# ENCLOSURE: TECHNICAL SUPPORT DOCUMENT FOR EPA NONCONCURRENCE ON OZONE EXCEEDANCES MEASURED AT THE NORTHBROOK WATER PLANT, NORTHBROOK, ILLINOIS ON JUNE 18-19, 2020 AS EXCEPTIONAL EVENTS

In November of 2020, the Illinois Environmental Protection Agency (IEPA) identified several wildfires in Arizona that may have caused ozone ($O_3$) exceedances at one $O_3$ monitoring site operated by IEPA on June 18-19, 2020. On February 1, 2021, IEPA submitted an exceptional events demonstration to EPA for ozone exceedances observed at the Northbrook Water Plant monitoring site on those dates. On May 5, 2021, IEPA provided supplemental materials and analysis to support its demonstration. The Bush, Magnum, and Bighorn fires burned just under 955,000 acres in Arizona during the 2020 wildfire season. Under the EPA's Exceptional Events Rule, 40 CFR parts 50 and 51 (50.1, 50.14 and 51.930), air agencies can request the exclusion of event-influenced data, and EPA reviews the requests against the criteria in the Exceptional Events Rule to determine whether to exclude the data from use for certain regulatory decisions. The remainder of this document summarizes the Exceptional Events Rule requirements, the event at issue here, and EPA's review of IEPA's demonstration.

## EXCEPTIONAL EVENTS RULE REQUIREMENTS

EPA promulgated the Exceptional Events Rule in 2007, pursuant to the 2005 amendment of Clean Air Act (CAA) section 319. In 2016, EPA finalized revisions to the Exceptional Events Rule. The 2007 Exceptional Events Rule and 2016 Exceptional Events Rule revisions added sections §50.1(j)-(r), 50.14, and 51.930 to title 40 of the Code of Federal Regulations (CFR). These sections contain definitions, criteria for EPA approval, procedural requirements, and requirements for air agency demonstrations. EPA reviews the information and analyses in the air agency's demonstration package using a weight of evidence approach and decides to concur or not concur. The demonstration must satisfy all of the Exceptional Events Rule criteria for EPA to concur with excluding the air quality data from certain regulatory decisions.

Under 40 CFR §50.14(c)(3)(iv), the air agency demonstration to justify data exclusion must include:

A. "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);"

B. "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;"

C. "Analyses comparing the claimed event-influenced concentration(s) to concentrations at the same monitoring site at other times" to support requirement (B) above;

D. "A demonstration that the event was both not reasonably controllable and not reasonably preventable;" and

E. "A demonstration that the event was a human activity that is unlikely to recur at a particular location or was a natural event."[1]

In addition, the air agency must meet several procedural requirements, including:

1. Submission of an initial notification of a potential exceptional event and flagging of the affected data in EPA's Air Quality System (AQS) as described in 40 CFR §50.14(c)(2)(i);

2. Completion and documentation of the public comment process described in 40 CFR§50.14(c)(3)(v); and

3. Implementation of any applicable mitigation requirements as described in 40 CFR §51.930 for areas with recurring events.

For data influenced by exceptional events to be used in initial area designations, air agencies must also meet the initial notification and demonstration submission deadlines specified in Table 2 in 40 CFR §50.14. We include below a summary of the Exceptional Events Rule criteria, including those identified in 40 CFR §50.14(c)(3)(iv).

**Regulatory Significance**

The 2016 Exceptional Events Rule includes regulatory language that applies the provisions of CAA section 319 to a specific set of regulatory actions. As identified in 40 CFR §50.14(a)(1)(i), these regulatory actions include initial area designations and redesignations; area classifications; attainment determinations (including clean data determinations); attainment date extensions; findings of State Implementation Plan (SIP) inadequacy leading to a SIP call; and other actions on a case-by-case basis as determined by the Administrator. Air agencies and EPA should discuss the regulatory significance of an exceptional events demonstration during the initial notification process prior to the air agency submitting a demonstration for EPA's review.

**Narrative Conceptual Model**

The 2016 Exceptional Events Rule directs air agencies to submit, as part of the demonstration, a narrative conceptual model of the event that describes and summarizes the event in question and provides context for analyzing the required statutory and regulatory technical criteria. Air agencies may support the narrative conceptual model with summary tables or maps. For wildfire $O_3$ events, EPA recommends that the narrative conceptual model also discuss the interactions of emissions, meteorology, and chemistry of event and non-event $O_3$ formation in the area; and, under 40 CFR §50.14(a)(1)(i), must describe the regulatory significance of the proposed data exclusion.

**Clear Causal Relationship and Supporting Analyses**

EPA considers a variety of evidence when evaluating whether there is a clear causal relationship

[1] A natural event is further described in 40 CFR §50.1(k) as "an event and its resulting emissions, which may recur at the samelocation, in which human activity plays little or no direct causal role. For purposes of the definition of a natural event, anthropogenic sources that are reasonably controlled shall be considered not to play a direct role in causing emissions."

between a specific event and the monitored exceedance or violation. For wildfire $O_3$ events, air agencies should compare the $O_3$ data requested for exclusion with seasonal and annual historical concentrations at the air quality monitor to establish a clear causal relationship between the event and monitored data. In addition to providing this information on the historical context for the event-influenced data, air agencies should further support the clear causal relationship criterion by demonstrating that the wildfire's emissions were transported to the monitor, that the emissions from the wildfire influenced the monitored concentrations, and, in some cases, air agencies may need to provide evidence of the contribution of the wildfire's emissions to the monitored $O_3$ exceedance or violation.

For wildfire $O_3$ events, EPA has published a guidance document that provides three different tiers of analyses that apply to the "clear causal relationship" criterion within an air agency's exceptional events demonstration. This tiered approach recognizes the limited resources of the air agencies that prepare and submit exceptional events demonstrations and of the EPA Regional offices that review these demonstrations; therefore, the tiered approach aims to avoid the preparation and submission of extraneous information. Submitters should prepare and submit the appropriate level of supporting documentation, which will vary on a case-by-case basis depending on the nature and severity of the event, as appropriate under a weight of evidence approach. The EPA acknowledges that, due to a variety of factors including the type and severity of the event, pollutant concentration, spatial extent, temporal extent, and proximity of the event to the violating monitor, some exceptional events demonstrations may be limited or may need to be more extensive. If a wildfire/$O_3$ event satisfies the key factors for either Tier 1 or Tier 2 clear causal analyses, then those analyses are the only analyses required to support the clear causal relationship criterion within an air agency's demonstration for that particular event. Other wildfire/ $O_3$ events will be considered based on Tier 3 analyses.

- Tier 1: Wildfires that clearly influence monitored $O_3$ exceedances or violations when they occur in an area that typically experiences lower $O_3$ concentrations.
    - *Key Factor*: seasonality and/or distinctive level of the monitored $O_3$ concentration. The event-related exceedance occurs during a time of year that typically has no exceedances, or is clearly distinguishable (*e.g.*, 5-10 ppb higher) from non-event exceedances.
    - In these situations, $O_3$ impacts should be accompanied by clear evidence that thewildfire's emissions were transported to the location of the monitor.

- Tier 2: The wildfire event's $O_3$ influences are higher than non-event related concentrations, and fire emissions compared to the fire's distance from the affected monitor indicate a clear causal relationship.
    - *Key Factor 1*: fire emissions and distance of fire(s) to affected monitoring site location(s). Calculated fire emissions of nitrogen oxides ($NO_X$) and reactive-volatile organic carbons (VOCs) in tons per day (Q) divided by the distance from the fire to the monitoring site (D) should be equal to or greater than 100 tons per day/kilometers ($Q/D \geq 100$ tpd/km). The guidance document provides additional information on the calculation of Q/D.
    - *Key Factor 2*: comparison of the event-related $O_3$ concentration with non-event related high $O_3$ concentrations. The exceedance due to the exceptional event:
        - is in the 99th or higher percentile of the 5-year distribution of $O_3$ monitoring data, OR

    - is one of the four highest $O_3$ concentrations within 1 year (among those concentrations that have not already been excluded under the Exceptional Events Rule, if any).
  - In addition to the analysis required for Tier 1, the air agency should supply additional information to support the weight of evidence that emissions from the wildfire affected the monitored $O_3$ concentration.

- Tier 3: The wildfire does not fall into the specific scenarios (*i.e.*, does not meet the key factors) that qualify for Tier 1 or Tier 2, but the clear causal relationship criterion can still be satisfied by a weight of evidence showing.
  - In addition to the analyses required for Tier 1 and Tier 2, an air agency may further support the clear causal relationship with additional evidence that the fire emissions caused the $O_3$ exceedance.

**Not Reasonably Controllable or Preventable**

The Exceptional Events Rule requires that air agencies establish that the event be both not reasonably controllable and not reasonably preventable at the time the event occurred. This requirement applies to both natural events and events caused by human activities; however, it is presumed that wildfires on wildland will satisfy both factors of the "not reasonably controllable or preventable" element unless evidence in the record clearly demonstrates otherwise.[2]

**Natural Event or Event Caused by Human Activity That is Unlikely to Recur**

According to the CAA and the Exceptional Events Rule, an exceptional event is "an event caused by human activity that is unlikely to recur at a particular location or a natural event". The 2016 Exceptional Events Rule includes in the definition of wildfire that "[a] wildfire that predominantly occurs on wildland is a natural event." Once an agency provides evidence that a wildfire on wildland occurred and demonstrates that there is a clear causal relationship between the measurement under consideration and the event, EPA expects minimal documentation to satisfy the "human activity that is unlikely to recur at a particular location or a natural event" element. EPA will address wildfires on other lands on a case-by-case basis.

[2] A wildfire is defined in 40 CFR §50.1(n) as "any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire. A wildfire that predominantly occurs on wildland is a natural event." Wildland is defined in 40 CFR §50.1(o) as "an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities. Structures, if any, are widely scattered."

## EPA REVIEW OF EXCEPTIONAL EVENTS DEMONSTRATION

On December 1, 2020, IEPA submitted an Initial Notification of Potential Exceptional Event for two exceedances of the 2008 8-hour $O_3$ National Ambient Air Quality Standard (NAAQS) that occurred at Northbrook Water Plant (AQSID: 17-031-4201) in Northbrook, IL on June 18 and 19, 2020. On February 1, 2021, IEPA submitted an exceptional events demonstration to EPA for these two exceedances observed at Northbrook on those dates. On May 5, 2021, IEPA provided supplemental materials and analysis to support its demonstration.

### Regulatory Significance

The primary and secondary $O_3$ ambient air quality standards are met at an ambient air quality monitoring site when the 3-year average of the annual fourth-highest daily maximum 8-hour average $O_3$ concentration is less than or equal to 0.075 ppm. As shown in the table below, the daily maximum 8-hour average concentrations measured at Northbrook on June 18 and June 19, 2020 were 0.080 and 0.082 ppm, respectively. EPA determined that these exceedances have a regulatory significance because the Northbrook site is the only monitor in the Chicago-Naperville, IL-IN-WI nonattainment area that is violating the 2008 $O_3$ NAAQS, and had the monitor not recorded high values on these days, it would be attaining the 2008 $O_3$ NAAQS, as described and shown below. The Chicago-Naperville, IL-IN-WI nonattainment area[3] includes all of portions of eight counties in Illinois, two counties in Northwest Indiana, and one partial county in Southeast Wisconsin.

The 2018-2020 design value at Northbrook calculated with these two days of ozone data results in a design value of 0.077 ppm. Without these exceedances, the fourth-highest daily maximum 8-hour average for the 2020 ozone season at the Northbrook monitor is 0.075 ppm. Table 1 summarizes these exceedances and Table 1a shows the 2018-2020 design value for the Northbrook site calculated with and without the June 18 and June 19, 2020 data points identified in IEPA's demonstration.

Table 1: EPA Maximum Daily 8-hour Average $O_3$ Exceedance Summary

| Exceedance Date | Monitor/Site Name | AQS ID | Daily Max 8-hr Avg (ppm) |
|---|---|---|---|
| June 18, 2020 | Northbrook Water Plant | 17-031-4201 | 0.080 |
| June 19, 2020 | Northbrook Water Plant | 17-031-4201 | 0.082 |

[3] https://archive.epa.gov/ozonedesignations/web/pdf/2012-14097.pdf (77 FR 34221)

Table 1a: 2018-2020 Design Value calculation with and without exclusion

| Year | 1st Highest Daily Max (ppm) | 2nd Highest Daily Max (ppm) | 3rd Highest Daily Max (ppm) | 4th Highest Daily Max (ppm) | 5th Highest Daily Max (ppm) | 6th Highest Daily Max (ppm) | 2018-2020 Design Value (ppm) with exclusion | 2018-2020 Design Value (ppm) |
|---|---|---|---|---|---|---|---|---|
| 2018 | 0.096 | 0.086 | 0.084 | 0.083 | | | | |
| 2019 | 0.073 | 0.073 | 0.069 | 0.069 | | | | |
| 2020 | 0.082 | *0.082*[4] | *0.080*[5] | 0.079 | 0.078 | **0.074**[6] | 0.075 | 0.077 |

## Narrative Conceptual Model

IEPA's demonstration provided a narrative conceptual model to describe how emissions from Arizona wildfires caused $O_3$ exceedances at the Northbrook monitoring station. The narrative conceptual model includes:

- an area description;
- characteristics of typical ozone formation;
- a description of the wildfires;
- a conceptual model of ozone formation and transport from the wildfires; and
- meteorological conditions influencing smoke and ozone transport.

While IEPA's narrative conceptual model included discussion of each of the required elements, EPA's analysis of the meteorological conditions and observations in the Chicago area during this period do not support IEPA's interpretation and conclusions. As described in further detail in the next section, emissions from the wildfire did not reach the Chicago area (transport), characteristics of typical ozone formation were present on these days in Chicago, and local emissions and meteorology were the primary contributors to the elevated ozone concentrations observed at the Northbrook monitor on June 18 and 19, 2020. Because EPA's analysis does not support IEPA's conceptual model, the narrative conceptual model does not satisfy EPA's requirements for this criterion.

Table 2: Documentation of Narrative Conceptual Model

| Exceedance Date | Demonstration Citation | Quality of Evidence | Criterion Met? |
|---|---|---|---|
| June 18-19, 2020 | *Area description – Section B: page 5* | Sufficient | *Yes* |
| June 18-19, 2020 | *Characteristics of non-exceptional event ozone formation - Section B, page 5* | Sufficient | *Yes* |
| June 18-19, 2020 | *Wildfire description – Section B: page 8* | Sufficient | *Yes* |
| June 18-19, 2020 | *$O_3$ formation and transport - Section B: pages 14-15* | Not Sufficient | *No* |
| June 18-19, 2020 | *Meteorological conditions - Section B: pages 16-26* | Not Sufficient | *No* |

[4] 06/19/2020 – request for exceptional events data exclusion
[5] 06/18/2020 – request for exceptional events data exclusion
[6] If 06/18/20 and 06/19/20 values are excluded, becomes the 4th-Highest Daily Max Eight Hour Average

**Clear Causal Relationship and Supporting Analyses**

To support a demonstration of clear causal relationship, IEPA's demonstration provided the following items:

- *Comparison of event data to the key factors for Tier 3 analysis;*
- *Comparison of the fire-influenced exceedance with historical concentrations;*
- *Evidence of transport of fire emissions from the fire to the monitor;*
- *Evidence that the fire emissions affected the monitor for Tier 2 and 3 analysis; and*
- *Additional evidence that the fire emissions caused the O3 exceedance for Tier 3 analysis*

- IEPA's demonstration states:

  *"Although the meteorological conditions that existed during the event could have potentially caused elevated ozone at usual summer season levels without the increased burden of the additional wildfire-related precursor emissions, the influence of the Arizona wildfire smoke plume emissions caused significant additional impact that elevated ozone levels beyond normal expectations. As the smoke plume aged and mixed with anthropogenic NOx, ozone concentrations accumulated to levels likely not possible without the smoke.*

  *The comparisons and analyses provided within this document support Illinois' conclusion that the wildfire event affected air quality in such a way that there exists a clear causal relationship between the specific event and the monitored exceedances…and thus satisfy the clear causal relationship criterion."*

The analysis included in IEPA's demonstration, however, does not show a clear causal relationship between the emissions generated by the Arizona Bush, Magnum, and Bighorn wildfires and the exceedances measured at Northbrook.

Table 3: Documentation of Clear Causal Relationship and the Supporting Analyses

| **Exceedance Date** | **Demonstration Citation** | **Quality of Evidence** | **Criterion Met?** |
|---|---|---|---|
| June 18-19, 2020 | Tiered approach - *Section C: page 27* | Sufficient | *Yes* |
| June 18-19, 2020 | Comparison with historical - *Section C: pages 27- 30* | Sufficient | *Yes* |
| June 18-19, 2020 | Evidence of Transport - *Section C: pages 30-55* | Not Sufficient | *No* |
| June 18-19, 2020 | Evidence affecting monitor - *Section C: pages 56-59* | Not Sufficient | *No* |
| June 18-19, 2020 | Additional evidence - *Section C: pages 60-68* | Not Sufficient | *No* |

## *TRANSPORT OF EMISSIONS FROM THE WILDFIRE TO THE MONITOR*

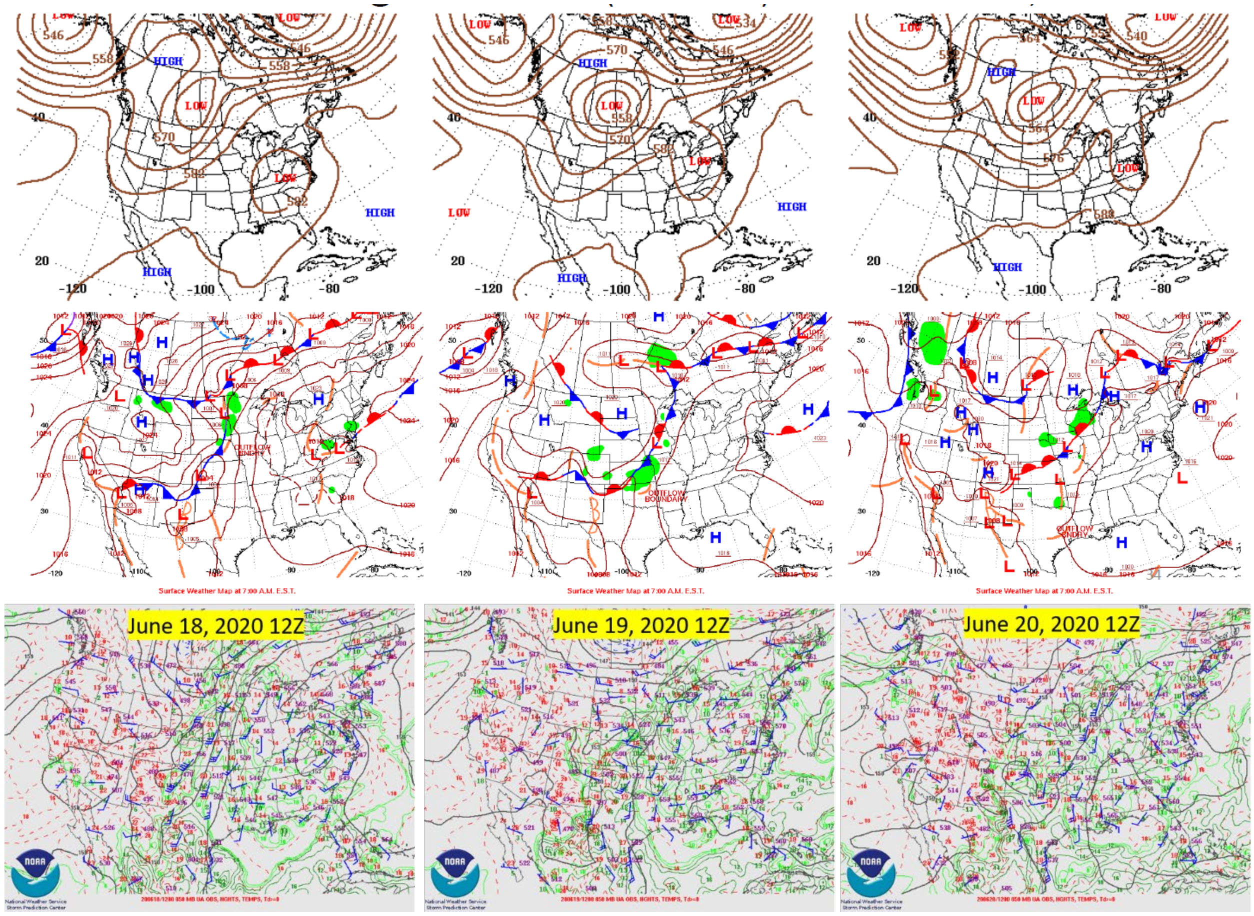


*Figure 1: 500 mb upper air (top row) and surface (middle row) meteorological analysis for June 18 to 19, 2020; 850 mb meteorological analysis for the same days are shown in the bottom row (https://www.spc.noaa.gov/obswx/maps/ (IEPA, 2021; EPA, 2021).*

In reviewing IEPA's demonstration, IEPA provided an analysis of surface and upper air meteorology (Figure 1). Both the 500 millibar (mb) and 850 mb analyses show a slow-moving frontal system from June 18 to 20, 2020, extending from Arizona northward to the upper central plains region of the United States and south-central Canada. With a high-pressure system over the western side of this frontal passage, air in the southwest moved toward the north through the intermountain west and into the western Dakotas and south-central Canada early in this period. Later in the period, a high-pressure system resulted in stagnant and disorganized winds over the southwest. Meteorological conditions do not support the transport of the emissions from Arizona to Chicago. Air from the wildfires in Arizona did not reach the Northbrook monitor in the Chicagoland area.

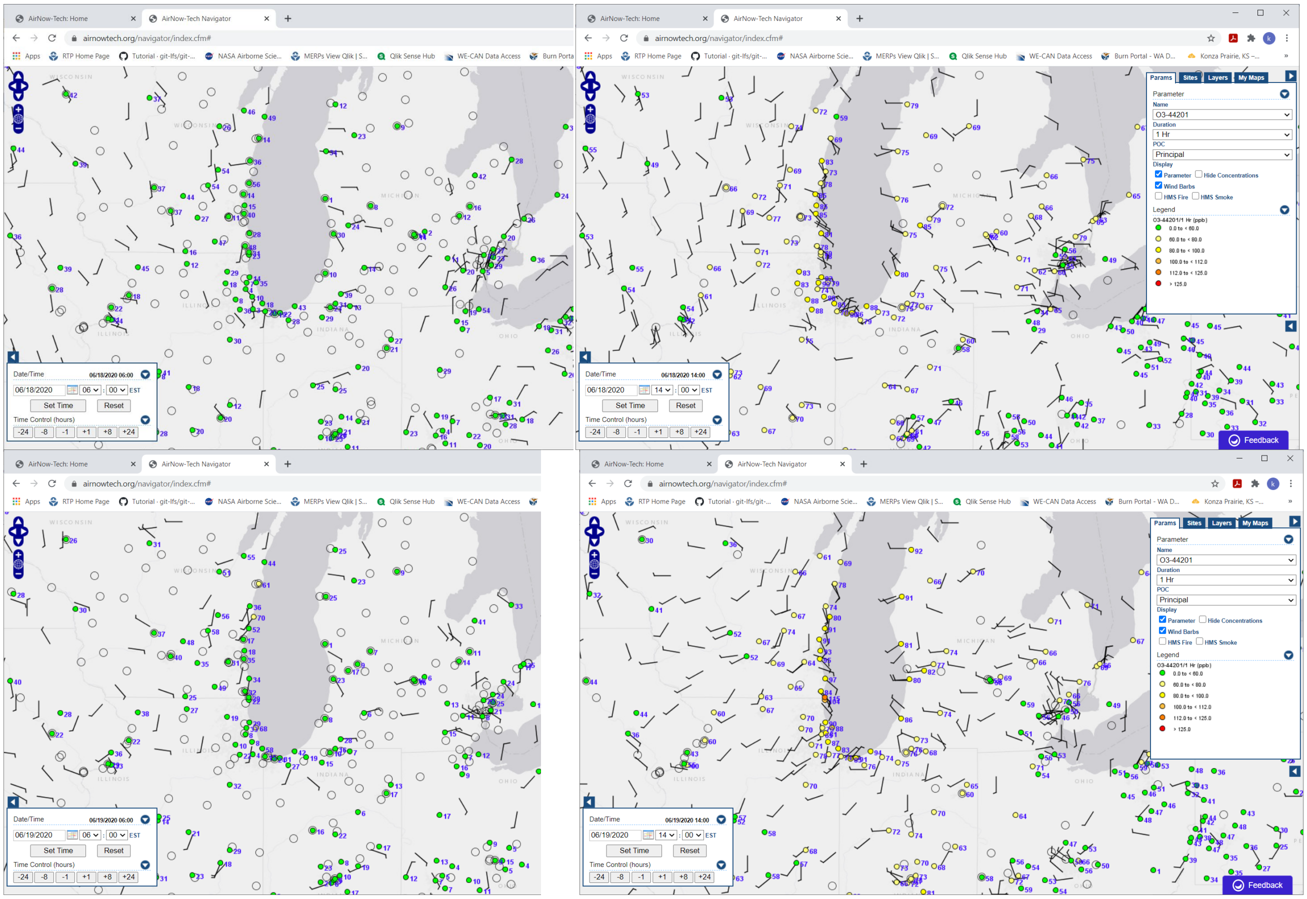

*Figure 2: Early morning (left panels) and afternoon (right panels) surface winds and hourly $O_3$ levels at monitors in the Lake Michigan area for June 18 (top row) and June 19 (bottom row), 2020 (EPA, 2021).*

Vermeuel *et al*. (2019) have researched typical conditions for $O_3$ formation in Chicagoland. They have found that stagnant winds allow for the buildup of $O_3$ precursors from the Chicago area's emissions. High temperatures and clear skies also present conditions common for $O_3$ production. Specifically, early morning stagnant winds, coupled with light land-to-lake flow, allow for emissions buildup in Chicagoland. Some of these emissions push out over Lake Michigan, where $O_3$ production is efficient due to abundant solar radiation and low mixing layers over the lake. Afternoon winds along the lakeshore shift to a lake-to-land circulation pattern, which is a common meteorological pattern associated with local $O_3$ production around Lake Michigan.

Figure 2 shows that winds in the Lake Michigan region were light and disorganized on the eastern side of this frontal passage on June 18 and 19, 2020. Stagnant wind conditions that allow for the buildup of $O_3$ precursors from the area's emissions, as described above, can be seen over the Chicagoland area in Figure 2. Furthermore, when the stagnant winds were coupled with the high temperatures and clear skies demonstrated in Figure 1, they led to $O_3$ formation. The surface and upper air meteorological analysis in Figure 1 also shows that surface and boundary layer winds (850 mb or 1,400 Mean Sea Level—the altitude above sea level in feet) were steady from the Gulf of Mexico northward along the eastern side of the frontal passage in the midwest, Great Lakes, and Ohio River valley regions. Neither surface level nor upper air came from Arizona on these days. Stagnant air with light disorganized winds were common in the eastern United States on these days.

IEPA's analysis confirms this by stating, "[t]*he high temperatures and low winds shown for June 18 and 19, 2020 are typical ozone formation characteristics in the Lake Michigan region. The average surface winds from the east are representative of the Lake Michigan influence on air quality. The overall collective of the readings indicates a low-level high-pressure system in the region."* [7]

The analyses in Figures 1-2 demonstrate that air from Arizona did not reach Chicagoland during the period identified in the exceptional events demonstration. Furthermore, conditions in Chicagoland were consistent with typical episodes of high summertime ozone events (*i.e.*, stagnant winds, high temperatures and clear skies).

## *AIR LOCAL IN NATURE*

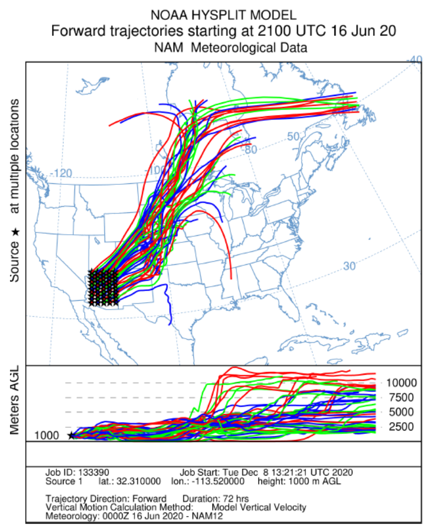


*Figure 3: HYSPLIT forward trajectories (72 hours) starting in Arizona on June 16, 2020; (IEPA, 2021).*

The Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model is a complete system for computing simple air parcel trajectories. A forward-trajectory analysis determines the distance and direction an air parcel will travel and predict transport of emissions. A back-trajectory analysis determines the origin of air masses and, similar to forward trajectories, helps establish source-receptor relationships.

IEPA's demonstration provided forward trajectories (Figure 3) from the HYSPLIT model. The trajectories start on June 16, 2020 at 21 Coordinated Universal Time (UTC) and move forward in time for 72 hours, ending on June 19, 2020 at 21 UTC. Starting points for the model were systematically placed over the entire state of Arizona to account for all potential locations of wildfire. This ensemble of forward trajectories follows a consistent transport pattern, where air flows from Arizona northward into central Canada. Most of the trajectories are well above the surface when reaching the north central plains region of the United States and central Canada on June 18 and 19, 2020. Further, none of the trajectory endpoints reach the surface in the region covering Missouri and beyond to the east and south. *None of the trajectory endpoints reach the Chicago Northbrook monitor—either aloft or at the surface*. *These trajectories do not show transport of the Arizona fire emissions to the Chicago area* *during this time period, and do not support IEPA's position that a clear causal connection exists between the Arizona fires and Northbrook*. Rather, the path of these trajectories is consistent with the large scale meteorological patterns present during this time period and described above, where air from the southwest was transported to the north along the western side of a slow moving frontal system and an area of high pressure over the eastern United States (Figure 1).

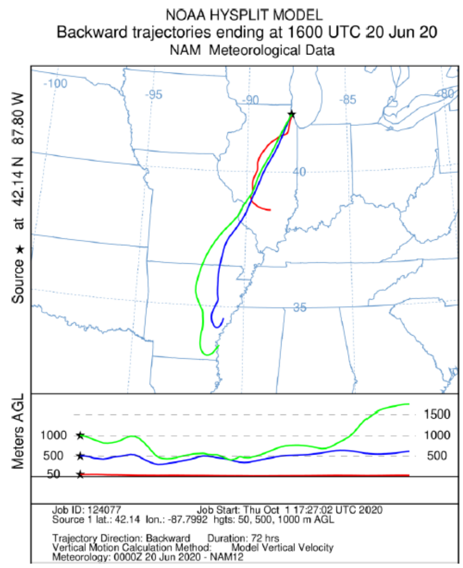


*Figure 4: HYPLIT back-trajectory (72 hours) starting at the Northbrook monitor location on June 20, 2020 (IEPA, 2021).*

IEPA's demonstration also provided HYSPLIT 3-day back trajectories (starting June 20, 2020) from the Northbrook monitor. As shown in Figure 4, the back trajectories extend south through Illinois to Missouri and northern Arkansas. The short distance of the trajectories for this 3-day period is caused by the light stagnant winds due to the high-pressure system covering the region.

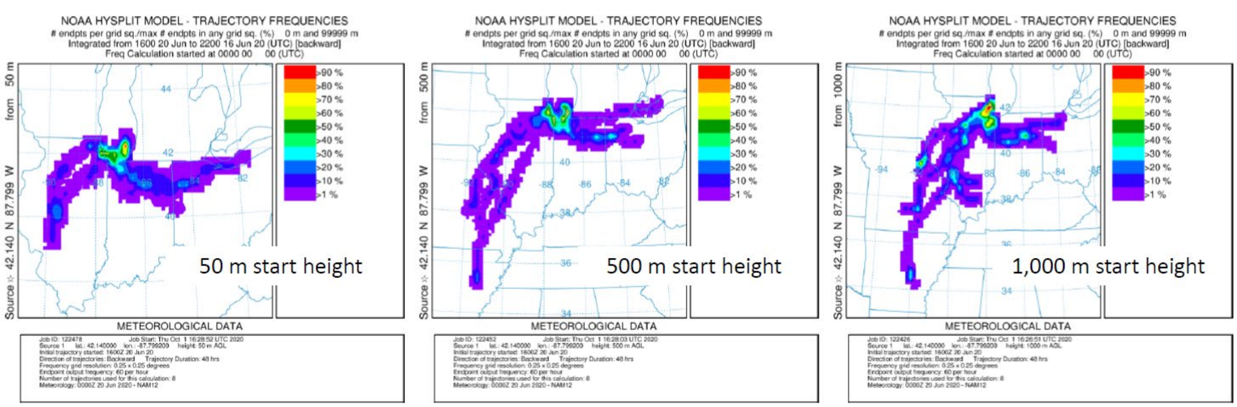


*Figure 5. HYPLIT model 3-day back-trajectory frequency analysis. Trajectories start at the Northbrook monitor location on June 20, 2020 (IEPA, 2021).*

IEPA provided a trajectory frequency analysis using the HYPLIT model at 50m, 500m, and 1000m starting heights, which allows for additional examination of areas influencing the Northbrook monitor on June 18 and 19, 2020 (Figure 5*). These plots show recirculation of emissions over Lake Michigan* *having the greatest frequency of air mass contribution to the Northbrook monitor. In addition, there is some contribution from central Illinois, Missouri, and areas to the east, including northern Indiana, northern Ohio, and southern Michigan.* The trajectory with the highest elevation starting point (right panel Figure 5) shows less contribution from the land-lake recirculation and more contribution from states bordering Illinois. This is consistent with the compressed surface mixing layers common over Lake Michigan. $O_3$ production is greatest over Lake Michigan due to the abundance of precursor emissions from the Chicago metropolitan area coupled with a shallow surface mixing layer and abundant solar radiation for photochemical reactions (Vermeuel *et al.*, 2019).

The land-lake recirculation patterns shown in the back-trajectory frequency analysis are consistent with the observed surface winds in the region shown in Figure 2. The back-trajectory endpoints spanning Missouri, northern Arkansas, Illinois, northern Indiana, northern Ohio, and southern Michigan are consistent with the larger scale meteorological systems in the region shown in Figure 1. The relatively short distance of the endpoints over the 3-day period of the back-trajectory is consistent with the stagnant wind conditions due to the high pressure system over the region and intermittent winds bringing air from the Gulf of Mexico and southern states (Texas to Florida) shown in Figure 1. These trajectory frequency analyses support that the Northbrook monitor was influenced by local conditions and not by an air parcel containing wildfire emissions transported from Arizona.

## *DAILY SPECIATED $PM_{2.5}$ COMPONENTS*

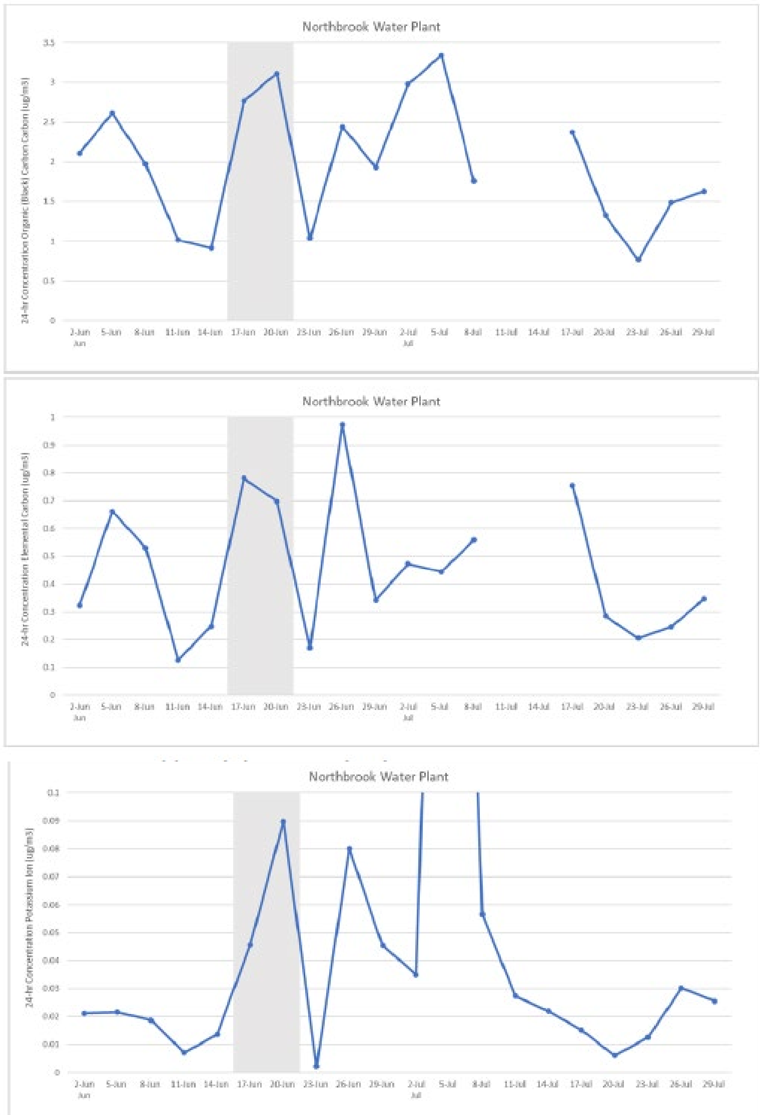


*Figure 6: Speciated $PM_{2.5}$ components measured at the Northbrook location. Components include organic carbon (top), elemental carbon (middle), and potassium (bottom) (IEPA, 2021). The shaded region on the timeseries indicates days around the June 18-19, 2020 period.*

IEPA looked at the concentrations of daily speciated $PM_{2.5}$ components (organic carbon, elemental carbon, and potassium) measured at the surface level of the Northbrook monitor (Figure 6). Organic carbon, elemental carbon, and potassium can sometimes provide an indication about the influence of biomass burning (Laing *et al*., 2017). *At the Northbrook monitor, the levels of $PM_{2.5}$ organic carbon, elemental carbon, and potassium show substantial day-to-day variability and peak levels are similar throughout the June 2020 period shown in this timeseries. Further, the meteorological conditions in the region during the June 18-19, 2020 period consist of regional scale stagnant air masses, which would result in build-up of $PM_{2.5}$ components and cause levels that are higher than days immediately preceding and following June 18-19, 2020.*

$PM_{2.5}$ potassium is sampled every three days at Northbrook. Samples were collected on June 17 and 20, 2020. No samples were collected on June 18 or 19, 2020 (Figure 6 bottom). Potassium levels on June 17 and June 20 at Northbrook were above typical annual averages, but similar to other days during the summer of 2020. They were also similar to potassium concentrations measured at Northbrook over the previous five years. Over the years, many of the highest potassium concentrations at Northbrook occur in late June and early July due to fireworks emissions near the July 4$^{th}$ holiday. Potassium, as well as other metals associated with fireworks, had higher concentrations and greater variability across the Chicago area during this period of time in 2020, as well as other previous years. Not having potassium data on June 18 or 19, 2020, the potential for fireworks to dominate potassium contributions, and a stagnant airmass supporting the build-up of local emissions over several days make potassium concentrations reported on June 17 and 20 an unreliable indicator for attribution of biomass burning impacts from the Arizona fires at Northbrook.

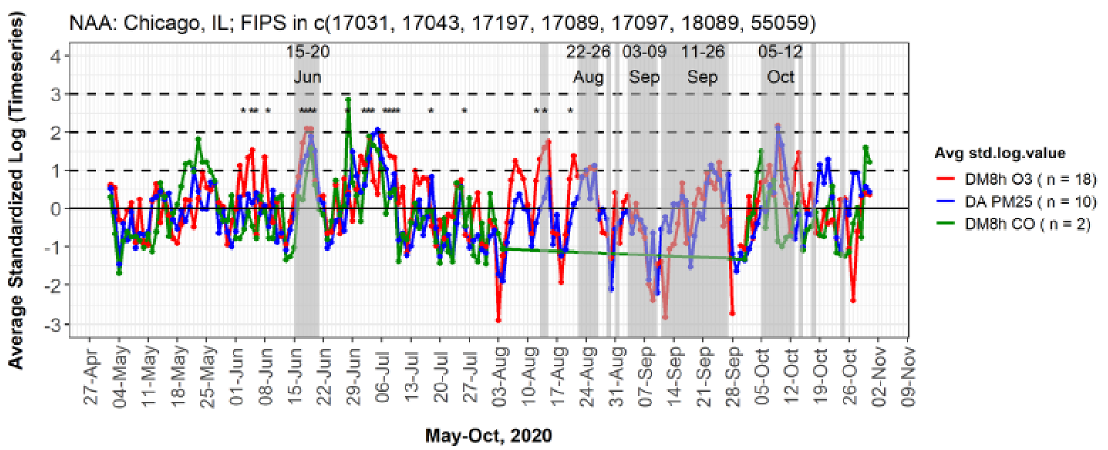


**Figure 60. Average anomaly plots for the daily maximum 8-hour ozone, daily average PM2.5, and daily maximum 8-hour CO concentrations measured in the Chicago NAA.**

*Figure 7: Average anomaly plot for the daily maximum 8-hr ozone, daily average $PM_{2.5}$, and daily maximum 8-hr CO concentration measured in the Chicago area (IEPA, 2021).*

Figure 7 shows a time series statistical analysis showing average anomaly plots for multiple pollutants measured in the Chicago area. Coincident anomalous carbon monoxide (CO), $PM_{2.5}$, and $O_3$ concentrations are shown for days IEPA suggests have potential smoke impacts, but not all. *However, these pollutants being simultaneously elevated is also expected during stagnation events that are unrelated to fires.* The Chicagoland has many sources that emit $PM_{2.5}$ and CO and, when coupled with stagnant winds, could be coincidentally elevated with $O_3$. This relationship would likely be stronger for monitors in close proximity to wildfire rather than over a thousand miles apart.

In Figure 7, when $O_3$, CO, and $PM_{2.5}$ values are above the dotted lines, concentrations are one to three geometric standard deviations above the five-year geometric mean. However, these are not necessarily days that had smoke impacts. The June 15-20 period has elevated levels of all three pollutants. There is also a period from the end of June through mid-July in which all three pollutants are elevated, but there is no smoke indicated. *Showing these pollutants are coincidentally elevated on the same day is not enough evidence on its own to support a fire impact, especially when there is insufficient evidence of transport of wildfire emissions to the Chicago area.* The days when these pollutants coincidentally are elevated several standard deviations above the five-year mean occur during periods of stagnation in the area. The build-up of these pollutants is expected during periods of stagnation, especially for pollutants with low reactivity in the atmosphere, like $PM_{2.5}$ and CO.

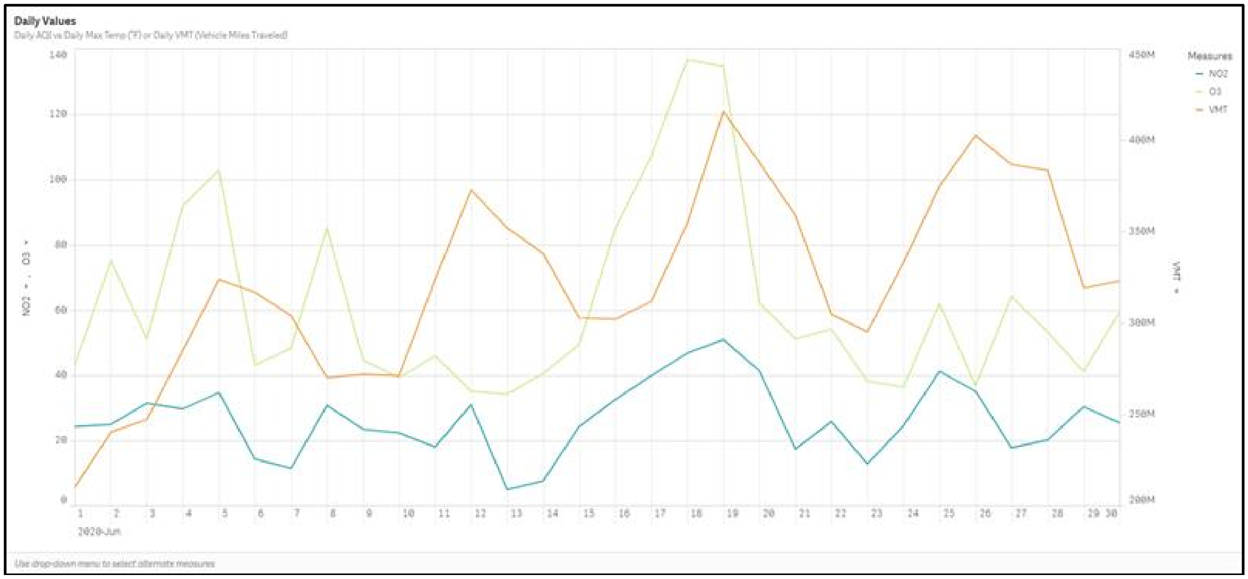

*Figure 8: $O_3$, $NO_2$ AQI vs Vehicle Miles Traveled for June 2020 (EPA, 2021)*

Figure 8 shows the Air Quality Index (AQI) values for $O_3$ and nitrogen dioxide ($NO_2$) and Vehicle Miles Traveled (VMT) that EPA developed for the entire month of June 2020. *Notably, the $O_3$ and $NO_2$ AQI peaks closely follow the VMT, and the multi-day period leading up to and including June 18 and 19 has some of the highest VMT for the month of June 2020*. VMT during this period also exceeds the VMT earlier in June, when an additional $O_3$ exceedance (0.082 ppm) was recorded at Northbrook, indicating the potential for elevated $O_3$ with existing conditions in this area. High VMT also results in an increase in $O_3$ precursor emissions, such as VOCs, $NO_x$, PM2.5, and CO.

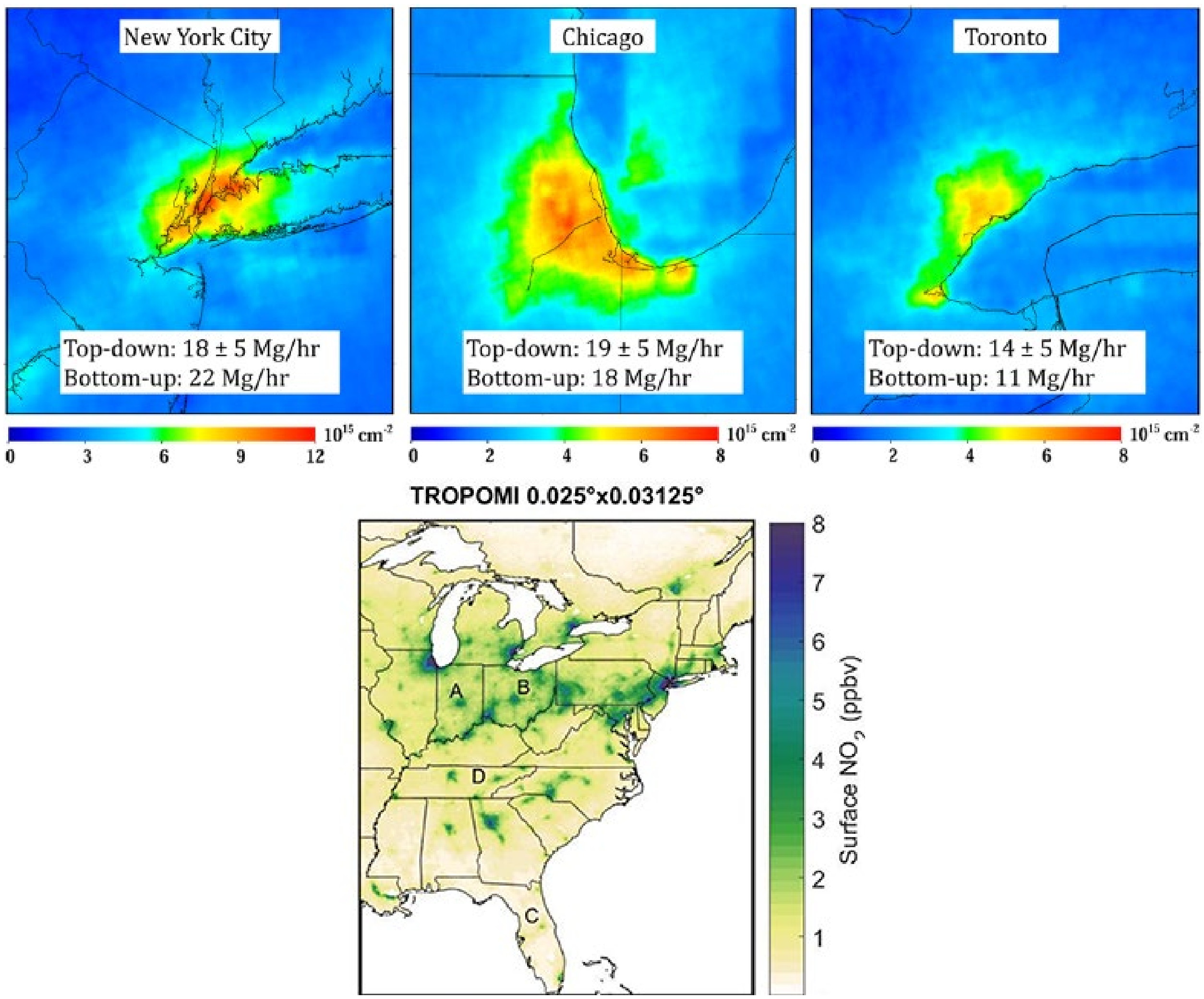


*Figure 9: TROPOMI $NO_2$-based NOX emissions estimates for the summer of 2018 (Goldberg et al., 2019) for New York City, Chicago, and Toronto (top row) and the eastern U.S. for June 2018 to June 2019 (bottom row) (Cooper et al., 2020).*

In addition to (1) meteorological conditions not supporting transport of the emissions from Arizona to Chicago, (2) forward and backward trajectories showing that the air parcel did not reach the Chicagoland area and did not originate from Arizona, and (3) optimal conditions for local formation of $O_3$ from local precursor emissions, evidence in the literature demonstrates that this region has a substantial amount of emissions that can contribute to $O_3$ production. Space-based measurements of $NO_2$ (Figure 9) from 2018-2019 show a large collection of emissions in the Chicago area. Figure 9 further demonstrates that the level of $NO_2$ column in Chicago, estimated using data collected by the TROPOMI satellite, is similar to or greater than other large cities in North America, as recently as 2018 (Goldberg *et al*., 2019). Anthropogenic emissions are also evident over the Great Lakes and Ohio River Valley, based on a similar type of analysis using TROPOMI $NO_2$ column data (Cooper *et al*., 2020). The location of these $O_3$ precursor emissions are spatially coincident with the back-trajectory analysis provided by IEPA.

## *REMOTELY SENSED DATA*

IEPA's demonstration contained examples of remotely sensed data. Remotely sensed data from satellites can provide an indication of whether smoke may be in the atmosphere. These include visible images that show clouds and smoke, hazard mapping system (HMS) smoke products, aerosol optical depth (AOD), $NO_2$, and CO from one or more satellite platforms. Most satellite-based products do not provide information about surface-level smoke and none provide information about surface-level $O_3$ impacts from smoke. Wildfires are not the only source of $NO_2$, CO, and aerosol in the atmosphere, so interpretation of these products for the purposes of identifying causality from specific fires to specific monitors over large distances can be challenging. For instance, $NO_2$ column data can provide useful information about large emissions sources, but does not provide a clear link between sources and receptors far apart (*i.e.*, hundreds to thousands of miles).

AOD is the sum of optical influence across all aerosol species, often dominated by more reflective anthropogenic aerosols, like sulfate. Isolating a smoke signal with AOD on individual days is very difficult, especially when it is far away from very large emissions sources, like a wildfire or a complex of wildfires.

EPA plotted NOAA's AOD Visible Infrared Imaging Radiometer Suite (VIIRS) product on the AerosolWatch website for several days to provide context about how this type of data might be used to inform demonstrations.

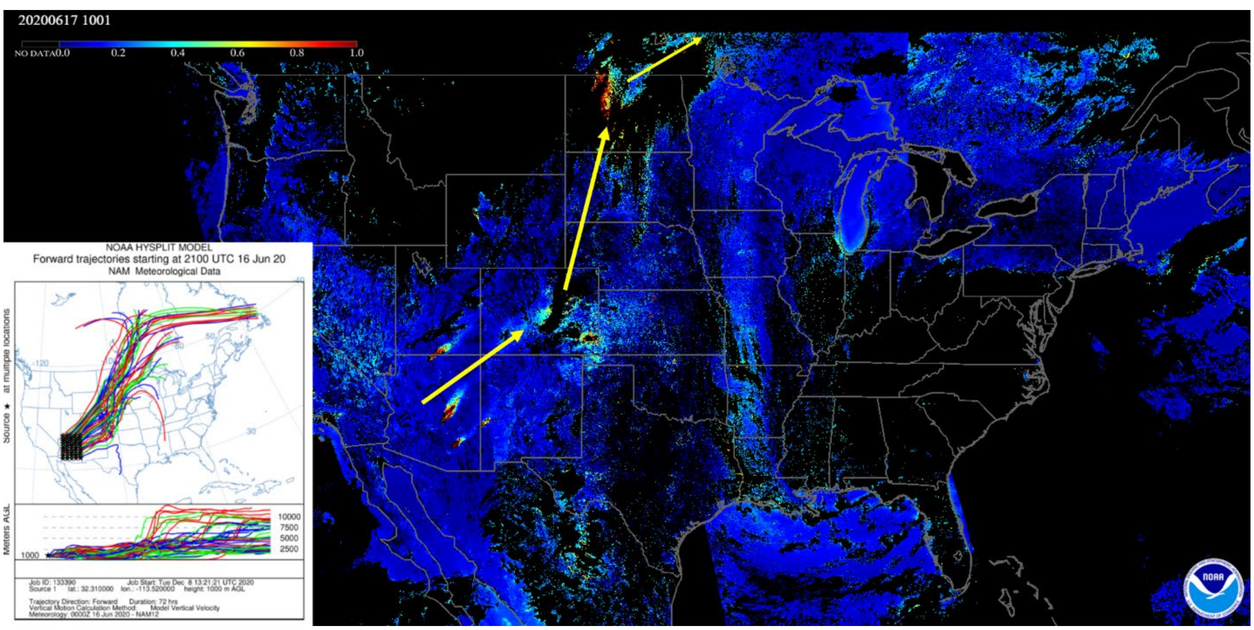


*Figure 10: VIIRS AOD product for June 17, 2020 (www.star.nesdis.noaa.gov). HYSPLIT forward-trajectory ensemble overlaid at the bottom left starting on June 16, 2020 and extending forward in time for 72 hours (IEPA, 2021).*

Figure 10 shows the VIIRS AOD product for June 17, 2020. IEPA's forward-trajectory is inset into this graphic and shows the forward-trajectory of parcels of air from Arizona starting on June 16, 2020 and extending forward in time for 72 hours.

The information in this figure represents total column data and does not provide information about $PM_{2.5}$ or $O_3$ at the surface. However, it can sometimes be used as corroborative information about large-scale transport, if clouds and missing data do not overwhelm a daily composite image. In this case, on June 17, 2020, the areas with warm-colored AOD—representing relatively higher levels of AOD—tend to match up with the multi-day transport projected by the HYSPLIT model (Figure 3; inset). Winds transported smoke from the Arizona fires to the northeast into the central plains region, where southerly winds took the smoke north into the Dakotas and central Canada. This transport pattern is also consistent with the large-scale meteorological features in the region during this period. Air from the southwest flowed northward into the Dakotas and south-central Canada and was blocked by high pressure systems over the eastern United States and the slow-moving frontal passage over the central plains region (Figure 1).

*While Figure 10 shows useful corroborative information for the HYSPLIT forward trajectories, it does not provide information about whether smoke from wildfire in Arizona impacted the surface at specific locations downwind*. The origin of the aerosol in these images is speculative at best. The trajectories and meteorological conditions have established that the air parcel from Arizona did not reach the Northbrook monitor. AOD is the sum of all optical aerosols and it is difficult to isolate smoke from other anthropogenic sources. Visible images from satellites can be even more difficult to discern source-receptor relationships, especially when long distances are between the source and monitor.

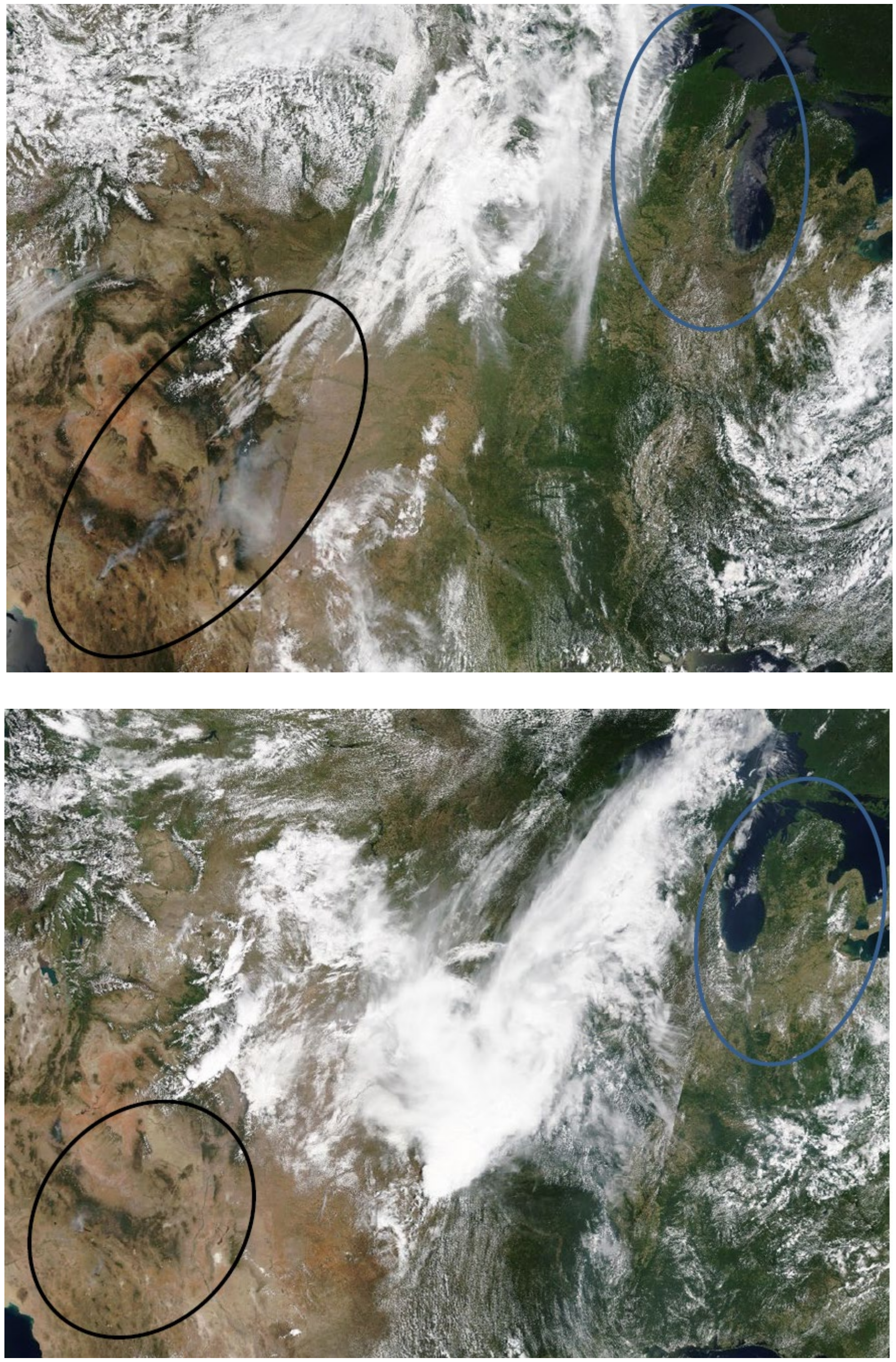

*Figure 11:MODIS Terra true color satellite imagery from June 18, 2020 (top) and June 19, 2020 (bottom) from NASA WorldView (IEPA, 2021).*

Figure 11 is the Moderate Resolution Imaging Spectroradiometer (MODIS) color satellite imagery, which IEPA included in their demonstration. Wildfire smoke is evident near wildfires in Arizona in Figure 11 based on a true color image for June 18 and 19, 2020. Smoke is not apparent over the Great Lakes region on either day. The blue circle in Figure 11 shows features that look like cloud cover (perhaps fog) or glint over the water, which is a known issue for the MODIS instruments.

Additionally, the large cloud complexes across the middle of the United States further complicate using these images to connect smoke from wildfire in Arizona to the Lake Michigan region. The presence of so much cloud cover during this period also calls into question any satellite product attempting to identify smoke plumes in the region, whether it is an automated retrieval from MODIS or a human-quality-assured product, like HMS.

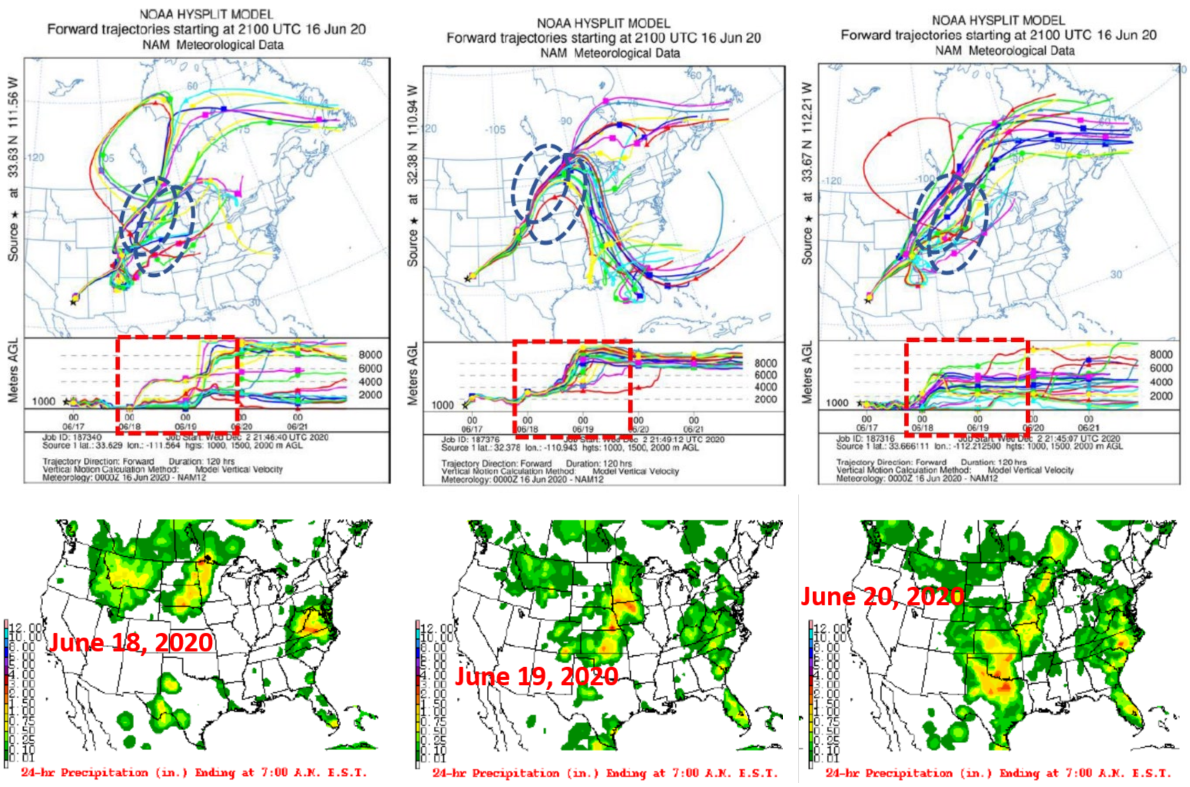


*Figure 12: Top row - HYPLIT forward trajectories from three different fires in Arizona: Bush (left), Bighorn (center), Magnum (right). The red box indicates June 18 and 19, 2020 and the blue ovals indicate areas of rainfall based on the 3 images shown in the bottom row. Bottom row - 24-hour precipitation for June 18, June 19, and June 20, 2020 (IEPA, 2021).*

Figure 12 shows daily precipitation (bottom panels) and forward HYSPLIT trajectories (top panels) from three wildfires in Arizona. The trajectories start on June 16 and end on June 21, 2020.

- For the Bush fire (Figure 12 left panel top row), trajectories do not reach the Chicago area. Further, all of the trajectories are well above the surface by June 19. The trajectories that appear near the surface on June 18 are not over the Chicago area on that date, which is consistent with the HYSPLIT forward-trajectory shown in Figure 3.
- For Bighorn fire (Figure 12 center panel top row), trajectories are well above the surface mixing layer when shown over the Chicago area and are not impacting the surface. Further, these trajectories are very inconsistent with forward trajectories from nearby fires and those shown in Figure 3 that show a consistent transport pattern, with air flow from Arizona northward into central Canada.
- For the Magnum fire (Figure 12 right panel top row), the trajectory cluster is consistent with surface and aloft weather maps, which show a high pressure system in the lower Great Lakes/Ohio Valley region pushing air flow from the southwest into central Canada. It is also consistent with the HYSPLIT forward trajectories shown in Figure 3. The trajectories do not intersect the Chicago area.

Rainfall in the path of the forward trajectories for each of these fires (Figure 12 bottom row) suggest smoke would experience some degree of scavenging before reaching central Canada or potentially the eastern United States. The regional cloud cover highlights an additional issue. Extensive precipitation, seen in the bottom panels of Figure 12, scavenges aerosol and other pollutants out of the atmosphere. This precipitation is directly in the forward-trajectory path of air predicted by the HYSPLIT model from Arizona as shown in Figure 3.

One important limitation with remotely sensed satellite products that needs to be stressed for the purposes of understanding the contribution of wildland fire smoke is that *the information is only available for the total atmosphere and no information is provided for the surface.*

One such example of a remote sensed satellite product is CALIPSO – the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation. CALIPSO is a joint mission between NASA and the French space agency to provide insight into the role clouds and atmospheric aerosols plan in the Earth's weather, climate, and air quality.

CALIPSO transects suffer limitations because uncertainty increases for near-surface data. Data is classified using source categorization that makes source attribution very difficult since many sources could contribute similar types of pollution at the surface (Burton *et al.*, 2013). CALIPSO products poorly distinguish between aerosol types, especially between urban (anthropogenic) and smoke (Burton *et al.*, 2013). For instance, CALIPSO often categorizes aerosol as "smoke," where a higher resolution airborne High Spectral Resolution Lidar (HSLR) instrument categorizes the same aerosol as "urban" in origin (Burton *et al.*, 2013). Further, research indicates that CALIPSO is challenged when categorizing aerosol (Burton *et al.*, 2013) and the "polluted dust" and "polluted continental/smoke" category should not, by default, be interpreted as smoke.

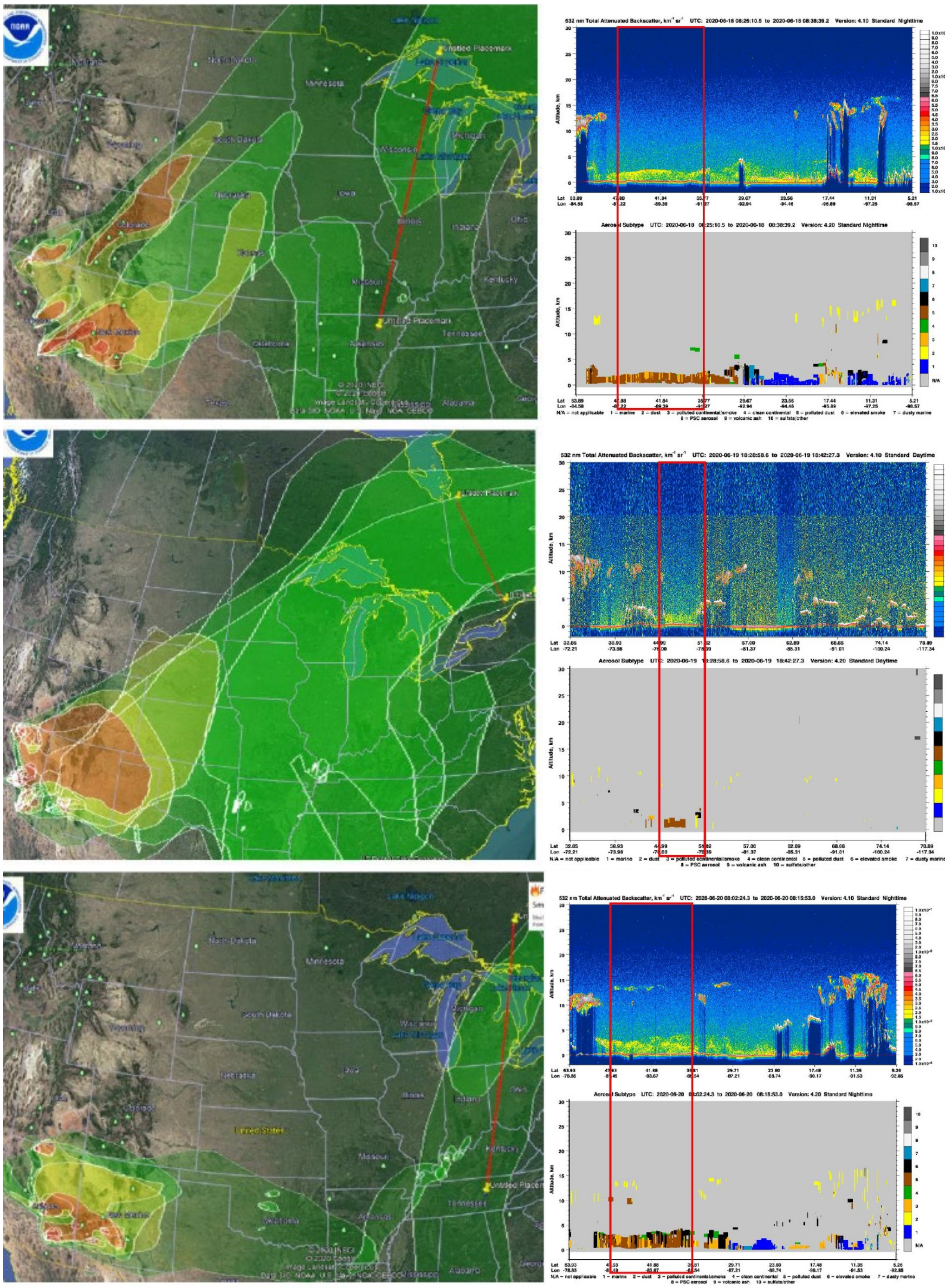

*Figure 13: Approximate path of CALIPSO satellite (red line) on June 18, 2020 with HMS smoke overlay (left) and CALIPSO aerosol attenuated backscatter vertical profile and aerosol subtype collected on June 18, 2020 (right). Similar information is shown for June 19 (middle) and June 20 (bottom), 2020. (IEPA, 2021).*

Figure 13 (right panel) shows a CALIPSO aerosol backscatter profile for the region upwind of the Chicago area overnight on June 18, 2020. None of the CALIPSO transects shown in Figure 13 align with the forward trajectories from Arizona shown in Figure 3. Based on large-scale meteorological features, the origins of the air in these CALIPSO transect were likely from the southern U.S. and brought northward on the eastern side of the frontal passage separating the high-pressure system over the eastern U.S. from the western U.S.

Figure 13 shows an example of HMS smoke products (left panel) for June 18, 2020. The contours represent human-drawn lines, based on satellite visible imagery.[8] Polygons are colored with a human-interpreted correspondence to aerosol concentration somewhere in the vertical column, but do not provide quantitative information. Documentation for this product specifically emphasizes the "qualitative nature of the visual analysis" when interpreting the smoke layers. These smoke sketches do not provide any information about whether smoke is at the surface or aloft in the atmosphere.

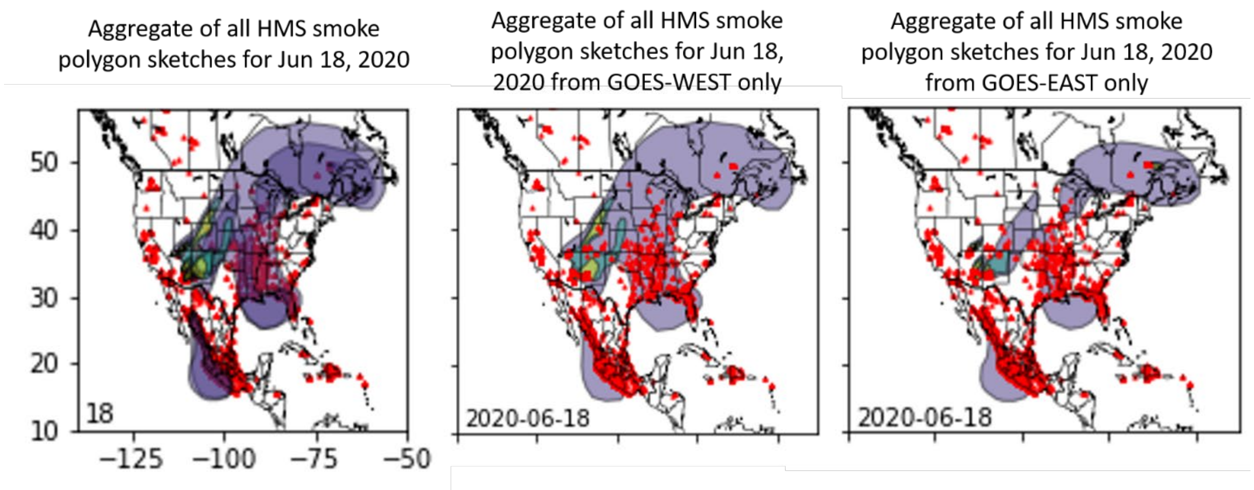


*Figure 14: All HMS smoke sketches superimposed for June 18, 2020 (left), just GEOS-WEST based sketches (center), and just GOES-EAST sketches (right). HMS smoke detections shown as red points.*

Figure 14 shows that visible smoke is not evident in the Chicago area on June 18, 2020, based on visible satellite images from NOAA's Geostationary Operational Environmental Satellite (GOES). GOES provides a key source of information for the HMS smoke sketches.

Visible smoke is seen near the fires in Arizona on June 18, 2020, which roughly compares to the HMS sketch polygons with the warmest color. The green contour color represents the potential for smoke with a concentration ranging from 0 to 10 $\mu g/m^3$ somewhere in the column. This means a green shading might represent very small or no actual smoke impact. This suggests that this product is most useful for understanding smoke impacts closer to fires where aerosol concentrations are higher. Confidence would be highest for using the warmest color contours, recognizing that even in this situation the product does not provide information about smoke at the surface.

Figure 14 illustrates a complication with interpretation of the HMS smoke sketches. When multiple contours from a given day are superimposed, it provides the appearance of a large smoke impact, even though the HMS smoke sketches represent multiple increments in time. In many situations, presenting the contours in this way may provide reasonable information; however, when attempting to establish a clear causal relationship, it is important to determine whether potential smoke impacts happen at relevant times of the day or progress through time in a way that would suggest a continuous impact from a particular location.

[8] https://www.ospo.noaa.gov/Products/land/hms.html#about

Figure 14 illustrates how superimposing multiple time segments from a particular day can lead to a misperception of more intense smoke in a particular location. This figure illustrates the differences in sketches from using different satellite (GEOS-EAST and GOES-WEST) satellite imagery. Figure 14 also shows HMS smoke detections. HMS detections are useful for understanding the location of potential biomass burning (wildfire, prescribed fire, agricultural burning, other burning activity). Fire detection does not mean biomass burning activity at that particular detection location. Even a collection of detections in a given area might be large enough to generate regional smoke.

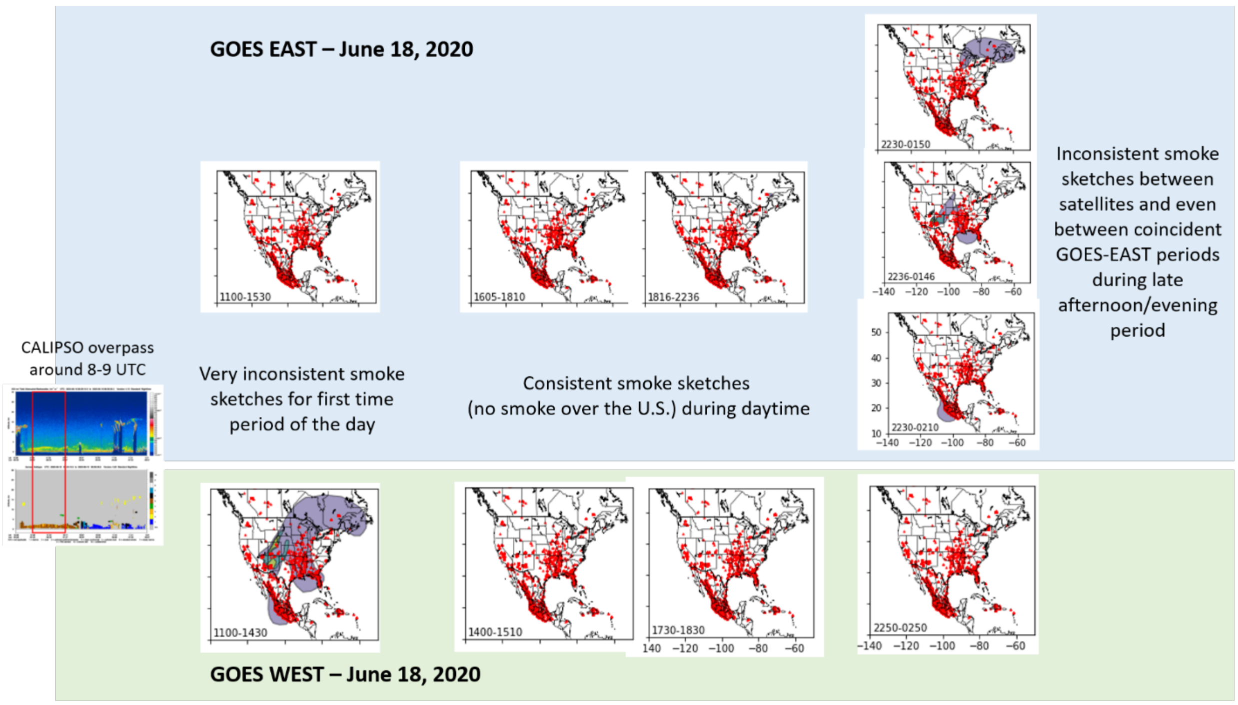


*Figure 15: HMS smoke sketches from GOES-EAST (top) and GOES-WEST (bottom) shown at specific time intervals provided by NOAA for June 18, 2020. The approximate timing of the CALIPSO overpass is also shown. Each HMS smoke sketch also includes HMS smoke detections for that day.*

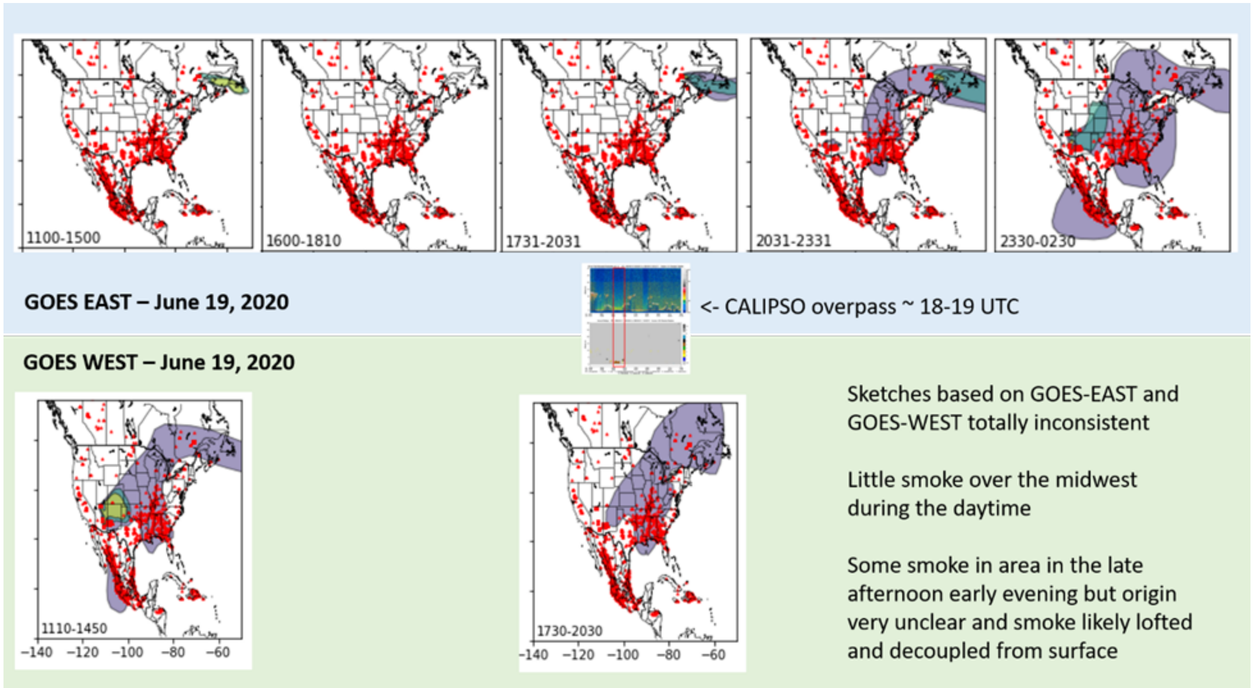


*Figure 16: HMS smoke sketches from GOES-EAST (top) and GOES-WEST (bottom) shown at specific time intervals provided by NOAA for June 19, 2020. The approximate timing of the CALIPSO overpass is also shown. Each HMS smoke sketch also includes HMS smoke detections for that day.*

Figures 15 (for June 18, 2020) and 16 (for June 19, 2020) show the individual sketches which correspond to time segments within those days provided by NOAA as part of the HMS smoke product. These contours get superimposed and presented as daily images as shown in Figure 14 and elsewhere (such as Figure 13). Looking at specific time increments of the smoke sketches, along with the general timing of the CALIPSO overpass, provides additional detail about how potential smoke plumes progress over time. It also shows where information may be less robust, as different sources of imagery result in inconsistent smoke sketches.

Figure 15 shows that the HMS smoke sketch for this day is largely driven by the early morning GOES-WEST image. As the day progresses, little to no smoke is seen over the contiguous U.S. until late afternoon and early evening. It is not clear from this progression that smoke sketches drawn in the late afternoon and early evening originated from wildfire in Arizona. Further, the smoke products for the late afternoon and early evening provide inconsistent information about the location of smoke, which suggests more uncertainty in the location of smoke at this particular time on June 18, 2020. Based on large scale meteorological features shown in Figure 1, it is unlikely that the CALIPSO transect is measuring air that originated west of the frontal passage that centered over the central plains, separating the high pressure system over the eastern U.S. from the western U.S.

Figure 16 shows the same type of information as Figure 15 for the HMS smoke products available for June 19, 2020. The GOES-EAST and GOES-WEST smoke sketches are inconsistent on this day. The pattern of progression over the day also makes the origin of the potential smoke in the Great Lakes region very difficult to determine, as thin smoke is spread over a large region with many fire detections. This suggests that aerosol detected in the vertical transect of the CALIPSO satellite may not have originated from Arizona fires. The CALIPSO transect for June 19, 2020 is in Ontario—far to the northeast of the Great Lakes region. Based on forward trajectories (Figure 3) and large-scale meteorological patterns (Figure 1), it is likely that the air in the region of the CALIPSO transect was impacted to some degree by air from western Canada.

*HMS smoke sketches can provide useful information when impacts are large and can be corroborated with other information like visible images and trajectory analysis. They are most useful for areas near large wildfire and less useful for supporting a clear connection between specific fires and areas hundreds to thousands of miles downwind where smoke impacts are very uncertain and most likely lofted well into the free troposphere. As the Arizona fires are greater than 1500 mi from Northbrook, HMS is not as useful in this situation.*

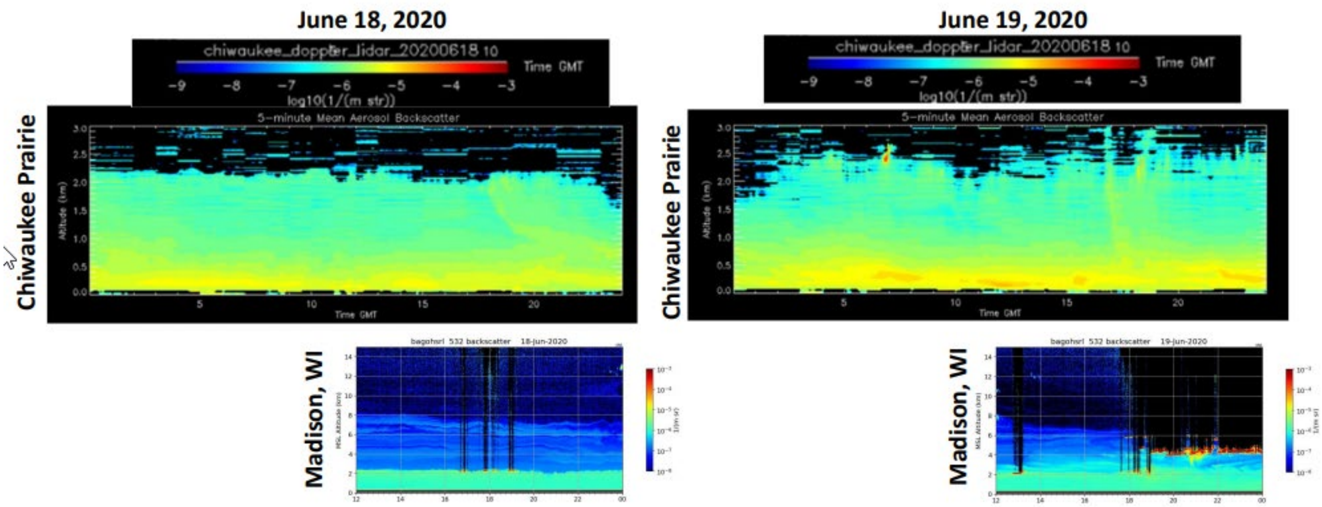


*Figure 17: Ceilometer data for June 18 - 19, 2020 at Chiwaukee Prairie (IEPA supplement, 2021)*

Ceilometers measure the vertical profile of aerosol backscatter in the atmosphere. The aerosol backscatter profile can provide useful information about the vertical extent of the surface mixing layer. Ceilometers were operating at Madison, WI and Chiwaukee Prairie, WI during the June 18-19, 2020 period. Both ceilometers show very strong stratification of mixing layers during the period of high $O_3$ at Northbrook (Figure 17). All of these layers have very low levels of aerosol. Both ceilometers show a very strong gradient between the surface mixing layer and the layers aloft at 2 km altitude over all hours on June 18 and 19, 2020, which indicates little to no mixing from above 2 km to the surface. Further, a very strong near-surface aerosol gradient (surface to ~0.5 km) is seen at the Chiwaukee Prairie ceilometer within the surface mixing layer, which is consistent with very low mixing heights related to land-lake recirculation patterns that are associated with meteorological conditions favorable to local $O_3$ formation.

The ceilometers provide no information about the source of aerosol (or $O_3$) at either location. These ceilometers do not provide any evidence of upper atmosphere air impacting the surface. The strong stratification between layers preventing mixing between the upper atmosphere and surface coupled with other information about meteorological conditions (hot temperatures and stagnant winds) during this period support the conclusion that $O_3$ formation was local in origin and enhanced by land-lake circulation patterns. The ceilometer data (Figure 19) is consistent with EPA's conceptual understanding of $O_3$ formation on June 18 and 19, 2020. There were stagnant conditions and a land/lake breeze with a very shallow surface mixing layer, which was conducive to local $O_3$ formation. Mixing was not evident between the surface layer and free troposphere.

## *AIR QUALITY MODELS*

Photochemical models could provide a useful connection between specific fires and downwind monitors. These models use meteorological inputs that are comparable and sometimes higher resolution than those used by HYSPLIT and would be expected to provide similar source-receptor information as HYSPLIT. A photochemical model can provide additional information that HYSPLIT cannot provide—an estimate of $O_3$ and other chemicals from specific fires at specific monitors downwind when the model is configured and applied in a way to reasonably quantify these impacts. Photochemical grid models have been shown to overpredict $O_3$ from wildland fire, which means these models can provide an indication about whether specific fires impact certain downwind monitors, but the predicted levels may be overstated to a large degree.

Some air quality forecast systems predict $O_3$ and $PM_{2.5}$ from wildland fire. Forecasting systems are not set up to provide information about specific fire impacts on specific downwind monitors. Forecasting systems predicting $O_3$ from wildland fires will also overstate impacts similar to retrospective photochemical modeling. Forecasting systems that do not include wildland fire emissions do not provide any information about the impacts from wildland fires on downwind monitors. The difference in forecasted $O_3$ and observed $O_3$ could be due to many reasons not related to the absence of wildland fire emissions in the model simulation: (1) poorly characterized stagnant meteorological conditions are challenging features for prognostic meteorological models, (2) day-specific emissions may not be adequately captured (*e.g.*, anthropogenic emissions), or (3) other physical aspects of the modeling system, such as representation of deposition and chemical reactions.

Several operational forecasts provide information about $PM_{2.5}$ impacts from wildland fire. NOAA's High-Resolution Rapid Refresh-Smoke model (HRRR-Smoke) is a numerical weather prediction model that forecasts the impact smoke has on several weather variables. Based on satellite observations of fire location and intensity, HRRR-Smoke predicts the movement of smoke in three dimensions across the country over 48 hours. It simulates how the weather will impact smoke movement and how smoke will affect visibility, temperature, and wind. A key limitation with this forecast for assessing the link between specific fires and downwind monitors is that it does not provide surface-level impacts of $PM_{2.5}$, only a total column integration. This means smoke could be anywhere in the atmosphere and, as distance between a fire and monitor increases, the impacts are more likely to be lofted in the upper troposphere.

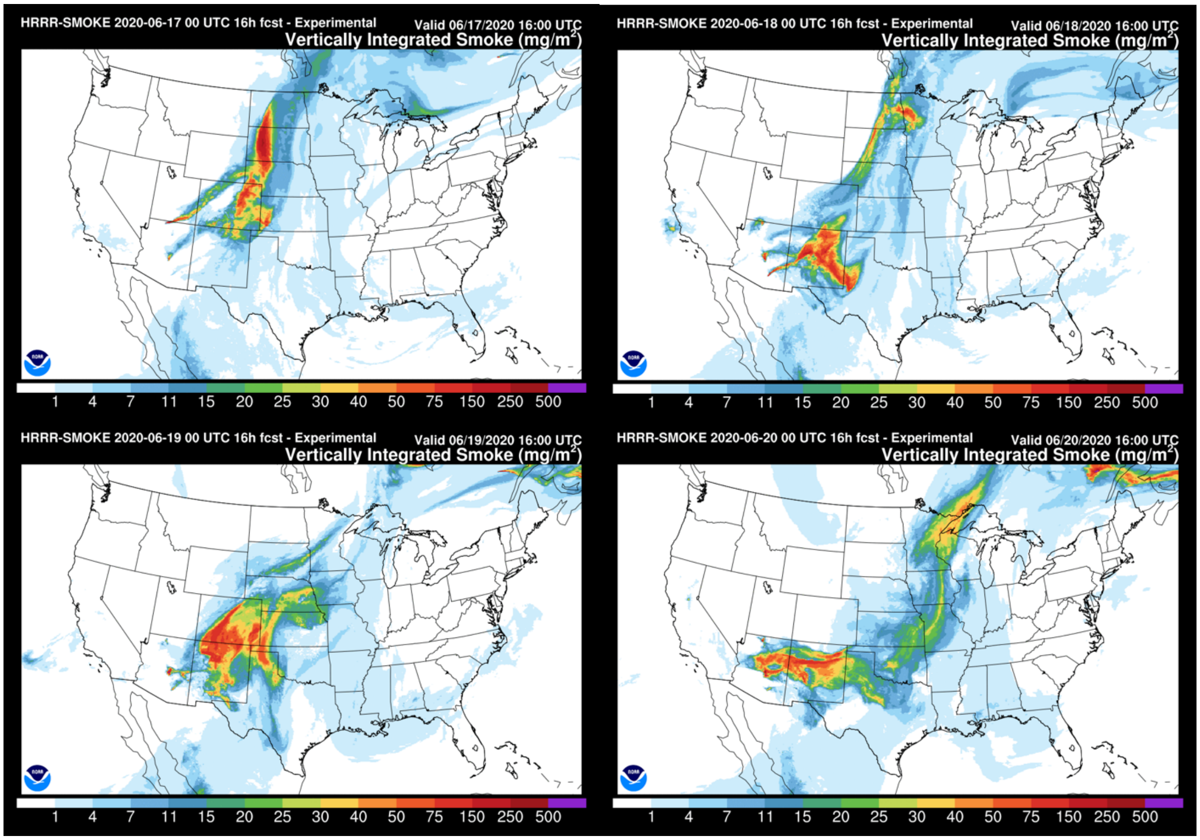

*Figure 18: HRRR-Smoke forecast for the distribution of vertically integrated smoke from wildfires at 12 p.m. EDT on June 17 (top left), June 18 (top right), June 19 (bottom left), and June 20 (bottom right), 2020 {Michigan Department of Environment, 2021 #8}.*

Figure 17 shows HRRR estimates of total column smoke from wildfires for June 17-20, 2020. The spatial pattern of impacts matches the forward trajectories from Arizona wildfire (Figure 3) and large-scale meteorological features (Figure 1*). Air from the southwest U.S. is transported north into the Dakotas and south-central Canada early in the period. Later in the period, the stagnant winds and slow moving frontal passage trap air in the southwest and allow for a large build-up of smoke from wildfire in this region. Even when considering the entire troposphere, the HRRR model predicts no substantive smoke impacts in the midwest, Great Lakes, or Ohio Valley areas*. This is due to the large high-pressure system in the eastern U.S., resulting in stagnant winds with some flow from the southern U.S.

The Naval Research Laboratory (NRL) has developed a global, multi-component aerosol analysis and modeling capability, known as the Navy Aerosol Analysis and Prediction System (NAAPS). NAAPS combines satellite data streams with other available data and the global aerosol simulation and prediction model for predicting the distribution of tropospheric aerosols. NAAPS surface level predictions of smoke impacts on $PM_{2.5}$ are shown in Figure 18 for June 18, 19, and 20, 2020.

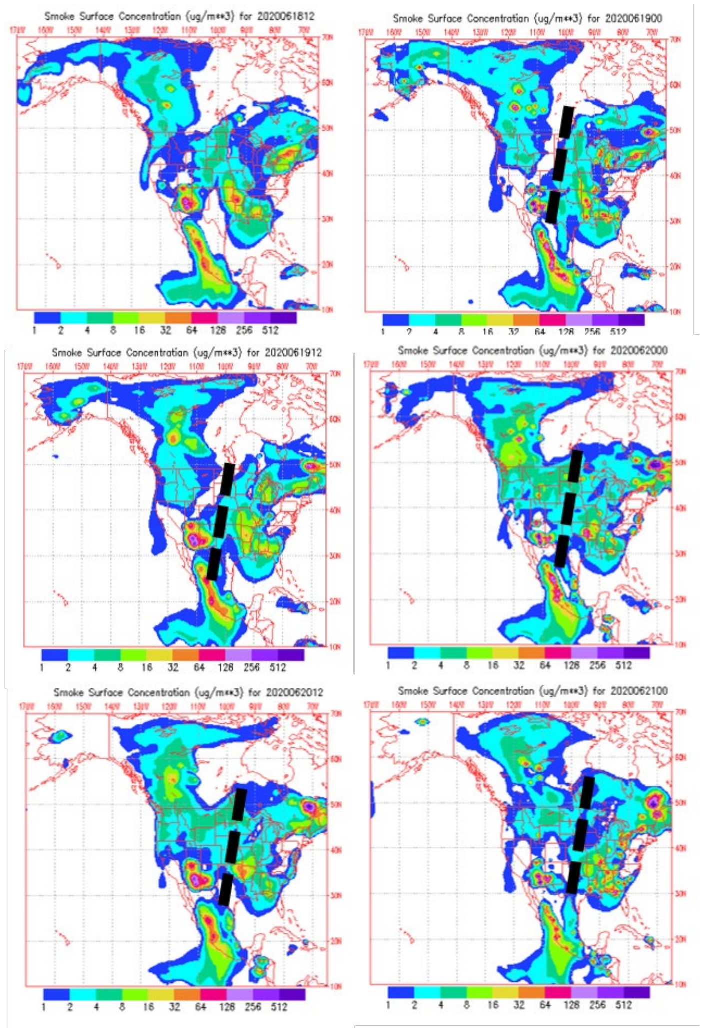


*Figure 19: NAAPS smoke surface concentration (µg/m3) for June 18 (top), June 19 (middle), and June 20 (bottom), 2020 at 8 AM EDT (left) and 8 PM EDT (right).*

The NAAPS predictions of surface level $PM_{2.5}$ from wildland fire smoke are not consistent when compared to the HRRR product. The NAAPS system is a coarser scale to cover a larger geographic area. Another difference is that the HRRR relies on satellite detected fires with fire radiative power to generate emissions estimates. Fires detected without reported radiative power, those in cloudy areas, and smaller fires not detectable by satellite may not be captured by the HRRR modeling system. This is likely a key cause of the inconsistencies in the eastern U.S. between HRRR and NAAPS. The NAAPS system modeled numerous small fires, which were detected during this period in the midwest and southern U.S. and likely do not have reportable fire radiative power (Figure 18). The backward HYSPLIT trajectories from Northbrook (Figures 4 and 5) and large-scale meteorological features (Figure 1) suggest the $PM_{2.5}$ predicted by the NAAPS modeling system is likely due to regional biomass burning in the midwest and southern U.S. during this period. Wildfires in the southwest U.S. did not contribute smoke to the eastern U.S.

**Not Reasonably Controllable or Preventable**

The Exceptional Events Rule presumes that wildfire events on wildland are not reasonably controllable or preventable [40 CFR §50.14(b)(4)]. IEPA's demonstration provided evidence that the wildfire event meets definition of wildfire. Specifically, IEPA states that "[t]he exact cause of the Mangum fire remains under investigation; however, fire officials have confirmed it was human-caused and burned in the Kaibab National Forest of Arizona. The Bush Fire was a human-caused wildfire that started in the Tonto National Forest northeast of Phoenix, Arizona. Lightning has been identified as the cause of the Bighorn fire in the Santa Catalina Mountains north of Tucson, Arizona. Each of these wildfires predominantly occurred on wildland. There is no evidence clearly demonstrating that prevention or control efforts beyond those made would have been reasonable. Therefore, emissions from these wildfires were not reasonably controllable or preventable." The documentation provided by IEPA sufficiently demonstrates that the event was not reasonably controllable and not reasonably preventable.

Table 4: Documentation of not Reasonably Controllable or Preventable

| Exceedance Date | Demonstration Citation | Quality of Evidence | Criterion Met? |
|---|---|---|---|
| June 18-19, 2020 | *Section E: page 71* | Sufficient | *Yes* |

**Natural Event or Event Caused by Human Activity That is Unlikely to Recur**

The definition of "wildfire" at 40 CFR §50.1(n) states, "A wildfire that predominantly occurs on wildland is a natural event." *IEPA's* demonstration includes documentation that the event meets the definition of a wildfire and occurred predominantly on wildland. IEPA has therefore shown that the event was a natural event.

Table 5: Documentation of Natural Event

| Exceedance Date | Demonstration Citation | Quality of Evidence | Criterion Met? |
|---|---|---|---|
| June 18-19, 2020 | *Section F: page 72* | Sufficient | *Yes* |

**Schedule and Procedural Requirements**

In addition to technical demonstration requirements, 40 CFR §50.14(c) and 40 CFR §51.930 specify schedule and procedural requirements an air agency must follow to request data exclusion. Table 6 outlines EPA's evaluation of these requirements. IEPA's demonstration did not meet the public notification requirement for this event. While IEPA's air quality forecasts and real-time continuous data provided the public advanced notice that ozone concentrations were likely to be elevated and updates on ozone concentrations in Chicago throughout the period of elevated ozone, IEPA's air quality forecast did not mention the potential for smoke impacts (the fire "event"), so it did not satisfy the public notification criteria.

Table 6: Schedules and Procedural Criteria

| | **Reference** | **Demonstration Citation** | **Criterion Met?** |
|---|---|---|---|
| Did the agency provide prompt public notification of the event? | 40 CFR §50.14 (c)(1)(i) | *Section G: page 73* | *No*[9] |
| Did the agency submit an Initial Notification of Potential Exceptional Event and flag the affected data in EPA's Air Quality System (AQS)? | 40 CFR §50.14 (c)(2)(i) | *Section G: page73* | *Yes* |
| Did the initial notification and demonstration submittals meet the deadlines for data influenced by exceptional events for use in initial area designations, if applicable? Or the deadlines established by EPA during the Initial Notification of Potential Exceptional Events process, if applicable? | 40 CFR §50.14 Table 2<br>40 CFR §50.14 (c)(2)(i)(B) | December 21, 2020 email from Julie Armitage to John Mooney | *Yes* |
| Was the public comment process followed and documented?<br>• Did the agency document that the comment period was open for a minimum of 30 days?<br>• Did the agency submit to EPA any public comments received?<br>• Did the state address comments disputing or contradicting factual evidence provided in the demonstration? | 40 CFR §50.14 (c)(3)(v) | Described in final pages of demonstration, summitted to EPA on 2/1/21 | *Yes* |
| Has the agency met requirements regarding submission of a mitigationplan, if applicable? | 40 CFR §51.930(b) | page 73 | *NA* |

## **CONCLUSION**

EPA has reviewed the documentation in the demonstration and supplement provided by IEPA to support claims that smoke from wildfires in Arizona caused exceedances of the 2008 8-hour $O_3$ standard at the Northbrook monitoring site on June 18 and 19, 2020. Although IEPA has met many of the procedural requirements for exceptional events demonstrations, IEPA's technical information does not satisfy the exceptional events requirement that there is a clear causal relationship between the Arizona wildfires and the exceedances observed at the Northbrook monitoring site on June 18 and 19, 2020.

9 IEPA declared an ozone driven Air Pollution Action Day Alert for June 17th with a forecast of an USG/orange day on June 18 and on June 18 with a forecast of an USG/orange day for June 19th indicating "current weather conditions and air quality monitoring data indicates air pollution levels may be elevated…" The forecast did not identify the potential for smoke impacts and/or the fire event.

The demonstration did not provide sufficient evidence of transport of emissions from the wildfire to the impacted monitor. Weather maps and forward trajectories from Arizona are consistent in showing the air parcel from the wildfire in Arizona moved to the northern U.S. plains and into central Canada. Once air was in Canada, it tended to be well above the surface mixing layer. Due to the lack of evidence of transport of the smoke from the fires into the Chicago area on these two days, the clear causal relationship cannot be met. EPA's assessment of additional information also did not support a clear causal relationship between the wildfires and the elevated ozone concentrations at Northbrook.

Weather maps and backward trajectories from the Northbrook monitor are consistent and indicate that the monitor experienced air largely local in origin with some contribution from Missouri and southern Great Lakes region. The net distance traveled by the 48-hr backward trajectories on June 18 and 19, less than 300 miles each, was likely due to the light stagnant winds due to the high-pressure system covering the region. The light and variable winds from high pressure systems centered over the lower Great Lakes and Ohio Valley caused stagnation of the air, high ambient temperatures, and clear skies. These conditions are consistent with typical episodes of high summertime ozone events in the Chicago area.

IEPA's assessment of co-pollutants also did not provide sufficient evidence of a clear causal relationship. Long-lived pollutants often used as tracers of biomass burning, such as CO and $PM_{2.5}$ (elemental carbon, organic carbon, and potassium), are higher in concentration during periods of stagnation due to emissions buildup and lack of dispersion. The surface level $PM_{2.5}$ organic and elemental carbon are not notably elevated on June 18 to 19, 2020 compared to other days.

The high $O_3$ on June 18 and June 19, 2020 in the Chicago area was largely local in nature with some contribution from the south and east—Missouri to the southern Great Lakes region. A significant contribution from wildfires in Arizona is not evident in the Chicago area on these dates, and a clear causal relationship is not evident between any specific wildfire or cluster of wildfires and the Northbrook monitor on these days. IEPA's $O_3$ forecast for the days identified in the demonstration were based on weather, not on smoke. Therefore, EPA has determined that the flagged exceedances at this monitoring site on these days do not satisfy the exceptional events criteria. The exceedances provided in IEPA's demonstration will continue to be used by EPA in regulatory determinations.

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