative

DESCRIPTIVE TEXT NARRATIVE FOR SMOKE/DUST OBSERVED IN SATELLITE IMAGERY THROUGH 1500Z July 14, 2025

SMOKE:

Alaska/Canada/Great Lakes/Atlantic Ocean...

Wildfires continued to burn across Northwestern Alaska, Northwestern and Central Canada, with widespread smoke dispersing eastward across northern Alaska, the majority of Canada with the exception of the western coast, the Great Lakes region and parts of the Northern Atlantic. Areas of higher smoke concentration were found along the Northwest Territories, Northeastern British Columbia, Southern Ontario and Central Quebec.

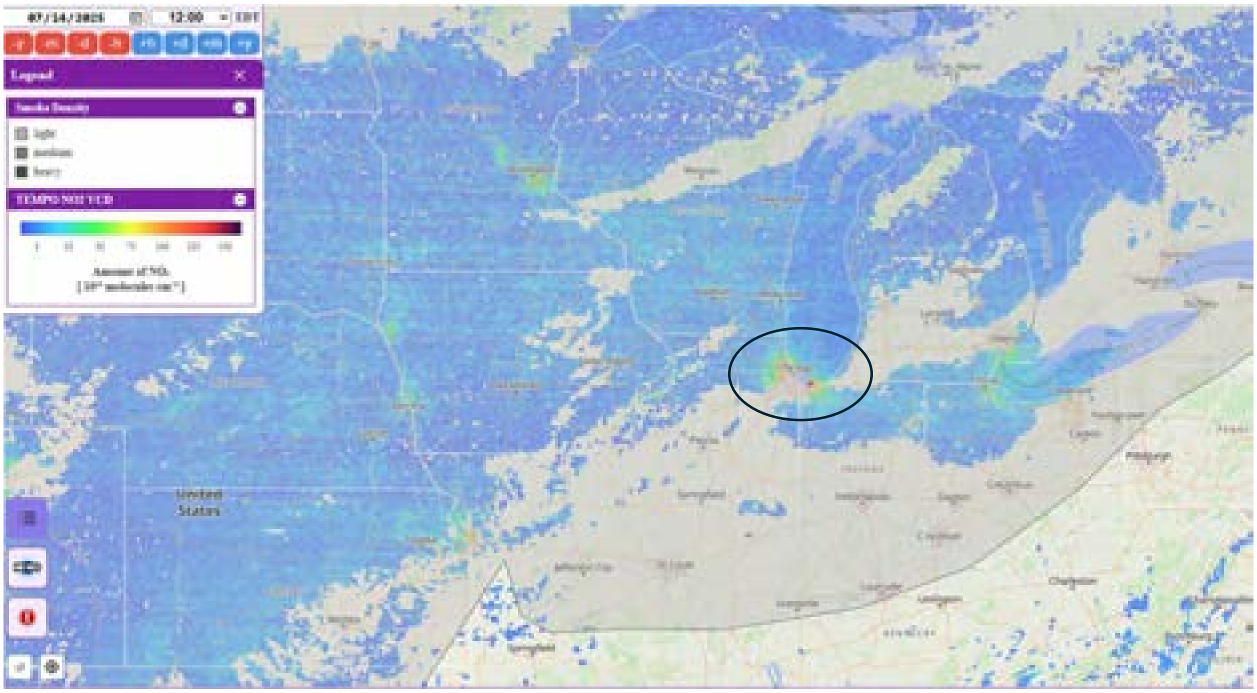
Western and North-Central U.S...

Several wildfires in Southern British Columbia, Northern California, Northern Arizona, and Western Colorado were spreading light-to-moderate density smoke across most of the Western and North-Central U.S., with higher concentrations found around Northern Arizona, Southeastern Utah and Northern Montana.

3.15.6 TEMPO Satellite Nitrogen Dioxide

TEMPO sensors use NO_2 as one indicator to identify and track wildfire plumes.

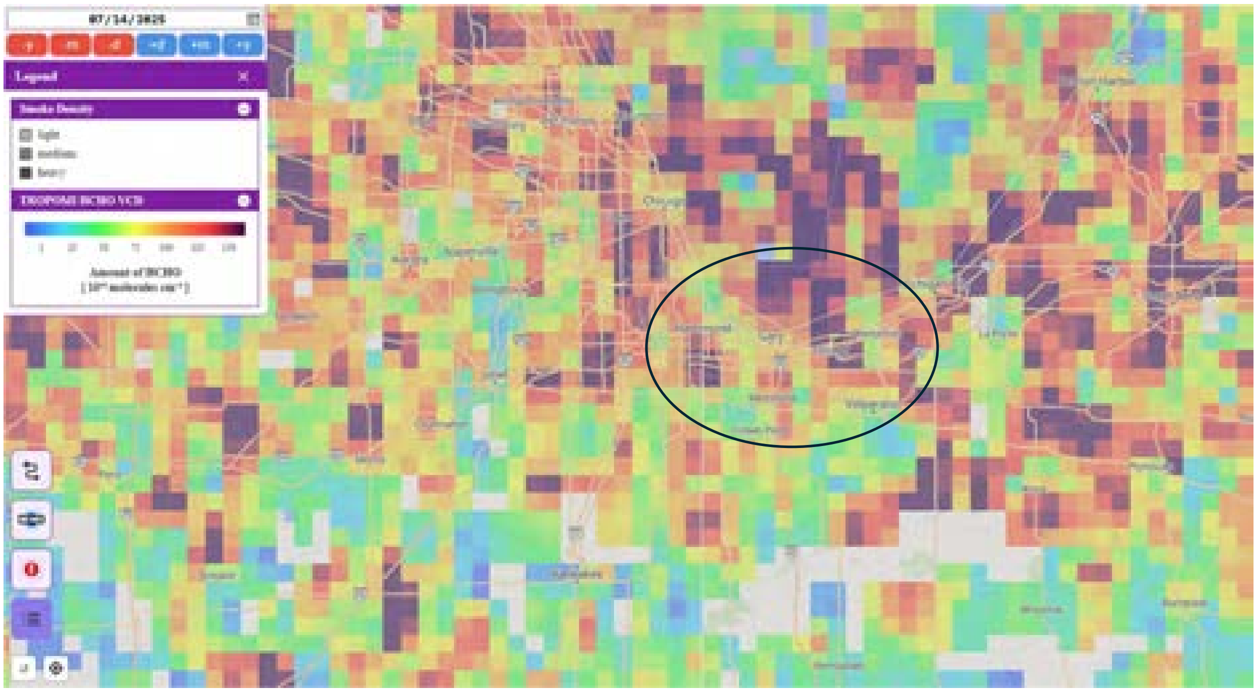
Figure 3.15.11 TEMPO Hourly NO2 Concentrations July 14, 2025



3.15.7 TROPOMI Satellite Daily Formaldehyde Monitoring

TROPOMI Satellite Monitoring use daily pictures with software to estimate the formaldehyde concentrations. The black circle in Figure 3.15.12 indicates the location of the Lake and Porter County monitors. Estimated concentrations are from 6-18 × 10^{15} molecules/cm^2 indicate strong to extreme wildfire smoke influence.

Figure 3.15.12- TROPOMI Satellite Daily Formaldehyde Monitoring



3.15.8 AirNow Smoke Maps

AirNow shows in Figures 3.15.13 through 3.15.16 the elevated ozone and $PM_{2.5}$ concentrations in northwest Indiana and surrounding area, indicating smoke impacts that elevated pollutant concentrations. Northwest Indiana is indicated by the black circles on the maps.

Figure 3.15.13 - AirNow Ozone Map - July 14, 2025

Figure 3.15.14 - AirNow $PM_{2.5}$ Map - July 14, 2025

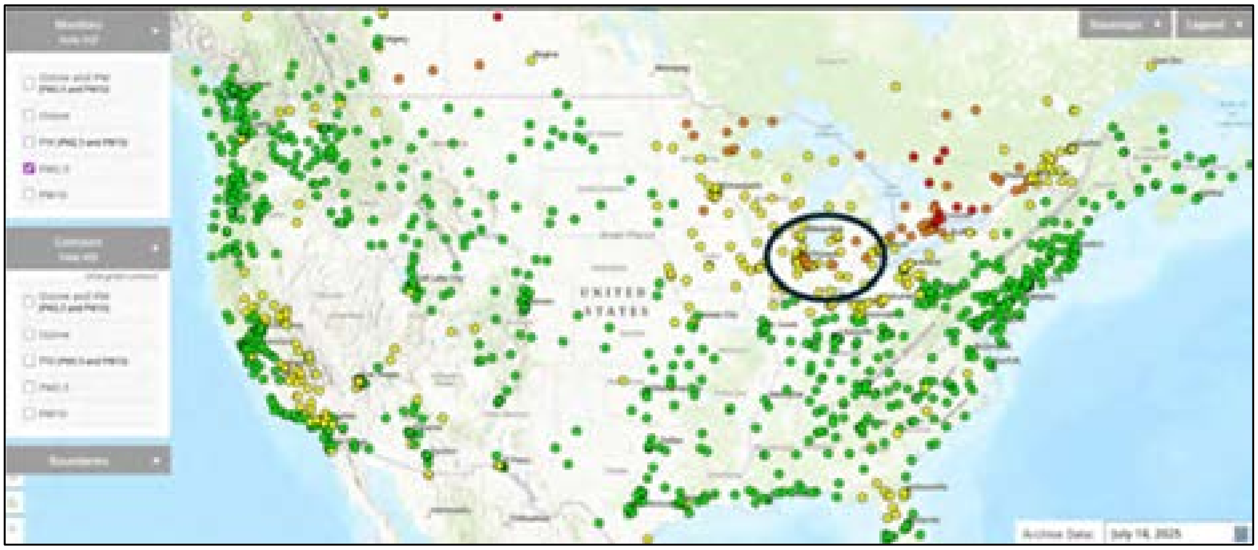
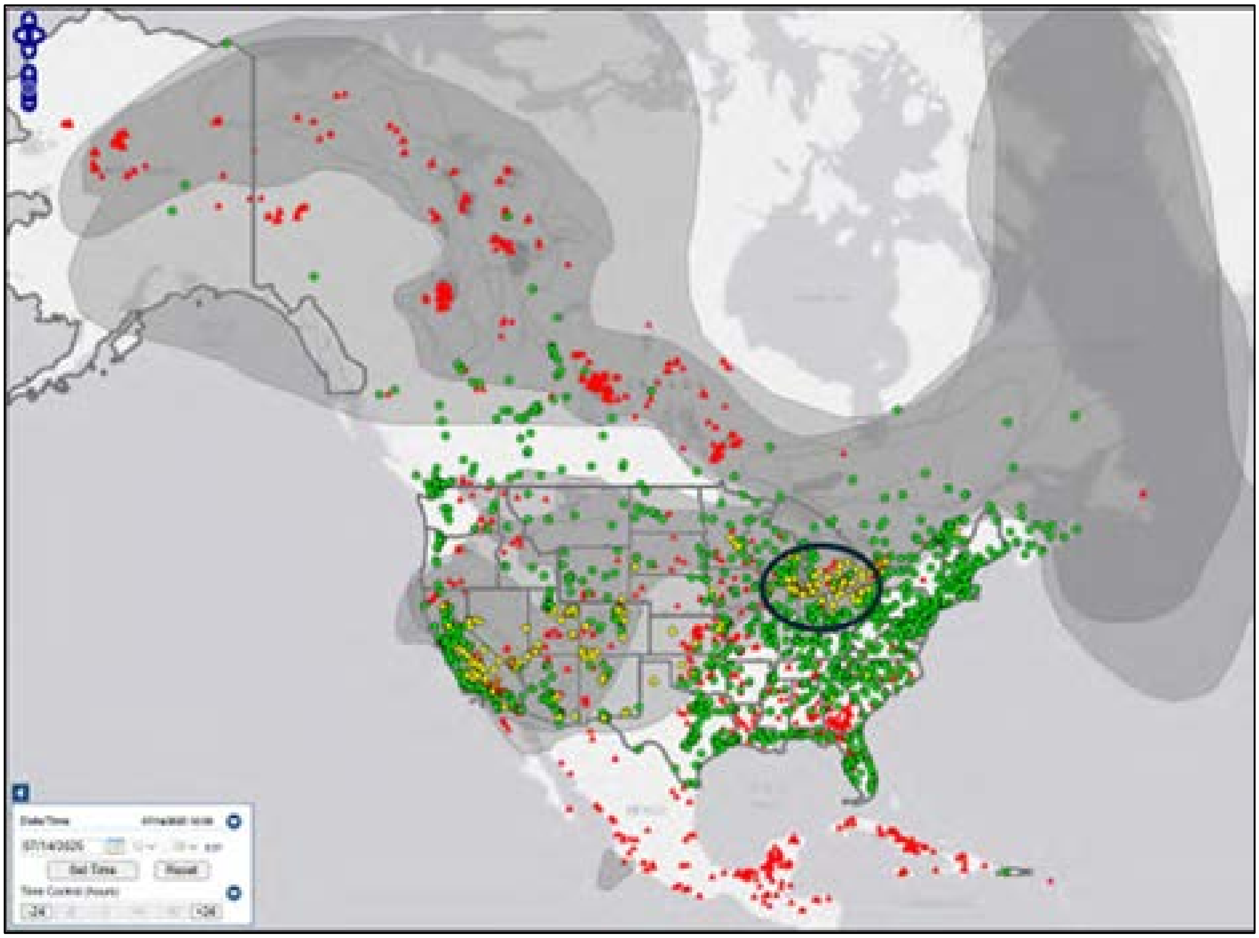


Figure 3.15.15 - AirNow Ozone Map - July 14, 2025

Figure 3.15.16 - AirNow Smoke and Ozone Map - July 14, 2025



3.15.9 Statistical Modeling Analyses

General Additive Modeling (GAM) is a statistical or machine learning framework that provides interpretability by applying smoothing functions to individual variables. Notably, GAMs can incorporate linear, nonlinear, and categorical predictors, providing flexibility for modeling complex relationships (Wood, 2017). In particular, such statistical/machine learning models can provide an efficient tool for analyzing air quality, especially in relation to wildfire smoke. For example, ozone can be used as the response variable and modeled using meteorological data, satellite-derived measurements, and/or backward air trajectories (Lee and Jaffe, 2024). This study demonstrated the importance of wildfire smoke as a contributor to exceedances of the health-based national air quality standards for $PM_{2.5}$ and ozone.

The Expedited Modeling of Burn Events Results (EMBER) provides photochemical model-based estimates to help identify ozone monitoring days that may have been influenced by fire emissions, assisting in the analysis of "exceptional events" for regulatory purposes. EMBER has not been updated to include 2025 data.

Figures 3.15.17 through 3.15.19 show indicate monitors influenced by wildfire smoke, the observed ozone averages for the day at each monitor and the estimate of smoke influence from GAM and EMBER.

Figure 3.15.17 - GAM Smoke Maps Indicating Smoke Days July 14, 2025

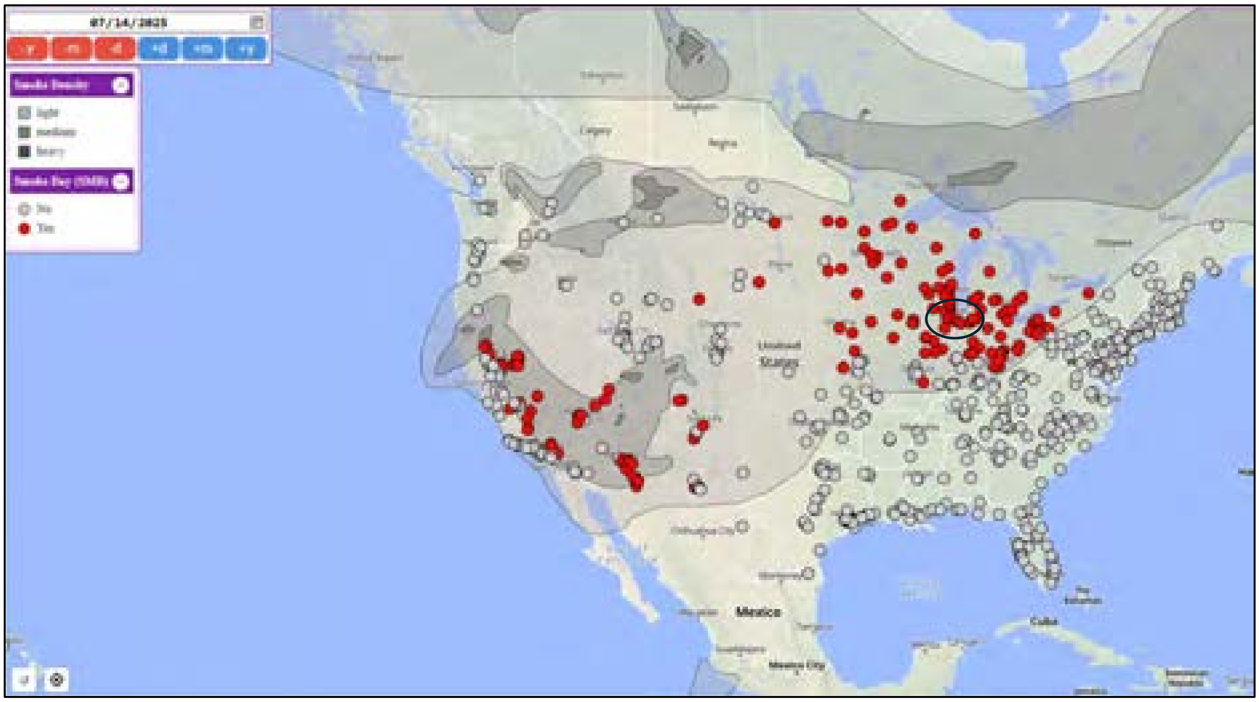


Figure 3.15.18 - GAM Smoke and $PM_{2.5}$ Maps Indicating Smoke Days July 14, 2025

Figure 3.15.19 - GAM Smoke Maps Indicating Smoke Days July 14, 2025

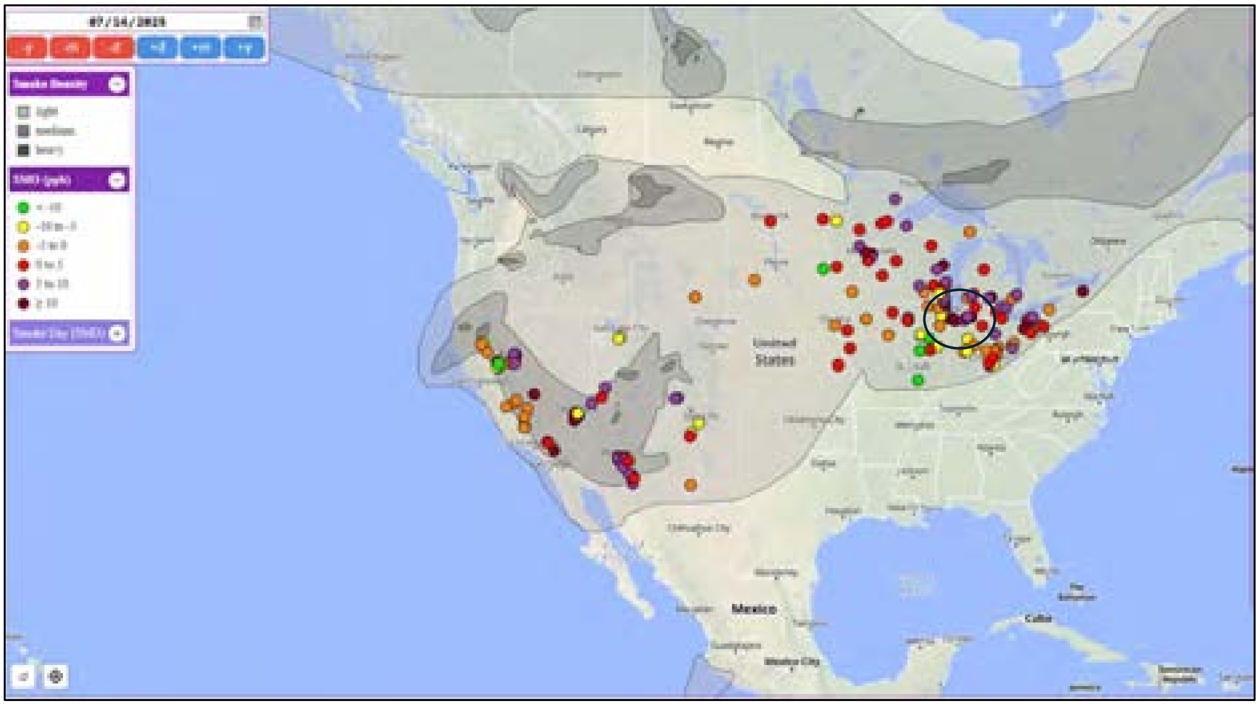


Table 3.15.3 summarizes the observed ozone average with the GAM and EMBER predicted averages and modeled smoke influence.

Table 3.15.3 - Observed versus GAM and EMBER Predicted MDA 8-hour Ozone Values

Site ID	Site Name	Observed 8-hour MDA Ozone (ppb)	GAM Predicted 8-hour MDA Ozone (ppb)	GAM Smoke Influenced 8-hour MDA Ozone (ppb)	EMBER Predicted 8-hour MDA Ozone (ppb)	EMBER Smoke Influenced 8-hour MDA Ozone (ppb)
180890022	Gary-IITRI	80	61	19	NA	NA
180892008	Hammond	87	NA	NA	NA	NA
181270024	Ogden Dunes	81	55.7	25.3	NA	NA
181270026	Valparaiso	70	57.3	12.7	NA	NA

3.15.10 Matching Day Analysis

IDEM performed a matching day analysis, to determine the impact wildfire smoke had on ozone concentrations on July14, as opposed to days with similar meteorological conditions without the impact of wildfire smoke. Table 3.15.4 shows the Ogden Dunes matching day analysis. The results show the average ozone concentration on the matching days was 23 ppb lower than the MDA8 ozone concentrations observed on July 14 with the maximum matching day MDA8 ozone concentration of 71.3 ppb.

Table 3.15.4 – Ogden Dunes Observed versus Matching Day MDA 8-hour Ozone Values July 14, 2025

Site Name	Observed 8-hour MDA Ozone (ppb)	Matching Day Maximum 8-hour MDA Ozone (ppb)	Matching Day Average 8-hour MDA Ozone (ppb)
Ogden Dunes	81	71.3*	57.6

* Indicates Matching days were influenced by wildfire smoke

3.15.11 Backward Trajectories and Smoke Map Analyses

The impact of smoke on this ozone event can be shown with HYSPLIT trajectories and Hazard Mapping System (HMS) smoke layers. The trajectories have three starting heights, 50 m (green), 100 m (blue), and 500 m (red). And higher transport at 1000 m (green), 2000 m (blue) and 3000 m (red). The back trajectories start from the location of the Lake County monitors. The HMS smoke layers become less opaque as the density of smoke increases. July 14 three-day back trajectories indicate smoke from central Canada being drawn down to northwest Indiana. The trajectories in Figure 3.15.22 are increased to seven days at 100 m (purple), 500 m (green) and 1000 m (blue) with higher concentrations found around Northeastern British Columbia and Central-Southern Alberta and Saskatchewan.

Figure 3.15.20 – July 14, 2025 50, 100 and 500 meters (-72 hours)

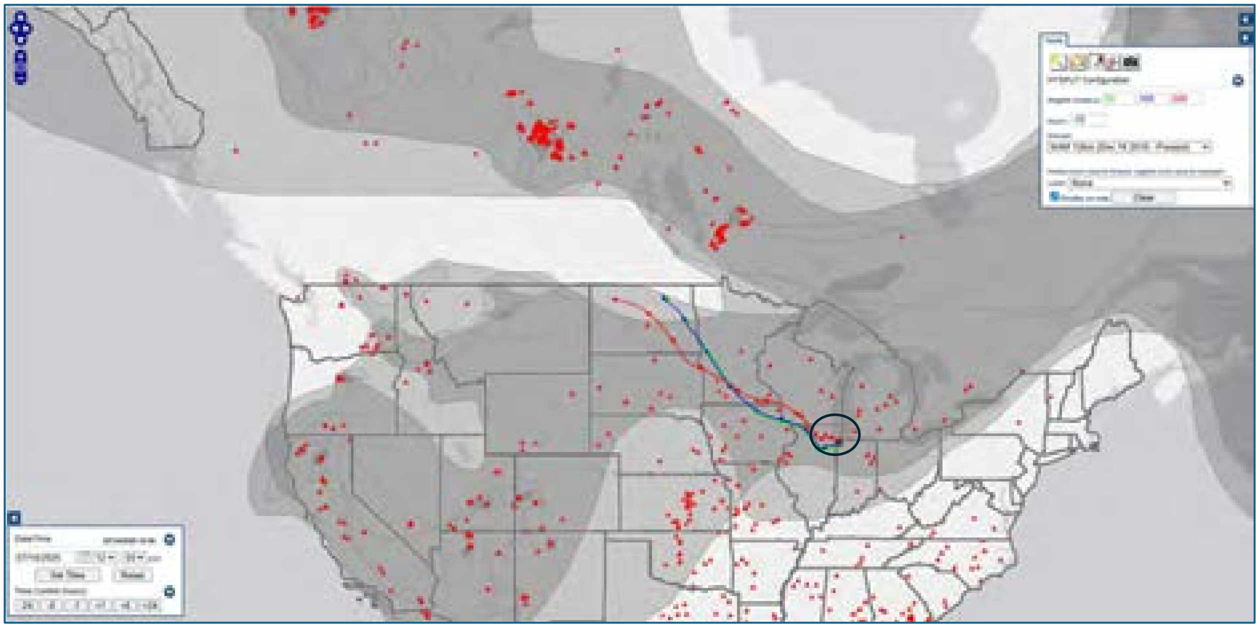


Figure 3.15.21 – July 14, 2025 1000, 2000 and 3000 meters (-72 hours)

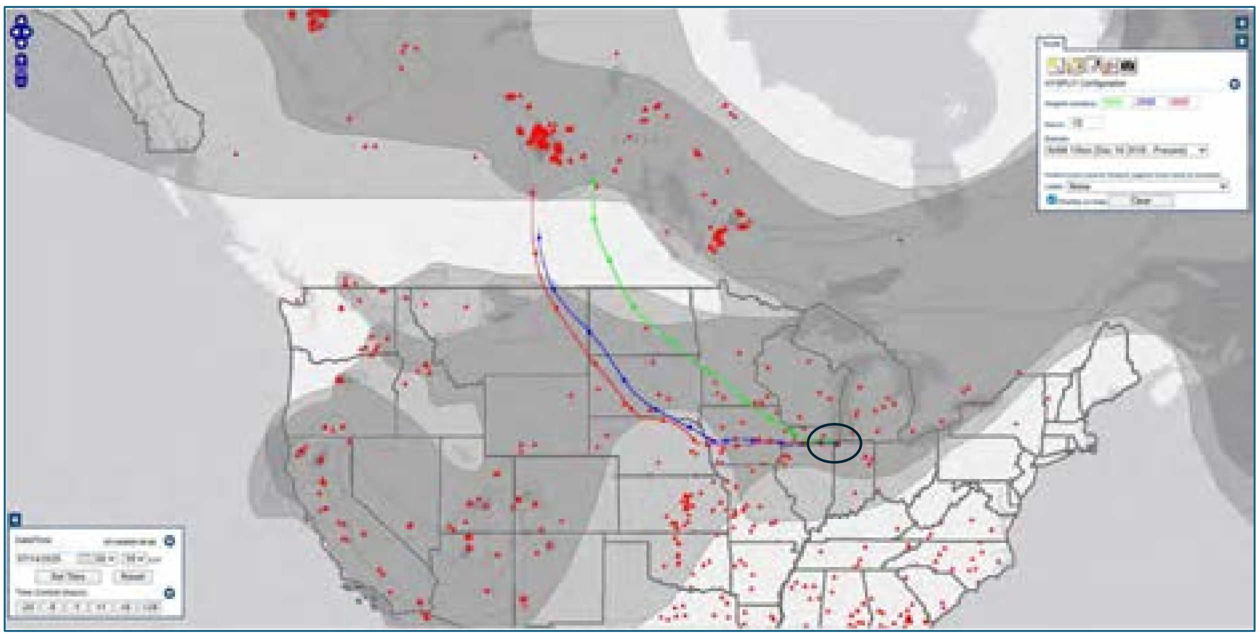
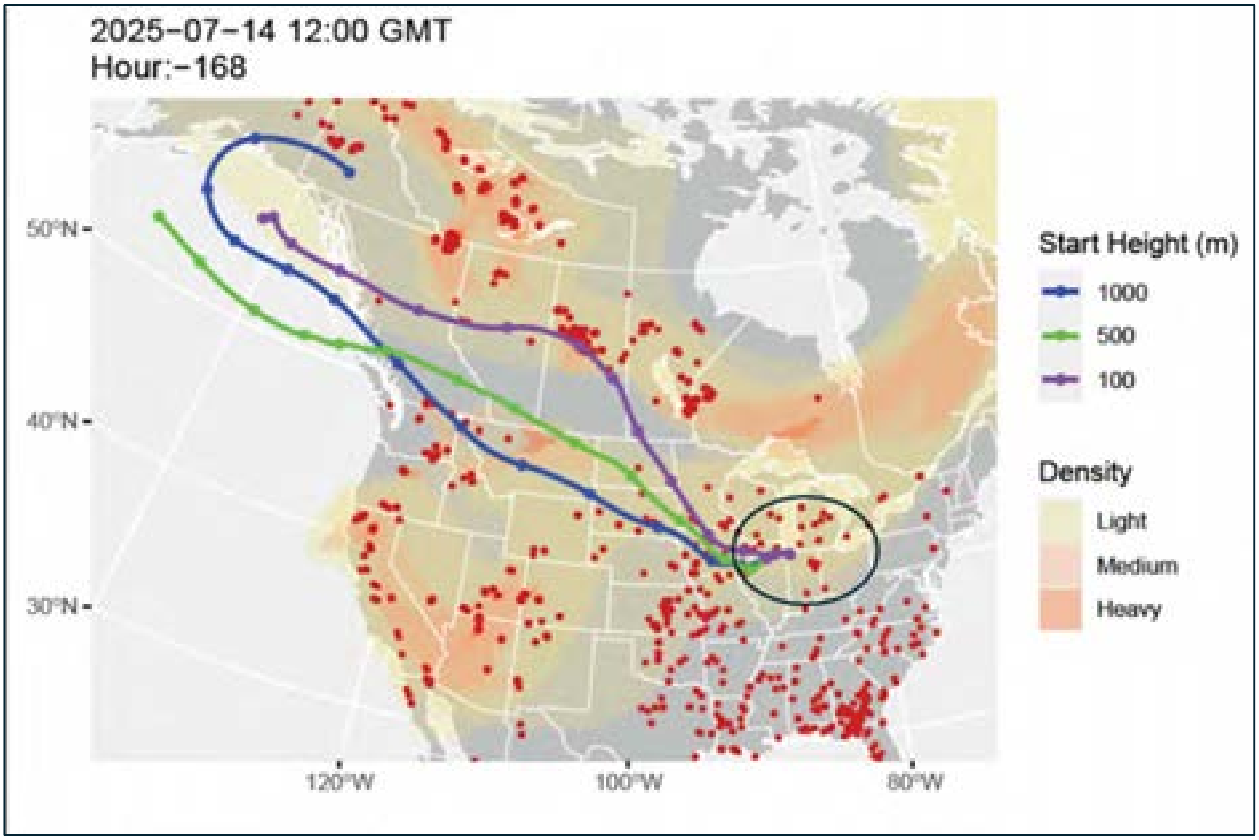


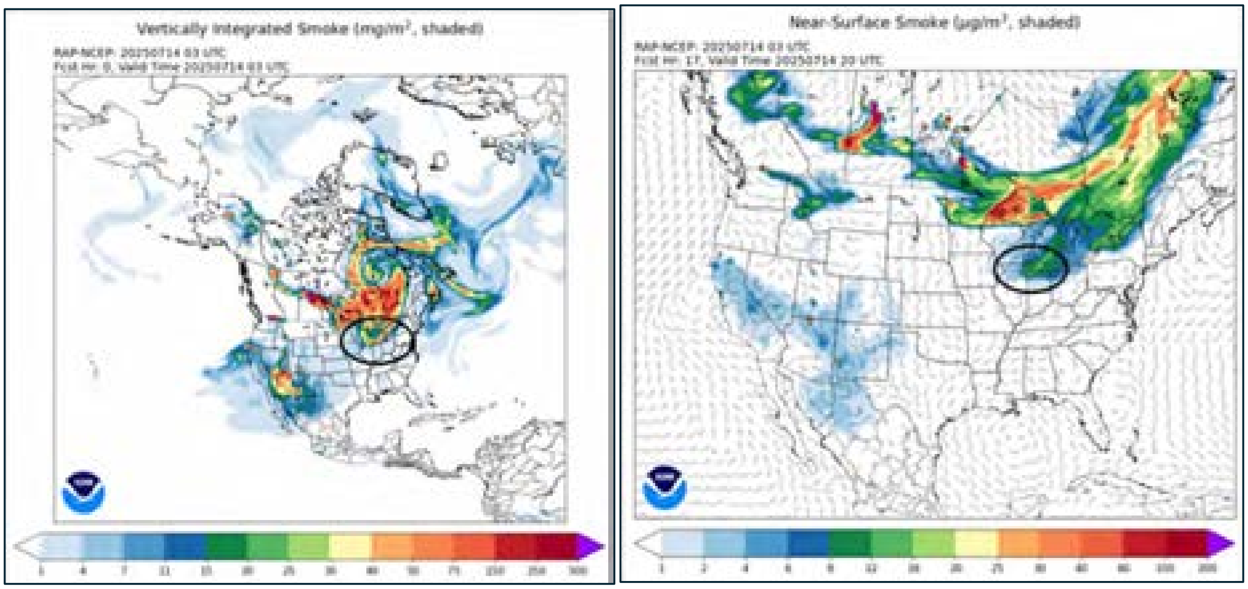
Figure 3.15.22- July 14, 100, 500 and 1000 meters (-168 hours)



3.15.12 HRRR Model

The HRRR is a NOAA real-time 3 km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3 km grids with 3 km radar assimilation. Radar data is assimilated in the HRRR every 15 min over a 1-h period adding further detail to that provided by the hourly data assimilation from the 13 km radar-enhanced Rapid Refresh. Models run for early 2023 did not account for Canadian wildfire smoke. Figure 3.15.23 indicates the vertically integrated smoke column on the left and the near surface smoke on the right.

Figure 3.15.23 HRRR Smoke Model



3.15.13 Media Mentions

[Sask. wildfire evacuations surge as smoke spreads in record fire season]

[Canadian wildfires 2025: Michigan under air quality alert. What to know]

[Air Quality Alert: What to know before heading outside in Chicago on Tuesday]

[Air Quality Alert Issued as Canadian Wildfire Smoke Returns to Chicago]

[Wildfire Smoke: Poor Air Quality]

3.15.14 Summary of Requested Exclusion of July 14, 2025

Table 3.15.4 - Summary Table - Ogden Dunes

Event Date	**July 14, 2025**
MDA8 Ozone Concentration (PPB)	81
Does Ozone Concentration exceed the 95th Percentile?	Yes
Are PM2.5, CO, NO2 and BC Concentrations elevated?	Yes
Does visual satellite imagery indicate smoke in Lake and Porter County?	Yes
Does TEMPO Satellite imagery show elevated NO2?	Yes
Does TROPOMI Satellite Imagery show elevated Formaldehyde?	Yes
Do AQI maps indicate regionally elevated Ozone?	Yes
Do AQI maps indicate regionally elevated PM2.5?	Yes
Does the HMS product indicate smoke in Lake and Porter County?	Yes
GAM predicted MDA8 ozone (PPB)	55.7
EMBER smoke impact (Observed MDA8 minus EMBER Impact) (PPB)	NA
Matching day MDA8 ozone (max., avg.) (PPB)	71.4, 57.6
HYSPLIT indicated wildfire regions	Shoe/Camp Fire and Muskeg Fire. Saskatchewan
Do HRRR Models indicate smoke?	Yes
Media Mentions	Yes
Clear causal relationship established?	Yes

4.0 Not Reasonably Controllable or Preventable

This section addresses the “submission of demonstration” requirement (40 CFR Part 50.14(c)(3)(iv)(D)) that the event was “both not reasonably controllable and not preventable”.

According to 40 CFR Part 50.14(b)(4):

The Administrator shall exclude data from use in determinations of exceedances and violations where a State demonstrates to the Administrator's satisfaction that emissions from wildfires caused a specific air pollution concentration in excess of one or more national ambient air quality standard at a particular air quality monitoring location and otherwise satisfies the requirements of this section.

Provided the Administrator determines that there is no compelling evidence to the contrary in the record, the Administrator will determine every wildfire occurring predominantly on wildland to have met the requirements identified in paragraph (c)(3)(iv)(D) *of this section regarding the not reasonably controllable or preventable criterion.*

The 2023 and 2025 Canadian wildfires burned boreal forests which meet the definition of wildlands. Therefore, there is no compelling evidence to the contrary that the 2023 and 2025 Canadian wildfires burned on wildlands, affected Lake and Porter County ozone, qualify as natural events and meet the criteria of being “both not reasonably controllable and not reasonably preventable”.

5.0 Natural Event or Human Event not likely to Recur

This section addresses the "submission of demonstration" requirement (40 CFR Part 50.14(c)(3)(iv)(E)) that the event "was a human activity that is unlikely to recur at a particular location or was a natural event".

Under 40 CFR Part 50.1(k):

"A natural event means an event and its resulting emissions, which may recur at the same location, in which human activity plays little or no direct causal role, anthropogenic sources that are reasonably controlled shall be considered to not play a direct role in causing emissions."

Furthermore, 40 CFR Part 50.1(n) defines:

"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 prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event."

Table 5.1: Fire Name and Source of Ignition

Fire Name	Source of Ignition
Long Lake Fire	Likely human-caused
Paskwa Fire	Lightning
Shaw Fire	Not confirmed (lightning and drought conditions present)
Barrington Lake Fire	Human-caused (intentionally set tire fire not extinguished)
Sept-Îles Fire	Sparks from a moving railcar
Lebel-sur-Quévillon Fire	Lightning
Radisson 2 Fire	Lightning
James Bay Priority Fires	Lightning (182 ignitions in one day)
Western-edge Wabakimi Fire	Not confirmed
Sioux Lookout 33 Fire	Not confirmed (regional lightning activity)
Lake Nipigon 13 Fire	Not reported (likely lightning based on conditions)
Lake Nipigon 19 Fire	Not confirmed (likely lightning)

Fire Name	Source of Ignition
Vermette Fire	Human-caused
Smith Fire	Human-caused
Pembina Fire (Complex)	Mixed human-caused and lightning ignitions (including debris-burn holdover)
St. Mary’s River Fire	Downed power line
Shoe Fire	Human-caused
Camp Fire	Not confirmed (season dominated by human-caused fires)
Flin Flon Fire	Not specified (drought and wind contributed)
Pisew Fire	Human-caused
EA061 Fire	Lightning
Red Lake 12 Fire	Likely lightning (storm activity)
Muskeg Fire	Likely lightning (extreme drought, heat dome conditions)

According to Table 5.1, many of Canada’s fires in 2023 and 2025 were ignited by summer lightning storms and burned for many months in remote areas. The intensity of the fires that were human-caused were increased by extreme weather conditions.

Therefore, the Canadian wildfires qualify as natural events and meet the criteria of “was a human activity that is unlikely to recur at a particular location or was a natural event”.

6.0 PUBLIC PARTICIPATION

In accordance with 40 CFR 51.102, IDEM provided an opportunity for public participation concerning the Exceptional Events Demonstration Addressing the 2015 8-Hour Ozone (O_3) National Ambient Air Quality Standard (NAAQS) Lake and Porter Counties, Indiana. Notice of availability was posted on IDEM's website under "Public Notices: Lake County" on April 17, 2026 and remained posted for at least 30 days. IDEM did not receive a request for public hearing but did receive public comments in support of the draft submittal. Those comments are included along with the details concerning public participation opportunities, including a copy of the legal notice and certification of publication, as contained in Attachment A.

IDEM offers the public near real time access to the statewide air monitoring data (IDEM: Air Monitoring: Air Quality Data). Through IDEM's Data Management and Display System, anyone has access to near-real time statewide and regional air quality maps and data including:

• The Air Quality Index (AQI) for pollutants including ozone and particulate matter (PM)

• Current pollutant concentrations (including carbon monoxide, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide)

• Meteorological data (including air temperature, barometric pressure, precipitation, relative humidity, solar radiation, and wind speed and direction)

• User-generated reports for ozone and PM.

7.0 SUMMARY

This demonstration establishes that elevated ozone concentrations observed in Lake and Porter counties during 2023 and 2025 were primarily driven by long-range transport of Canadian wildfire smoke. Using a comprehensive, multi-method evidence framework, including meteorological analysis, pollutant comparisons, satellite and AOD imagery, statistical modeling, and HYSPLIT trajectory assessments, the analysis consistently links each exceedance event to substantial smoke impacts. Across these events, ozone, $PM_{2.5}$, CO, NO_2, and black carbon levels were markedly elevated, with modeling estimating wildfire smoke contributions of up to 25 ppb. Satellite data and backward trajectories confirm that air masses arrived directly from large, intense wildfire complexes in Canada, while matching-day analyses show ozone levels significantly higher than comparable non-smoke days. Collectively, these findings meet U.S. EPA's Exceptional Events Rule criteria by demonstrating a clear causal relationship and supporting the exclusion of these smoke-impacted days from regulatory determinations for the 2015 8-hour ozone NAAQS.

Table 7.1 - 2023-2025 8-hour Ozone Design Values with Exceptional Event Days Removed

Monitor	2023 Fourth Highest MDA8 Ozone Value (ppb)	2024 Fourth Highest MDA8 Ozone Value (ppb)	2025 Fourth Highest MDA8 Ozone Value (ppb)	2023-2025 8-Hour Ozone Design Value (ppb)
Gary-IITRI	67	69	65	67
Hammond	69	67	70	68
Ogden Dunes	70	70	67	69
Valparaiso	65	65	67	65

Table 7.2 - Gary-IITRI Ranked 8-hour Ozone Concentrations for 2023 and 2025 With Exceptional Event Days Removed

Annual Rank	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)
1st	4/14/2023	80	9/19/2025	67
2nd	5/11/2023	72	9/18/2025	67
3rd	6/23/2023	68	8/5/2025	66
4th	5/29/2023	67	6/6/2025	65

Table 7.3 - Hammond Ranked 8-hour Ozone Concentrations for 2023 and 2025 With Exceptional Event Days Removed

Annual Rank	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)
1st	6/28/2023	75	8/6/2025	76
2nd	6/24/2023	70	9/19/2025	73
3rd	4/14/2023	70	7/29/2025	72
4th	6/21/2023	69	8/5/2025	70

Table 7.4 - Ogden Dunes Ranked 8-hour Ozone Concentrations for 2023 and 2025 With Exceptional Event Days Removed

Annual Rank	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)
1st	4/14/2023	75	8/6/2025	74
2nd	8/20/2023	73	8/5/2025	70
3rd	6/23/2023	71	6/6/2025	67
4th	5/13/2023	70	6/26/2025	67

Table 7.5 - Valparaiso Ranked 8-hour Ozone Concentrations for 2023 and 2025 With Exceptional Event Days Removed

Annual Rank	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)	Date	Daily Maximum 8-Hour Average Ozone Concentration (ppb)
1st	5/29/2023	71	9/18/2025	72
2nd	7/9/2023	67	7/3/2025	71
3rd	6/23/2023	67	9/19/2025	67
4th	6/22/2023	65	9/17/2025	67