Response to Comments
Regarding 2023 Exceptional
Events Demonstration

On April 9, 2024, the Department of Energy and Environmental Protection (DEEP) published notice of intent to submit an exceptional event demonstration request to EPA in accordance with Title 40 of the Code of Federal Regulations Part 50.14 (40 CFR 50.14(c)(3)(i)). Pursuant to such notice, the proposed exceptional event demonstration remained open for public comments through May 10, 2024.

This report addresses the comments received on the proposed exceptional events demonstration during the comment period and final recommendations for the demonstration revision.

During the comment period, written comments were received from the following persons/organizations:

1. Air and Radiation Division
   U.S. Environmental Protection Agency, Region 1
   5 Post Office Square, Suite 100
   Boston, MA 02109-3912

These comments are available on the DEEP website,[1] along with the proposed and revised Exceptional Events Demonstration. Comments, together with DEEP's responses, are provided below.

Comments by the U.S. Environmental Protection Agency (EPA), Region 1

1. Comment: The final demonstration prepared by CT DEEP should contain supporting information to sufficiently demonstrate a clear causal relationship between the wildfire and prescribed fire events and proposed monitor exceedances on April 13–14 and July 12 dates. CT DEEP should ensure the demonstration provides a weight of evidence approach to support the claim that fire emissions identified from the events caused the exceedances of the ozone NAAQS at the monitoring locations. EPA is offering comments below to further assist CT DEEP in the development of the final demonstration.

[1] https://portal.ct.gov/deep/air/planning/ozone/2023-exceptional-events#:~:text=Because%20of%20the%20persistent%20smoke,Events%20that%20May%20Influence%20Ozone

Response: DEEP agrees with EPA that a clear causal relationship between the fires and monitored concentrations of ozone for the events at each of the sites of concern is necessary for approval of the proposed Demonstration.

DEEP supported the causal relationship by demonstrating that smoke from the fires impacted the surface using ceilometer backscatter images, monitored PM2.5 pollutant concentrations and speciated PM2.5 data. Additionally, High-Resolution Rapid Refresh (HRRR) near surface smoke model runs show plume travel and surface impact for each of the events. The HRRR animations for the April 13-14 event, June 30 July 1 event, and July 12 event (identified dates) are available on our website and clearly show plumes from the specified fires likely reached the surface throughout Connecticut and particularly at the monitoring sites of concern. DEEP further established the plume trajectories with satellite data in section 3 and supported this with forward and backward trajectories from the fires to the monitors and from the monitors to the fires respectively in section 8.

DEEP provided analysis of each of the fires, including both local reports, in section 4 and quantitative analyses of emissions through an EPA recommended Q/d approach, which is intended to compare the emissions from the fires on the identified dates to other fires which were demonstrated to have clear causality. As shown in section 5, each of the fires on the identified dates compared favorably to the Fort McMurray fire.[2] DEEP also assessed the emissions of the fires in relation to anthropogenic emissions and showed that the magnitude of the anthropogenic emissions were insufficient to explain the exceedances.

In section 6, DEEP reviewed local ozone and particulate data and showed that particulate was higher than typical during the events and that the ozone increased as the particulate rose. In section 7, DEEP analyzed nearby and regional smoke related data to show that ozone during the events was enhanced by wood smoke.

Section 9 characterized the meteorology of the events. DEEP used this characterization to find meteorologically similar days and, in section 10, showed that such meteorologically similar days did not historically lead to ozone exceedances. In each case it was clear that typical anthropogenic emissions under the meteorological conditions during the events were insufficient to create the ozone levels that occurred and the only reasonable explanation for the increased ozone during the event days was enhancement due to fires.

[2] DEEP is unaware of any fire, other than the Fort McMurray fire, to have been demonstrated as having clear causality to an ozone exceptional event.

In response to EPA's comment, DEEP has made the following revisions/additions to the section summaries:

2.6 Summary

Recent trends and indications from modeling lead to the reasonable expectation of attainment in Greater Connecticut by 2023. The 2023 ozone season, however, was unique in recent years as having some of the most widespread site exceedances in Connecticut and across the OTR. These widespread ozone events used to be common occurrences, but in the past few years, the ozone plumes have become more localized in extent and diminished in magnitude and are now generally limited to impacting coastal southwest Connecticut. Ozone precursors, particularly high electric demand day EGU emissions, have been trending downward. Smoke has been shown, even at low concentrations, to significantly increase ozone formation. The 2023 ozone season stands out as distinct from recent and traditional ozone seasons. This distinction is most likely due to ozone and precursors transported to surface monitors in Connecticut from the smoke described in section 1.3 of this document.

3.4 Summary

Satellite data has the capability to show fire locations along with smoke plume formation and transport to Connecticut. In addition to the satellite view of the smoke plumes, the Cornwall haze camera images show hazy skies closer to the surface for each of the events. Near surface smoke modeling shows smoke impacted the monitors of interest during each event day. Other satellite data shows a higher sum of FRP for the Flint Hills burns in 2023 compared to the three previous years, indicating a relative increase of released fire emissions. Carbon monoxide is characteristic of fire emissions and is detected using satellite data, and the data shows an elevated impact to Connecticut during all three of the events.

7.6 Summary

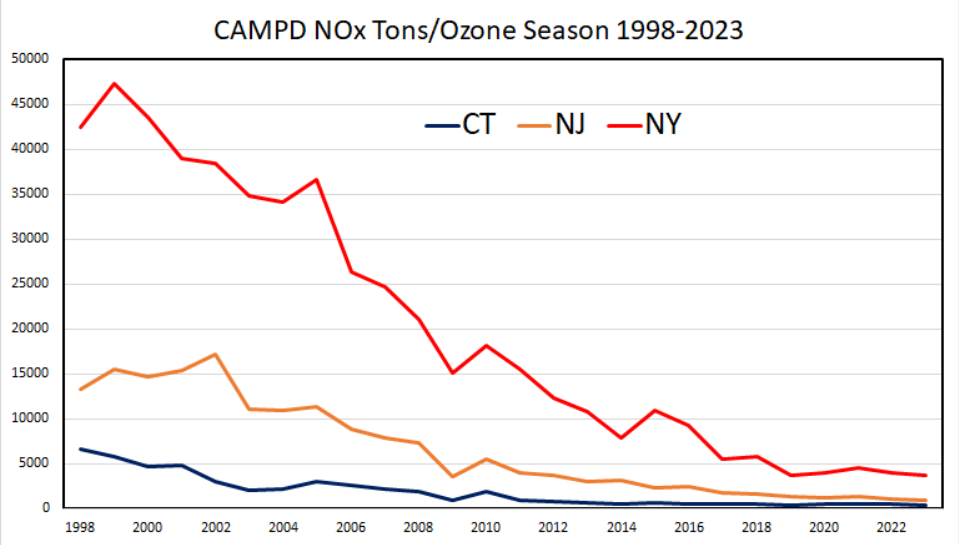
Local and regional data suggest the presence of a smoke plume for each of the three ozone events. Ceilometers show the backscatter from aerosols indicating smoke plumes reaching the surface level. The local and regional trends show monitored O3, CO, DeltaC PM2.5, BC, and PM2.5 levels at the surface before, during, and after each event. These trends confirm the presence of surface smoke in and beyond Connecticut's borders. Comparison of ozone spikes during the 2023 smoke events from regional monitors indicate both higher magnitude and more frequent exceedances compared to prior years for locations near Connecticut and emphasize the unique impact of the smoke. Speciated particulate data, including OC and K, give further evidence of a smoke plumes impacting monitors in and around Connecticut during the ozone events.

2. Comment: Ozone formation in CT is a complex problem that is affected by several factors such as interstate transport of ozone and precursors from upwind states, elevated

temperatures and solar insolation, and Long Island Sound meteorology. The demonstration should discuss the influence of such compounding factors when assessing the impact of wildfire smoke on the air monitoring locations for selected dates. These factors should be considered and discussed throughout the demonstration for each of the requested monitors and dates. Including supporting information before and after the exceedance days, in the context of the requested day, could also help illustrate the potential impact of smoke during the requested dates.

Response: In section 2 of the demonstration, DEEP provides the conceptual model of ozone formation and transport into Connecticut. Low-level southwest winds normally transport pollutants from along the Interstate 95 corridor through the New York metropolitan area and into Long Island Sound (LIS), producing ozone that then impacts southwest Connecticut's coastal monitors. As emissions have decreased over time, plumes of ozone produced over LIS have diminished in size. Although ozone formation over LIS and transport over a land/water interface is complex, the main factor is often the meteorology which carries pollutants to Connecticut's monitors. Though typically these pollutants originate from along the Interstate 95 corridor and through the New York metropolitan area, in the case of each of the identified events the pollutants originated from the specified fires as discussed in section 9 of the demonstration relating to the meteorology of the event days.

NOx emissions from nearby electrical generation units (EGU) sources discussed in section 2, did not appear to be well correlated with ozone exceedances in 2023, compared with 2022 and levels since 1998 have decreased sharply as shown in this figure:



While it is true that Connecticut continues to experience ozone exceedances on warm, sunny days with winds from the southwest, these exceedances are mostly expected to

occur along the southwest coast and not extend to the entire State or at concentrations that occurred during much of 2023. DEEP showed through its similar day analyses in section 10 of the demonstration that ozone exceedances were unlikely to occur on the event days. All indications are that ozone was enhanced by woodsmoke that was present at the surface and was not attributable to typical emissions scenarios. Thus, these days should be excluded from regulatory consideration in accordance with the exceptional events rule.

3. Comment: Although 40 CFR part 58, Appendix D defines the ozone monitoring season as beginning March 1, CT DEEP defines the ozone season as beginning on May 1 in the RCSA Section 22a-174-22e as discussed in footnote 1. EPA notes that the May 1 start date in RCSA Section 22a-174-22e results from the NOx Control Program that requires large sources of NOx emissions to utilize controls to reduce emissions during the May 1 – September 30 timeframe to reduce ozone pollution. Since the April 13–14 event is outside of this period for the NOx Control Program, the demonstration could benefit from an explanation of how the proposed April 13–14 event was not impacted by upwind NOx emissions.

Response: DEEP generally uses the term "ozone season" to indicate the time of year when ozone exceedances are likely to occur in Connecticut. The likelihood of an ozone exceedance is dependent on various factors such as, intensity of sunlight, number of hours of daylight, and proximity to sources of precursor emissions. DEEP considers June through August the peak ozone season and refer to May and September as the shoulder months, when ozone levels are expected to ramp up and down, respectively. This is the season DEEP generally refers to and coincides with the ***ozone forecast season*** and ***ozone control season*** as described below.

The ***ozone monitoring season*** is determined by EPA and is defined in Appendix D of 40 CFR Part 58. The ozone monitoring season was revised effective December 28, 2015, concurrent with the adoption of the more stringent 2015 ozone standards [80 FR 65292]. The revision extended the ***ozone monitoring season*** from April through September to March through September in Connecticut and was based on an analysis threshold of 60 ppb using data from 2010-2013. Consistent with the expectation that ozone formation is based on factors such as described in the paragraph above, the ozone monitoring season is set to different time periods for each of the states. Most of Connecticut monitors operate according to the schedule in Appendix D. However, low levels of ozone are present throughout the year and to better understand background levels Connecticut monitors ozone all year long at three of its sites: Cornwall, New Haven and East Hartford.

DEEP also makes air quality forecasts throughout the year in accordance with Appendix G of 40 CFR Part 58. However, it typically includes ozone in its forecasts only from May through September, the ***ozone forecast season***. Months outside this timeframe are unlikely to reach levels that would begin to affect public health. Due to the unusual

exceedances on April 13, 2023, DEEP included ozone in its forecast for April 14, 2023, having recognized the contribution of smoke to increased ozone levels on both the 13th and 14th. As noted in the discussion of figure 2-1 of the exceptional events document, the most recent April exceedance prior to the April 13-14 event occurred on April 22, 2016.[3]

As EPA indicates in its comment, emissions are an important factor in generating ozone. DEEP regulates anthropogenic ozone precursor emissions of nitrogen oxides during the ***ozone control season*** as defined in Regulations of Connecticut State Agencies (RCSA) section 22a-174-22e(a)(23). This coincides with the ozone forecast season and extends from May through September of each year. RCSA section 22a-174-22e also regulates nitrogen oxide emissions outside the ozone season and RCSA section 22a-174-7 requires the operation of control equipment while a source is in operation. A more detailed explanation of the sources regulated under RCSA section 22a-174-22e can be found in section 5.2 of our regional haze implementation plan. Along with the regulations mentioned above, and individual source permits to operate, the regional haze plan seeks to ensure the most effective use of control technologies on a year-round basis and consistently minimize emissions of haze precursors (e.g. nitrogen oxides).[4]

DEEP assessed anthropogenic nitrogen emissions from sources in section 2.4 of the exceptional events demonstration using data provided by EPA. Time series graphs of emissions in that section show that emissions during the April event were not near peak summer emissions and cannot account for such widespread ozone exceedances.

As a result of this comment, DEEP has reviewed the term "ozone season" as used throughout the exceptional event demonstration and has made the following clarifications:

The error in footnote 1 is corrected from "While the ozone monitoring season begins in May,…" to "**While the ozone monitoring season begins in March,…**"

The language in the heading for Table 6-2 is revised from "…over the past five ozone seasons…" to "…**over the past five ozone monitoring seasons**…"

The language describing figure 6-11 for Groton stating "Also, while April 13 and June 30 of 2023 at Groton do not reach the 99th percentile they are at the 98.5 and 97.6 percentiles, respectively." included several typographic errors and is corrected to read **"Also, while April 14 and June 30 of 2023 at Groton do not reach the 99th percentile, they are at the 98.4 and 97.5 percentiles, respectively."**

[3] While ozone exceedances in April are rare, high temperature days are less so. For example, the following year, 2017, April had several high temperature days at Bradley Airport in Hartford, but the highest MDA8 ozone value for that month in Connecticut was 59 ppb.

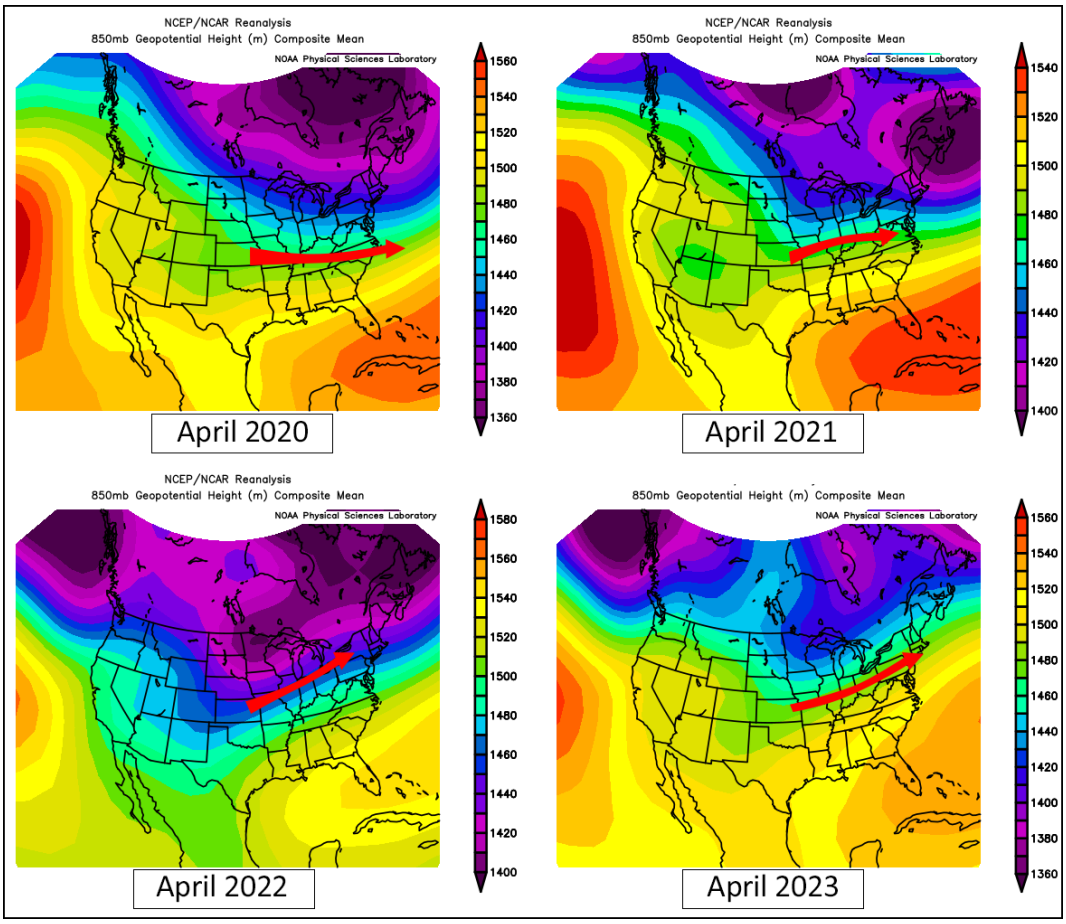
[4] https://portal.ct.gov/-/media/deep/air/comments/regional-haze-sip-comments/connecticut-2nd-regional-haze-plan---final.pdf

4. Comment: For the April 13–14, 2023, proposed event, the proposed demonstration discusses prescribed burning at Flint Hills; two major fires on April 6 and 7 in Riley County Kansas (agricultural burn); burn scars showing additional prescribed fires burning out of control; wildfires burning in PA (contained started April 12 and April 18), NY, and NJ; and a map of 8,000 other fires. The demonstration should describe how the agricultural burning and other fires in April of 2023 compared to a similar timeframe in other years.

Response: In section 3.2, DEEP included fire radiative power data from the agricultural burning in the Flint Hills based on the Hazard Mapping System (HMS). This shows how much hotter the fires were in 2023 compared to the three previous years, indicating that greater emissions were produced from the fires that impacted Connecticut's ozone levels for the April event. In addition, the Flint Hills fires occur every year under the burn plan, but given the large geographic region covered by the Flint Hills area it is unlikely that the same locations will be burned each year. As stated in section 11.1, the burn frequency averages approximately once every three years.

It is not simply the fact that the fires occurred, but that meteorological patterns were conducive to transport of the pollutants from the fires into Connecticut. The following image shows the composite 850mb pressure maps from 2020–2023. The variation in the upper air winds would have caused transport from the Flint hills region of Kansas. The 850mb heights also indicate the temperature of the atmosphere. Despite the fact that April 2023 was an unusually warm month, the average 850 mb winds for April 2023 would have been most favorable for transporting fire emissions into Connecticut from that region, as depicted by the red arrows in the figures.

As for the New York, New Jersey, and Pennsylvania fires, these were wildfires that are unlikely to occur again as they did in April 2023. The fires were described in section 4.1 and we noted the unusual conditions for each fire.



5. Comment: The proposed demonstration contains several figures used to illustrate the potential impact of smoke on the air monitoring locations for the requested dates. CT DEEP should ensure the trends identified for each figure in the proposed demonstration are clearly explained and discuss how each figure supports the requested exclusion dates in the demonstration.

Response: DEEP sought further explanation from EPA regarding the specific figures to which it was referring and made the following changes to the text of the demonstration as a result:

Section 3.1, formerly "Satellite Images", was retitled **"Satellite and Smoke Imagery"**

The last sentence in the introductory paragraph to section 3 was revised to include the language in bold: "Supplementary satellite images and videos are available at https://portal.ct.gov/DEEP/Air/Planning/Ozone/2023-exceptional-events **and include surface smoke model results for each of the events. Additional data supporting the influence of smoke on ozone, which became available after notice of this report, is available in the response to comments document.**"

The following paragraph was added to the end of the discussion of the April 13-14 event in section 3.1: **Near surface smoke can be observed in results of modeling conducted by the National Oceanic and Atmospheric Administration on both days as seen in these animations. In addition to the more significant fires documented here, the animations show smoke from a brush fire in Rhode Island impacting the area around Groton, Connecticut during the early hours of April 13th.[5]**

The following sentence was added to the end of the discussion of the June 30- July 1 event in section 3.1: **Near surface smoke can be observed in results of modeling conducted by the National Oceanic and Atmospheric Administration on both days as seen in these animations.**

The following sentence was added to the end of the discussion of the July 12 event in section 3.1: **Near surface smoke can be observed in results of modeling conducted by the National Oceanic and Atmospheric Administration on July 12 as seen in this animation.**

Having previously been too small to show the entire text, text boxes in figure 6-6 were expanded.

Additionally, the comments below regarding Generalized Additive Models further address how smoke impacted the air monitoring locations of concern.

Additional Comments: Generalized Additive Model Results

Informal comments were provided by Dr. Daniel Jaffe. While not submitted as formal comments during the comment period, DEEP includes them here as they were both timely and relevant. Dr. Jaffe is a professor at the University of Washington and is an expert on atmospheric chemistry, ozone photochemistry, urban and regional smog, and long-range transport of pollutants and is the author of more than 150 peer-reviewed publications on ozone, aerosols, mercury, and other air pollutants. He is also on the NASA Health and Air Quality Applied Sciences Team (HAQAST) TEMPO satellite ozone Tiger Team.

Dr. Jaffe presented his Generalized Additive Model (GAM) results on a May 1, 2024, HAQAST conference call that showed how the model analyzes the effect of smoke plumes on surface ozone levels. The model uses generally available meteorology and air pollutant monitoring data to statistically compare smoke and non-smoke days to predict influence of smoke on ozone levels. The model has been tested and applied to smoke events in the Salt Lake City area.[6]

[5] https://www.providencejournal.com/story/news/local/2023/04/13/west-greenwich-wildfire-burns-200-acres/70111223007/

[6] Haebum Lee & Daniel A. Jaffe (2024) Impact of wildfire smoke on ozone concentrations using a Generalized Additive model in Salt Lake City, Utah, USA, 2006–2022, Journal of the Air & Waste Management Association, 74:2, 116-130, DOI: 10.1080/10962247.2023.2291197

During the conference call DEEP mentioned its exceptional events demonstration and requested the GAM be applied to selected Connecticut ozone monitors. Subsequently, the following two paragraphs and table were provided by Dr. Jaffe:

A Generalized Additive Model (GAM) can serve as a useful tool to examine the relationship between O3, meteorology and other variables (Thompson et al., 2001). A number of studies have found that while the HMS product is very useful for tracking smoke plumes, generally, it is a weaker indicator of surface smoke (Kaulfus et al 2017; Buysse et al 2019). A "smoke day" was identified by combining the satellite derived HMS data with surface PM2.5 data, specifically using only the PM2.5 mass concentration. The U.S. EPA has proposed a fairly stringent criteria for using statistical models in exceptional event demonstrations. The positive model residuals for potential event days must exceed the 95th percentile of all days in the model, and the amount above this criterion can be considered as the "smoke contribution", which is equivalent to the 97.5th percentile of all results. However, because smoke days now represent a substantial fraction of the total number days, it is more appropriate to compare the residual with the non-smoke day distribution. In the table below, the residual quantile is shown for each proposed exceptional event day. All exceed a 97.5 percentile, with the exception of the Cornwall and East Hartford sites on 7/12/23.

[A] GAM was built for each site separately using only the no-smoke days data to quantify the "typical" O3 relationships without influence from smoke. The model can then be used to predict the MDA8 O3 for test/validation and smoke days. The GAM-Res method can be considered as the "maximum" estimate, assuming that all positive residuals on smoke days (i.e., residuals greater than zero on smoke days) are fully attributable to the wildfire contribution. The general method is documented in past publications by the University of Washington group. This specific analysis is in a publication that is currently in review for Environmental Science and Technology (H. Lee and D. Jaffe. Wildfire Impacts on O3 and PM2.5 in the Continental United States using a Generalized Additive Model (2018–2023). In review for ES+T, Feb. 2024.)

GAM Modeling Results for Smoke Influenced Ozone Residuals

	East Hartford 90031003			Cornwall 90050005			Groton 90110124		
Date	Smoke (yes/no)	GAM residual (ppb)	Residual quantile	Smoke (yes/no)	GAM residual (ppb)	Residual quantile	Smoke (yes/no)	GAM residual (ppb)	Residual quantile
6/30/23	yes	17.88	99.2	yes	27.55	100	yes	23.05	99.6
7/1/23	yes	30.32	100	yes	28.65	100	yes	29.03	99.9
7/12/23	yes	8.92	91.1	yes	2.55	70.2	yes	20.56	99.6

Dr. Jaffe produced the table above for the three event days for the selected monitors during the May 1- September 30, 2023, time period. Dr. Jaffe did not run the model for April, since he did not consider that part of the normal ozone season for our region. Nevertheless, the results show substantial 'residual' ozone likely caused by smoke for the monitors of interest. Lesser impacts were shown for Cornwall and East Hartford on July 12th, when a frontal system approached northern Connecticut and reduced the ozone levels in the northern section of the state, as was described in section 3 of the exceptional events demonstration.

DEEP appreciates the efforts of Dr. Jaffe and finds the GAM results to be consistent with, and supporting of, the findings of the Department.

Newly Available Data

On March 20, 2024, as DEEP's demonstration was being prepared for public notice, formaldehyde data from the 2023 Long Island Sound field studies was approved, cleared, and submitted to the NASA data archive for the Westport, Connecticut and Flax Pond, New York monitoring sites. DEEP obtained the newly available information and presents an analysis of the data here as formaldehyde and aerosol optical depth are indicators of woodsmoke and these monitors are near the Groton monitor. AOD data was presented in section 3.1 of the draft exceptional event demonstration. Formaldehyde data was not previously available.

The figures below show daily average formaldehyde data along with satellite measured Aerosol Optical Depth (AOD) by date for Westport and Flax Pond, respectively. AOD matchups were calculated courtesy of NOAA NESDIS STAR Aerosols and Atmospheric Composition Science Team.

AOD data from multiple satellites was matched to ground site locations using the spatiotemporal collocation methodology of the Multi-sensor Aerosol Products Sampling System (MAPSS)[7], which is the standard protocol for averaging satellite data in time and space for comparison to ground-based observations.

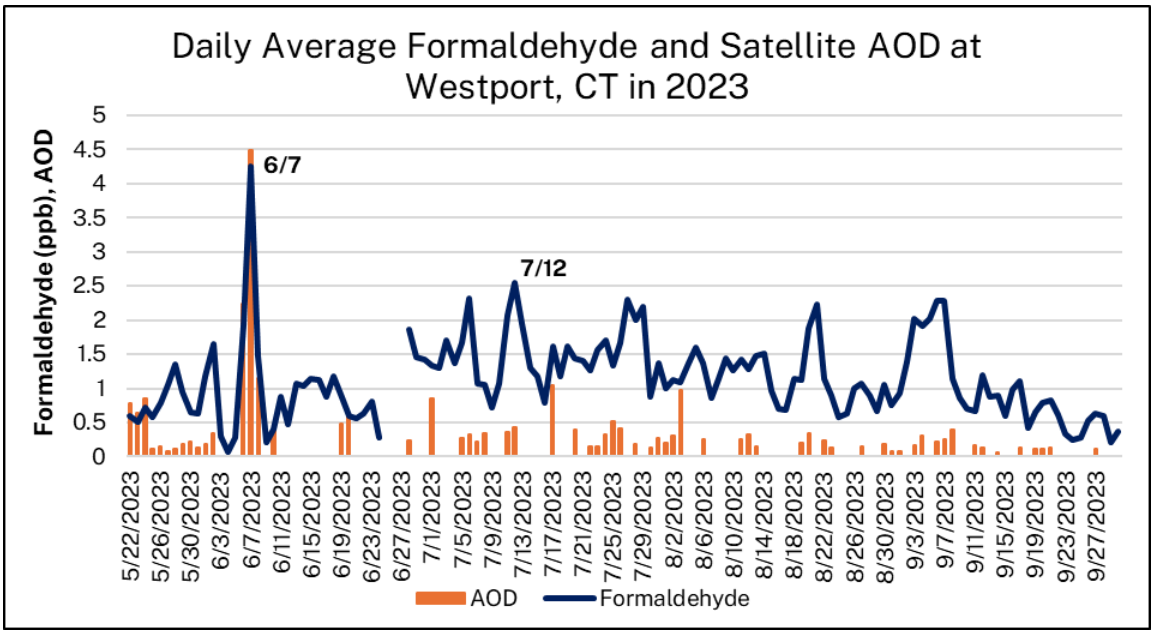
AOD is measured on a scale from -0.05 to 5. Satellite images typically only show data from 0 to 1 as background levels are typically 0 to 0.2 and levels above 0.75 indicate very thick aerosols. Levels above 0.2 to 0.4 are considered thin aerosols, while levels in the range of, 0.4 to 0.6 is moderately thick and levels between 0.6 to 0.75 are indicative of thick aerosols. The AOD index values for the following analysis include a mix of the VIIRS data from two different polar orbiting satellites. AOD matchups may be missing for a given day for several reasons, including the presence of clouds (which prevent satellite AOD retrievals), insufficient number of matched VIIRS AOD pixels (< 845), or missing VIIRS AOD data files. Due to any of these circumstances, some days only had a value from one satellite, while other days had neither or both. To

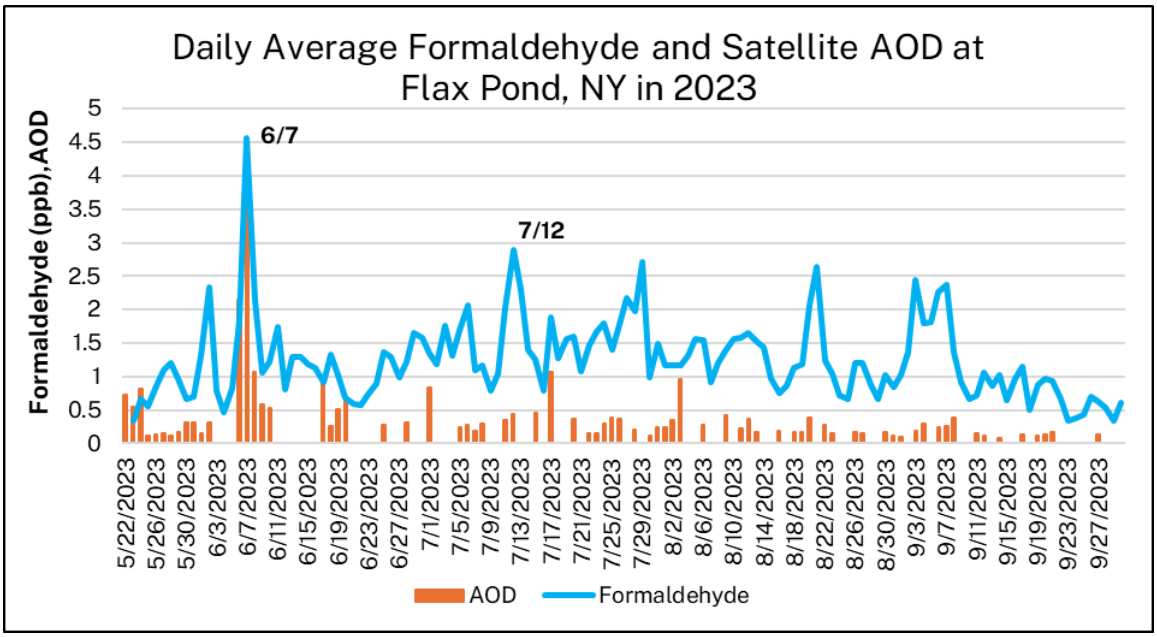
[7] Petrenko, M., C. Ichoku, G. Leptoukh, 2012: Multi-sensor Aerosol Products Sampling System (MAPSS). Atmos. Meas. Tech., 5, 913–926, doi:10.5194/amt-5-913-2012.

maximize available data, DEEP used the individual value from either satellite if only one was available or the average of both satellites if fortunate enough to have a value from each.

The Long Island Sound Tropospheric Ozone Study (LISTOS) did not commence formaldehyde data collection until late May, therefore formaldehyde/AOD charts are unavailable for the pre-season April 13-14 event. Collection of satellite AOD data is dependent on clear skies because cloud cover obscures the satellites' view. Therefore, AOD data is missing for the June 30 event day. However, the available data for July 1 is 0.84 at Westport and 0.83 at Flax Pond, placing both sites within the very thick aerosol category. Data for July 12 is 0.44 at Westport and 0.45 at Flax Pond, placing both sites within the moderately thick aerosol category. Therefore, smoke is indicated for the event days for which data is available, July 1 and 12.

In addition, on days with AOD in the moderately thick aerosol category or higher, the formaldehyde levels tend to be higher than they are under clean sky conditions. The two highest peaks on the charts are labeled with the date and the second highest peak on each chart is the July 12 event day. Notably the highest peak, for June 7th, occurred on one of the region's most extreme smoke days and was depicted in our demonstration as figure 1-2 supporting our overview of the intense smoke occurring throughout the 2023 ozone season.





Conclusion

Having completed the requirements for public comment the following language was added to the conclusion of the document:

11.3 Documentation of Comment Process

In accordance with 40 CFR 50.14(c)(3)(v) the Department proposed a draft of this document for a 30-day public comment period. Comments were received and responded to in a response to comments document, which together with this document meet the requirements for exceptional event demonstrations. All supporting documents can be found on DEEP's 2023 exceptional events webpage.

Errata

Upon final review of the Demonstration, DEEP has made additional minor text edits as necessary for clarity.

I therefore recommend that the exceptional events demonstrations, supplemented and revised as recommended in this report, be submitted to EPA for concurrence.

/s/ Amanda Fritz June 25, 2024