State of Ohio Environmental Protection Agency
Division of Air Pollution Control

May 2016 Canadian Wildfire Ozone and $PM_{2.5}$ Exceptional Event Demonstration

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Division of Air Pollution Control

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Introduction

The following is Ohio EPA's Exceptional Event demonstration showing that the plume from the Canadian wildfire which took place in May 2016 near Fort McMurray, Alberta adversely affected ozone and $PM_{2.5}$ data in a regulatory significant way at several monitors in Ohio. Table 1 identifies the monitors (seven ozone and one $PM_{2.5}$) that were affected such that the data from May 24-25, 2016 should be excluded from regulatory determinations.

Table 1. Data Requested for Exclusion

Parameter	Area	Monitor ID	Site Name	County	Date(s)
Ozone	Cleveland	39-035-0034	District	Cuyahoga	5/24/16, 5/25/16
		39-035-5002	Mayfield	Cuyahoga	5/24/16, 5/25/16
		39-055-0004	Notre Dame	Geauga	5/24/16, 5/25/16
		39-085-0003	Eastlake	Lake	5/24/16, 5/25/16
		39-093-0018	Elyria	Lorain	5/24/16
	Cincinnati	39-017-0018	Midd	Butler	5/24/16
		39-017-9991	Oxford	Butler	5/24/16
$PM_{2.5}$	Cleveland	39-035-0065	Harvard Yards	Cuyahoga	5/24/16

40 CFR 50.14 establishes the procedures for submitting an exceptional event demonstration. Specifically, 40 CFR 50.14(c)(3)(iv) states: "The 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 the requirement at paragraph (c)(3)(iv)(B) of this section. The Administrator shall not require a State to prove a specific percentile point in the distribution of data;
(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."

The following demonstration was prepared in accordance with 40 CFR 50.14, U.S. EPA's September 16, 2016 "Guidance on the Preparation of Exceptional Events Demonstrations for Wildfire Events that May Influence Ozone Concentrations"[1] (herein referred to as Exceptional Events Guidance), and U.S. EPA's "EPA Review Technical Support Document Template for Wildfire/Ozone Events."[2]

Exceptional Event Demonstration

A. Regulatory Significance

The Exceptional Events rule applies to data showing an exceedance of a standard which may affect regulatory determinations regarding attainment designation status or other actions by the Administrator. While the wildfire plume was regional in nature and was observable over the State during the event, it did not cause all monitors to exceed the standard throughout the event.

Ohio EPA maintains an air monitoring network that meets the minimum monitoring requirements for criteria pollutants as put forth in Title 40 Part 58 of the Code of Federal Regulations (CFR), Appendix D. A detailed description of the monitoring network is provided in the Ohio 2016-2017 Ohio Air Monitoring Network Plan[3]. All air monitoring data is this analysis was retrieved from the U.S. EPA's Air Quality System (AQS)[4]. As of 2017, the ozone monitoring season is March 1 through October 31; previously, it was April 1 to October 31.

Attainment designation status is determined by design values derived from monitored values. For ozone, the design value is determined by taking the three-year average of the fourth highest 8-hour maximum daily average monitored ozone level. For $PM_{2.5}$, the design value is determined by taking the three-year average of the annual average.

Exclusion of the May 24-25, 2016 data may impact designations for the 2015 ozone standard. Table 2 compares 2014-2016 design values calculated with and without the inclusion of data from of the event. Exclusion of the May 24 and 25, 2016 ozone data would reduce the 2014-2016 design value for the Notre Dame monitor (39-055-0004), the sole monitor in Geauga County, from 71 ppb (nonattainment) to 70 ppb (attainment). If designations for the 2015 ozone standard are based on 2014-2016 design values, exclusion of the May 24-25, 2016 data may influence boundary recommendations in the Cleveland-Akron-Lorain, OH area.

Exclusion of May 24, 2016 data would likewise reduce the 2014-2016 design value from 71 ppb to 70 ppb for the Midd monitor (39-017-0018) in Butler County. However, there

[1] https://www.epa.gov/sites/production/files/2016-09/documents/exceptional_events_guidance_9-16-16_final.pdf
[2] https://www.epa.gov/sites/production/files/2017-06/documents/tsd_template_ozone_wildfire_ee_2017_0606.pdf
[3] http://epa.ohio.gov/dapc/ams/amsmain.aspx#126983982-air-monitoring-plan
[4] https://www.epa.gov/aqs

is another monitor in Butler County (Hamilton, 39-017-0004) which continues to exceed the 2015 ozone standard. Therefore, exclusion of this data does not affect Ohio's recommended designation for Butler County.

Table 2. 2014-2016 Design Values with and without May 24-25, 2016 Data

Parameter	Area	Monitor ID	Site Name	County	Maximum 8-hr Avg Ozone (ppb)/ $PM_{2.5}$ (µg/m³)		2014-2016 Design Value	
					5/24/16	5/25/16	Current	Excluding Data
Ozone	Cleveland	39-035-0034	District	Cuyahoga	74	73	69	69
		39-035-5002	Mayfield	Cuyahoga	73	71	68	67
		39-055-0004	Notre Dame	Geauga	82	79	71	70
		39-085-0003	Eastlake	Lake	77	83	75	74
		39-093-0018	Elyria	Lorain	70	66*	66	65
	Cincinnati	39-017-0018	Midd	Butler	78	66*	71	70
		39-017-9991	Oxford	Butler	74	65*	69	69
$PM_{2.5}$	Cleveland	39-035-0065	Harvard Yards	Cuyahoga	21.7	Not Measured	12.2	12.1

* Not requested for data exclusion

Depending on 2017 and 2018 data, exclusion of the May 24-25, 2016 data may have regulatory significance for other actions by the Administrator, including future clean data determinations, redesignations, violations of the 2008 ozone standard, triggers of contingency measures under the 2008 ozone NAAQS, violations the 2015 ozone NAAQS, or violations of the $PM_{2.5}$ NAAQS.

Appendix A1 shows the 2017 critical 4th-high value for ozone, which is the fourth highest annual 8-hour average value that would produce a 2017 design value that violates the 2008 ozone NAAQS, triggers contingency measures under the 2008 ozone NAAQS, or violates the 2015 ozone NAAQS. Appendix A2 shows the 2017 critical annual average for $PM_{2.5}$ that would produce a 2017 design value that violates the 2012 $PM_{2.5}$ NAAQS. The difference in critical values is shown in the final columns. Where there is a difference in critical value, there may be a regulatory significance to excluding data from the event. The monitors highlighted in yellow in Appendices A1 and A2 (seven ozone and one $PM_{2.5}$) were affected such that the data from May 24-25, 2016 should be excluded from regulatory determinations. For example, the Eastlake monitor in Lake County (39-085-0003) would currently need a 2017 4th high of 76 ppm to trigger contingency measures under the 2008 ozone standard; excluding May 24-25, 2016 data would increase the 2017 4th high needed to trigger contingency measures to 78 ppm.

For each of the highlighted monitors in Appendices A1 and A2, excluding May 24-25, 2016 data would impact the 2017 critical 4th high values, potentially influencing designations under the 2015 ozone NAAQS, clean data determinations, redesignations, violations of the 2008 ozone standard, triggers of contingency measures under the 2008 ozone NAAQS, or violations of the $PM_{2.5}$ NAAQS.

B. Narrative Conceptual Model

Area Description

Two areas in Ohio are of interest in this demonstration: Cleveland and Cincinnati. Both Cleveland and Cincinnati are currently in attainment for the 1979, 1997 and 2008 ozone standards and area expected to be designated marginal nonattainment under the 2015 ozone standard. The Cincinnati area is currently in attainment for the 1997, 2006 and 2012 $PM_{2.5}$ standards. The Cleveland area is in attainment for the 1997 and 2006 $PM_{2.5}$ standard but is currently in nonattainment for the 2012 $PM_{2.5}$ standard.

The Cleveland-Akron-Lorain, OH area (Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit counties) was redesignated to attainment for the 2008 eight-hour ozone standard on January 6, 2017 [82 FR 1603]. On September 30, 2016, Ohio EPA recommended designating Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit Counties as nonattainment under the 2015 ozone standard. Ohio EPA anticipates this area will be classified as marginal nonattainment. The Cleveland, OH area (Cuyahoga and Lorain counties) was designated nonattainment under the 2012 Annual $PM_{2.5}$ standard on January 15, 2015, corrected April 7, 2015 [80 FR 2206 and 80 FR 18535], effective April 15, 2015.

The Cincinnati, OH-KY-IN area (Butler, Clermont, Clinton, Hamilton and Warren counties) was redesignated to attainment for the 2008 eight-hour ozone standard on December 16, 2016 [81 FR 91035]. On September 30, 2016, Ohio EPA recommended designating Hamilton, Butler, Clermont and Warren Counties as nonattainment under the 2015 ozone standard. Ohio EPA anticipates this area will be classified as marginal nonattainment.

Ozone and $PM_{2.5}$ have both significantly decreased in both the Cleveland and Cincinnati areas due to significant and sustained reductions in ozone precursor emissions, direct $PM_{2.5}$ and $PM_{2.5}$ precursors. This is evident in Figure 1 below, taken from U.S. EPA's Air Trends website[5], showing the number of days in each year since 2000 reaching "Unhealthy for Sensitive Groups" or above on the Air Quality Index (AQI) for either ozone or $PM_{2.5}$.

[5] https://www.epa.gov/air-trends

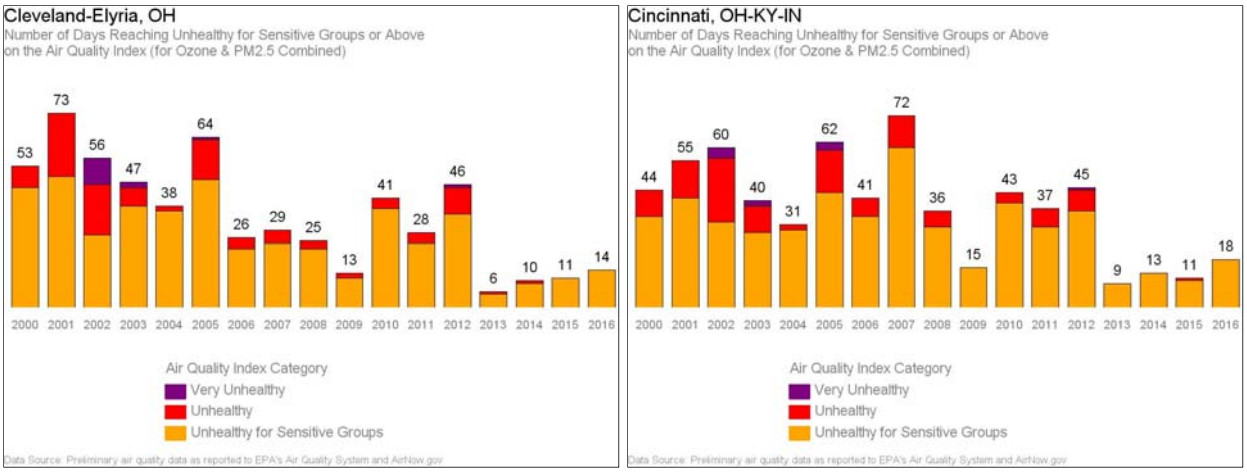

Figure 1. Number of Days Reaching Unhealthy for Sensitive Groups or Above on the AQI (Ozone and $PM_{2.5}$)

Figures 2 to 4 show the location of the ozone and $PM_{2.5}$ monitors requested for data exclusion.

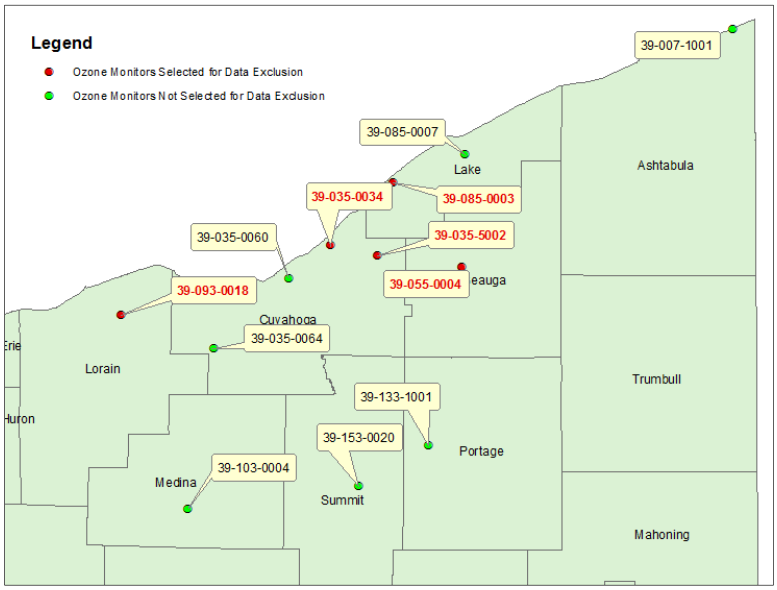

Figure 2. Cleveland Area Ozone Monitors Requested for Data Exclusion

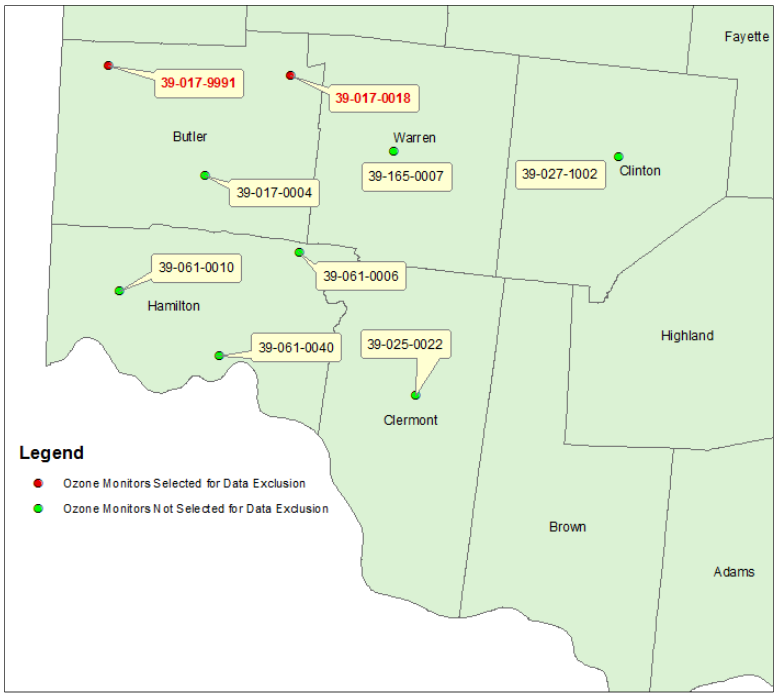

Figure 3. Cincinnati Area Ozone Monitors Requested for Data Exclusion

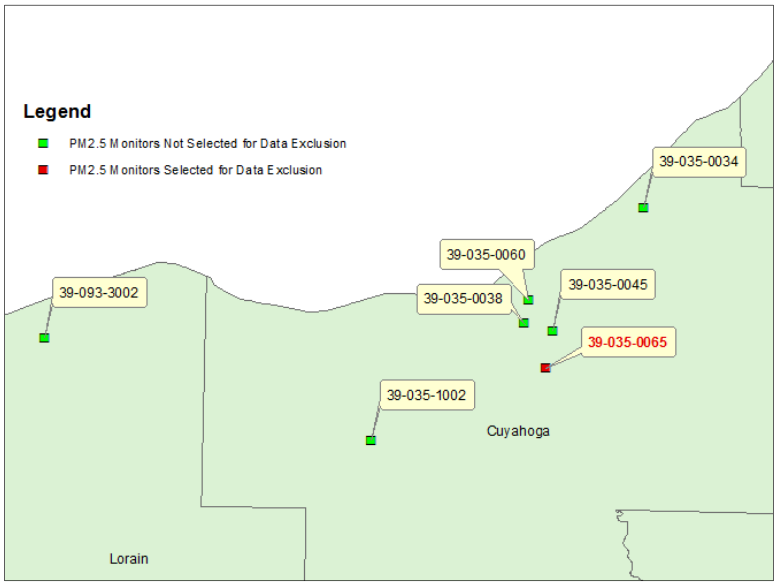

Figure 4. Cleveland Area $PM_{2.5}$ Monitors Requested for Data Exclusion

The District site (Cuyahoga County; Monitor ID 39-035-0034; Lat +41.55523, Lon -81.575256) is a neighborhood scale site located in a residential/industrial area in the northeast side of Cleveland. This is a SLAMS FRM $PM_{2.5}$ and ozone station located at the 6th district police station 1.2 miles south of Lake Erie and the Easterly Water Treatment Plant.

The Mayfield site (Cuyahoga County; Monitor ID 39-035-5002; Lat +41.537041, Lon -81.45889) is an urban scale site on the east side of Cuyahoga County. This SLAMS ozone monitor is located on the roof of Mayfield Heights HS. The site is considered a maximum downwind impact site for ozone for the Cleveland metropolitan statistical area (MSA).

The Notre Dame site (Geauga County; Monitor ID 39-055-0004; Lat +41.515, Lon -81.2499) is an urban scale site located in a very rural area on the western edge of Geauga county. The SLAMS ozone monitor is located on the roof of a school building. The site is considered a maximum downwind site for the measurement of ozone emanating from the Cleveland metropolitan area. The terrain is one of the highest points just southeast of Cleveland.

The Eastlake site (Lake County; Monitor ID 39-085-0003; Lat +41.673, Lon -81.422455) is a neighborhood scale site located in Lake county. The SLAMS ozone and sulfur dioxide monitor was located to monitor the Lake Shore power plant situated several miles to the NW, which shut down in 2015 and is scheduled for demolition.

The Elyria site (Lorain County; Monitor ID 39-093-0018; Lat +41.420882, Lon -82.095729) is an urban scale site located in Lorain county. The SLAMS ozone monitoring site is located to monitor the upwind transport of ozone into the Cleveland MSA from the west.

The Midd site (Butler County; Monitor ID 39-017-0018; Lat +39.529444, Lon -84.393453) is an urban scale site located in Butler county. The SLAMS ozone monitoring site monitors population exposure in the Cincinnati area.

The Oxford site (Butler County; Monitor ID 39-017-9991; Lat +39.531115, Lon -84.723547) is a U.S. EPA CASTNET monitor located in Butler county. This site is located in rolling agriculture north of Cincinnati.

The Harvard Yards site (Cuyahoga County; Monitor ID 39-035-0065; Lat +41.446682, Lon -81.662419) is a neighborhood scale site located on the premises of the Cleveland Water Department in an industrial area located just north of several major plants. This site is a SLAMS monitoring site that samples for SO2, $PM_{2.5}$ and PM_{10}.

Characteristics of Non-Event Ozone Formation

The following conceptual model of typical ozone formation characteristics is adapted from Lake Michigan Air Directors Consortium's (LADCO) February 3, 2017 "Modeling Demonstration for the 2008 Ozone National Ambient Air Quality Standard for the Lake Michigan Region Technical Support Document."[6] This regional description is applicable to the Cleveland and Cincinnati areas.

[6] http://www.ladco.org/reports/ozone/post08/LADCO%20Ozone%20TSD%20FINAL%20(Feb%203%202017).pdf

Ozone concentrations are significantly influenced by meteorological factors. Ozone production is driven by high temperatures and sunlight, as well as precursor concentrations. Ozone concentrations at a given location are also dependent on wind direction, which governs which sources or source regions are upwind.

Qualitatively, ozone episodes in the region are associated with hot weather, clear skies (sometimes hazy), low wind speeds, high solar radiation, and winds with a southerly component. These conditions are often a result of a slow-moving high pressure system to the east of the region. As shown in Figure 5, the bulk of exceedance days at the monitors included in this request for data exclusion typically occur during June and July.

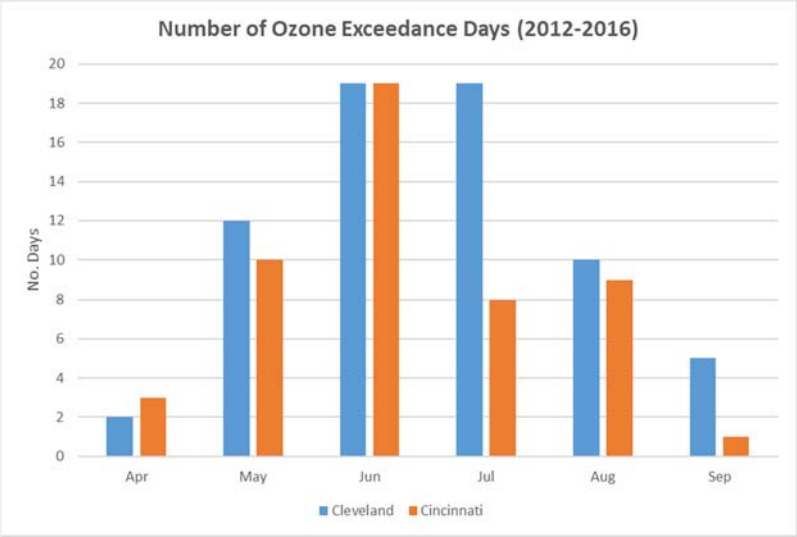

Figure 5. Number of Ozone Exceedance Days (2012-2016)

Transport of ozone and its precursors is a significant factor and occurs on several spatial scales. Regionally, over a multi-day period, somewhat stagnant summertime conditions can lead to the build-up in ozone and ozone precursor concentrations over a large spatial area. This polluted air mass can be transported long distances, resulting in elevated ozone levels in locations far downwind.

Locally, emissions from urban areas add to the regional background leading to ozone concentration hot spots downwind. Depending on the synoptic wind patterns (and local land-lake breezes), different downwind areas are affected.

Electric generating units (EGUs) are a major source of ozone precursors. EGUs are capable of producing a large amount of emissions over a short duration and generally emit at elevations conducive to transport. During hot days many of the less frequently used high-emitting EGUs come online to supply the high electric demand of air conditioning and refrigeration along with base load units operating at full capacity.

U.S. EPA's preliminary transport modeling for the 2015 ozone standard shows that ozone at these monitors is most influence by emissions from Illinois, Indiana, Kentucky,

and Michigan, in addition to Ohio's own emissions. Figure 6 shows NOx emissions[7] from these states during the ozone season (left) and during May (right) has significantly decreased from 2012 to 2016.

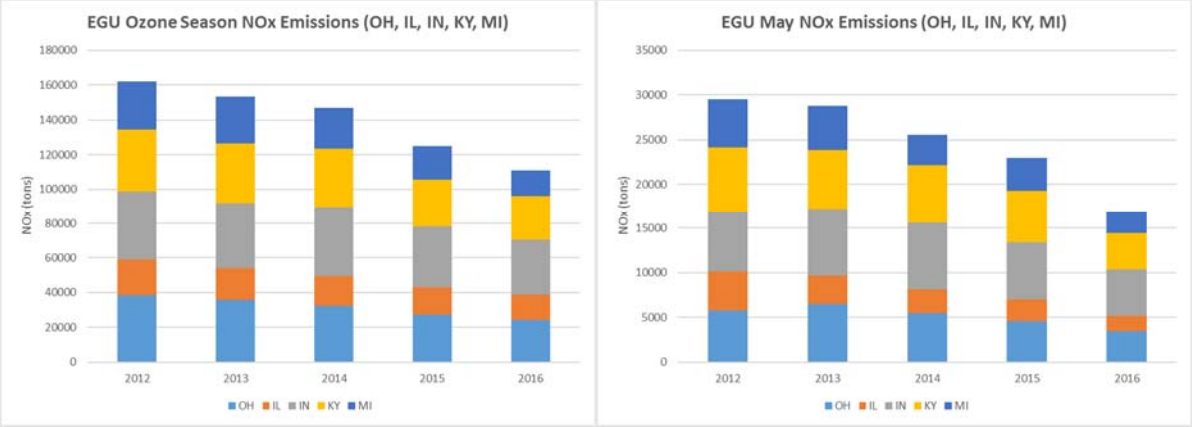

Figure 6. 2012-2016 EGU NOx Emissions (OH, IL, IN, KY, MI) – Ozone Season (left) and May (Right)

Characteristics of Non-Event $PM_{2.5}$ Formation

The following conceptual model of typical $PM_{2.5}$ formation characteristics in the Cleveland area is taken from LADCO's August 22, 2016 "Attainment Demonstration for the 2012 $PM_{2.5}$ National Ambient Air Quality Standard for Cleveland, Ohio Technical Support Document."[8]

$PM_{2.5}$ concentrations are not as strongly influenced by meteorology as ozone, but the two pollutants share some similar meteorological dependencies. In the summer, conditions that are conducive to ozone (hot temperatures, stagnant air masses, and low wind speeds due to stationary high pressure systems) also frequently give rise to high $PM_{2.5}$. In the case of PM, the reason is two-fold: (1) stagnation and limited mixing under these conditions cause $PM_{2.5}$ to build up, usually over several days, and (2) these conditions generally promote higher conversion of important precursors (SO_2 to SO_4) and higher emissions of some precursors, especially biogenic carbon. Wind direction is another strong determinant of $PM_{2.5}$; air transported from polluted source regions has higher concentrations.

Seasonally, concentrations of $PM_{2.5}$ in Cleveland are typically highest in the winter and summer, with lower concentrations in the spring and fall. Seasonal patterns are driven partly by changes in emissions (for example, from changing electrical demand) and partly by the influence of meteorology on $PM_{2.5}$ (for example, ammonium nitrate is present in significant amounts during the colder winter months).

[7] Data obtained from U.S. EPA's Clean Air Markets Division (CAMD) at https://ampd.epa.gov/ampd/
[8] http://www.ladco.org/reports/pm25/post08/LADCO_Ohio_PM2.5_TSD_FINAL_(August_22_2016).pdf

Chemically, $PM_{2.5}$ is made up of mostly ammonium sulfate, ammonium nitrate, and organic carbon in approximately equal proportions on an annual average basis. Elemental carbon and crustal matter (also referred to as soil) contribute less than 5% each.

Spatially, $PM_{2.5}$ concentrations in urban areas are higher than in upwind rural areas, indicating that local urban sources add a significant increment of 1-3 $\mu g/m^3$ to the regional background of 6-10 $\mu g/m^3$. The components of $PM_{2.5}$ also vary spatially and exhibit notable urban and rural differences. Urban areas, including Cleveland, have higher local contributions to EC and soil. Sources of EC are usually combustion processes (for example, mobile sources - especially diesel, and industrial fuel use), and the soil fraction of $PM_{2.5}$ is generally from mechanical processes, road dust, and construction.

The major components of $PM_{2.5}$ vary seasonally. In Cleveland, ammonium sulfate peaks in the summer and winter. Sulfate is formed when sulfuric acid (an oxidation product of sulfur dioxide) and ammonia react in the atmosphere, especially in cloud droplets. Coal combustion is the primary source of sulfur dioxide, whereas ammonia is emitted primarily from animal husbandry operations and fertilizer use. Ammonium nitrate peaks in the winter. Ammonium nitrate forms when nitric acid reacts with ammonia, a process that is enhanced when temperatures are low and humidity is high. Nitric acid is a product of the oxidation of nitric oxide, a pollutant that is emitted by combustion processes. Organic carbon concentrations are generally slightly higher in the summer than in other season. Particulate organic carbon can be emitted directly from cars and other fuel combustion sources or formed in a secondary process as volatile organic gases react and condense. In rural areas, summer organic carbon has significant contributions from biogenic sources.

$PM_{2.5}$ mass is sensitive to reductions in sulfate at all times of the year and all parts of the region. Even though sulfate reductions cause more ammonia to be available to form ammonium nitrate (PM nitrate increases slightly when sulfate is reduced), this increase is generally offset by the sulfate reductions, such that $PM_{2.5}$ mass decreases.

$PM_{2.5}$ mass is also sensitive to reductions in nitric acid and ammonia. The greatest $PM_{2.5}$ decrease in response to nitric acid reductions occurs during the winter, when nitrate is a significant fraction of $PM_{2.5}$. Under conditions with lower sulfate levels (i.e., proxy of future year conditions), $PM_{2.5}$ is more sensitive to reductions in nitric acid compared to reductions in ammonia. Ammonia becomes more limiting as one moves from west to east across the region.

$PM_{2.5}$ chemical species show noticeable transport influences. High PM sulfate is associated with air masses that traveled through the sulfate-rich Ohio River Valley. High PM-nitrate is associated with air masses that traveled through the ammonia-rich Midwest.

A large portion of $PM_{2.5}$ mass consists of secondary, regional impacts, which cannot be attributed to individual facilities or sources (e.g., secondary sulfate, secondary nitrate, and secondary organic aerosols). A smaller, yet significant portion of $PM_{2.5}$ mass is due to emissions from nearby (local) sources. Local (urban) excesses occur in many urban areas for organic and elemental carbon, crustal matter, and, in some cases, sulfate.

Wildfire Description

The following description of the Fort McMurray wildfire is adapted from the Exceptional Event demonstrations submitted by the Connecticut Department of Energy and Environmental Protection (CT DEEP) (Appendix B), and the Rhode Island Department of Environmental Management[9].

On May 1, 2016, a wildfire began in a remote portion of forest southwest of Fort McMurray, Alberta, Canada. Within days, it swept through the community, destroying approximately 2,400 homes and buildings and forcing the largest wildfire evacuation in Albertan history. By May 11, The Guardian Newspaper was reporting on the wildfire that was now nicknamed "the beast" and stated that it was "… an extremely intense fire…so intense the soil is likely scorched, tree roots burned… [and] will likely smoulder and have hotspots for months mainly because of thick peat." [10]

Figure 7. Wildfire as it approaches Fort McMurray. This photo taken Wednesday, May 4, 2016 shows the plume rising into the atmosphere forming pyro-cumulus clouds. (photo by Jeff McIntosh/CP).

[9] http://www.dem.ri.gov/programs/air/documents/aq-exceptionalevent-draft.pdf
[10] Leahy, Stephen, *Canada Wildfire – what are the environmental impacts,* The Guardian, May 11, 2016.

Similarly, the Edmonton Journal was reporting that "firefighters started to realize the uniquely destructive nature of the Fort McMurray wildfire when they saw aspen poplar trees instantaneously and loudly explode into fire." The article continued the fire was so intense it was generating its own weather producing pyro cumulonimbus clouds and thunder and lightning storms.[11]

Additional news articles describe a massive plume of global proportions resulting from the Fort McMurray fire:

Wildfires in western Canada send haze to New England
PORTLAND, Maine (May 12, 2016)
"If you thought the sky didn't seem quite as brilliantly blue on Thursday, you were right, and you can blame wildfires in western Canada.

Smoke continues to billow from fires in western Canada, fanned eastward by winds in the middle and upper atmosphere.

The smoke is just potent enough to cause the sky over much of New England to appear a bit hazy or "milky" in appearance."

Fort McMurray wildfire ash reaches all the way to Spain
By Wallis Snowdon, CBC News Posted: May 25, 2016 2:02 PM MT
"*The massive plume of particulates from the fire would have travelled more than 12,000 metres into the atmosphere, before the haze was carried east along the jet stream.*

When that column started to build over a couple of those really key days, it got the smoke way, way up into the atmosphere and it basically gets stuck in the jet stream, Gray said.

The jet stream will grab it, and like a river it will carry it down and take it as far as the volume goes. It could circumnavigate the globe if there's enough of it.

…Before the plume travelled east across the Atlantic Ocean, Gray said, it also travelled south, hitting large swaths of the southern United States."

No official cause for the wildfire has been determined to date, though it is suspected to be caused by human activity[12]. The conditions leading up to the outbreak were a bit unusual. A hot air mass (temperatures 90 degrees or higher) with very low humidity (less than 20%) combined with intense winds of 45 mph on May 4th contributed significantly to the fire's growth. The conditions prior to the outbreak were unusually dry, with a low snowpack due to an El Nino cycle, followed by an abnormally warm and dry spring which resulted in a fire season start some four weeks sooner than usual, creating the dry tinder and soil conditions.

[11] Staples, David, *Alberta battles The Beast, a fire that creates its own weather and causes green trees to explode*, Edmonton Journal, May 7, 2016.
[12] CTV News, *Lack of lightning suggests a human caused Fort McMurray fire: professor*, May 4, 2016

The fire spread across approximately 590,000 hectares (1,500,000 acres) and became the costliest natural disaster in Canadian history[13] before it was declared to be under control on July 5, 2016.

Conceptual Model of Ozone and $PM_{2.5}$ Formation and Transport from Fort McMurray Wildfire

The following description of the transport of emissions from the Fort McMurray fire to the US Upper Midwest and Great Lakes region, including Ohio, is adapted from the Exceptional Event demonstration submitted by the CT DEEP (Appendix B). Additional information regarding the formation and long-range transport of emissions from wildfires is adapted from Maryland's Exceptional Event demonstration for Canadian Wildfires during July 2016[14].

Winds during the May 2016 event originated from the direction of the Fort McMurray fire. Wildfire smoke plumes contain gases including non-methane hydrocarbons (NMHCs), carbon monoxide (CO), nitrogen oxides (NOx), and aerosols, which are all important precursors to photochemical production of tropospheric ozone (O_3), and can travel thousands of kilometers. This may cause urban areas where forest fires seldom occur to see greater enrichment of ozone, as much as 25 ppb in the northeastern United States, than areas where wildfires more frequently occur.[15]

Many variables, such as type of fuel or forest burned, plume path and distance burned, affect the intensity of the fire and ability of a plume to enhance downwind ozone production. Emissions from boreal forests such as in the area of the Fort McMurray fire can be much higher than from typical forests in the U.S. due to the high available biomass (on the order of 100 tons per acre) that may be stored in the forest floor as lichens, moss, peat and duff.[16] The Fort McMurray fire occurred following an unusually hot dry spring season. Under these conditions the fire can burn and smolder deeper into the forest floor to add considerable emissions to the plume.

Typically, NOx emissions react within a few days and are no longer available to participate in ozone reactions. However, at high latitudes cooler ambient temperatures are conducive to the sequestering of NOx emissions as peroxyacetyl nitrates (PAN), aerosols which can decompose back to NOx far downwind. Study of boreal wildfires

[13] Insurance Bureau of Canada, *Northern Alberta Wildfire Costliest Insured Natural Disaster in Canadian History – Estimate of insured losses:$3.58 billion*, July 7, 2016.
[14] http://www.mde.state.md.us/programs/Air/AirQualityMonitoring/Documents/MDE_JUL_21_22_2016_EE_demo.pdf
[15] Brey, Steven J. and Emily V. Fischer, Smoke in the City: How Often and Where Does Smoke Impact Summertime Ozone in the United States?, Environmental Science and Technology, vol. 50, pp1288-1294, 2016.
[16] Ottmar, Roger D. and Stephen P. Baker, Forest Floor Consumption and Smoke Characterization in Boreal Forested Fuelbed Types of Alaska, Final Report JFSP Project #03-1-3-08, May 25, 2007.

indicate that as much as 40% of the NOx emitted from the fire can be converted to PAN and transported downwind for six to fifteen days before returning to NOx.[17]

Jaffe and Wigder[18] and others have confirmed that the maximum ozone production is often observed substantially downwind of the fire, after the smoke plumes have aged for several days. Dreessen et al[19] noted in their analysis of a June 2015 wildfire that at peak smoke concentrations in Maryland, wildfire-attributable Volatile Organic Compounds (VOCs) more than doubled, while non-NOx oxides of nitrogen (NOz) tripled, suggesting long range transport of NOx within the smoke plume. They also noted that ozone peaks a few days after the maximum smoke plume due to ultra violet (UV) light attenuation, lower temperatures, and non-optimal surface layer composition. Putero et al.[20] observed the largest increases in ozone from fires five days (120 hours) after the initial pollutants were emitted from the fire (Figure 8).

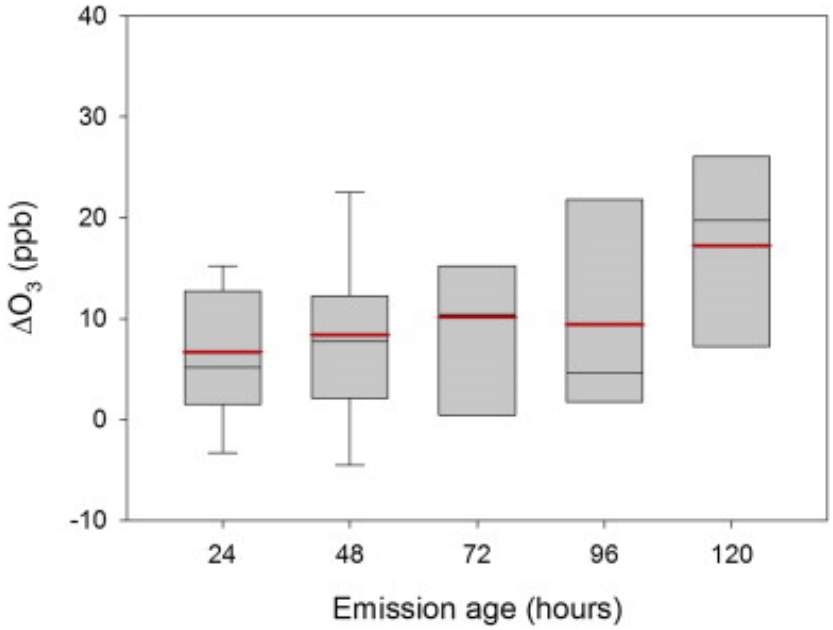

Figure 8. Ozone Enrichment by Age of Plume

Tracking Smoke and Wildfire Emissions Transport to Ohio

Based on its considerable size, significant amounts of ozone and $PM_{2.5}$ precursors were emitted from the Fort McMurray wildfire, in addition to other smoke ingredients. On May 18, the plume from the Fort McMurray wildfire began dispersing toward the US upper

[17] Jaffe, Daniel A. and Nicole L. Wigder, Ozone production from wildfires: A critical review, Atmospheric Environment, vol 51, pp1-10, 2012.
[18] Jaffe, D.; Wigder, N. Ozone production from wildfires: A critical review. Atmos. Environ. 51, 1−10, 2012.
[19] Dreessen, J. et. Al., Observations and impacts of transported Canadian wildfire smoke on ozone and aerosol air quality in the Maryland region on June 9–12, 2015. Journal of the Air & Waste Management Association, 66(9), 842-862, 2016.
[20] Putero, D. et. al., Influence of open vegetation fires on black carbon and ozone variability in the southern Himilayas, Environmental Pollution, vol 184, pp 597-604, 2014.

Midwest and Great Lakes region where it became trapped due to subsidence, atmospheric stability, and light winds associated with a large area of high pressure. Figure 9 shows the progression of the smoke plumes over North America, as analyzed by the Hazard Mapping System (HMS) staff at NOAA, using the satellite images. This series of maps shows the movement of the Fort McMurray smoke plume as it tracks over the Ohio region on May 21-23, 2016.

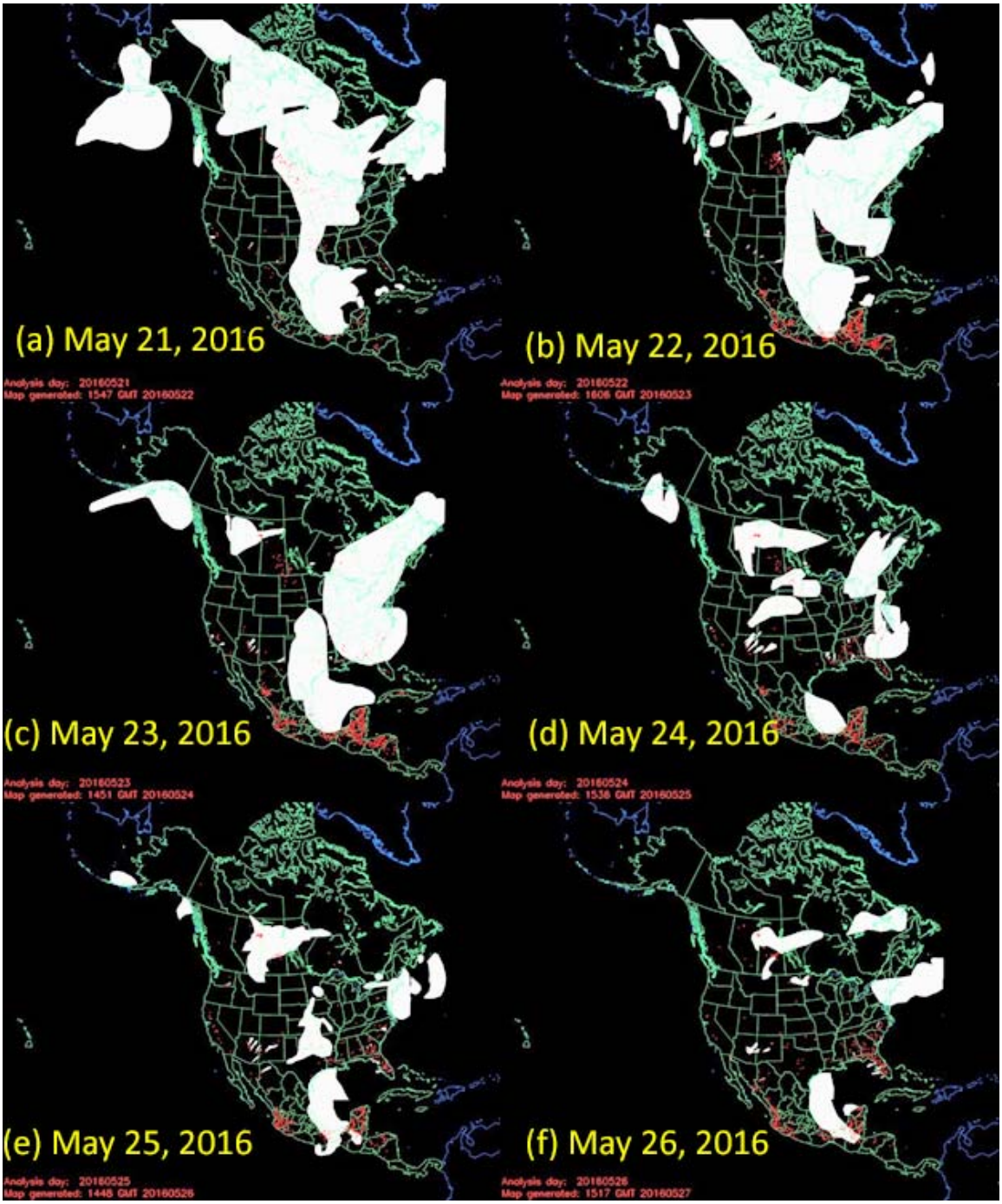

Figure 9. HMS Smoke Analysis from May 21-26(a-f), 2016.

As shown in Figure 10, the Ozone Air Quality Index (AQI) from May 24, 2016 showed an impact at monitors in both the Cleveland and Cincinnati areas, while the AQI from May 25, 2016 showed an impact at monitors in the Cleveland area. A comparison of Figures 9 and 10 show the Ozone AQI tracks well with the smoke plume. Figure 11 shows the $PM_{2.5}$ AQI on May 24, 2016 is also consistent with the smoke plume.

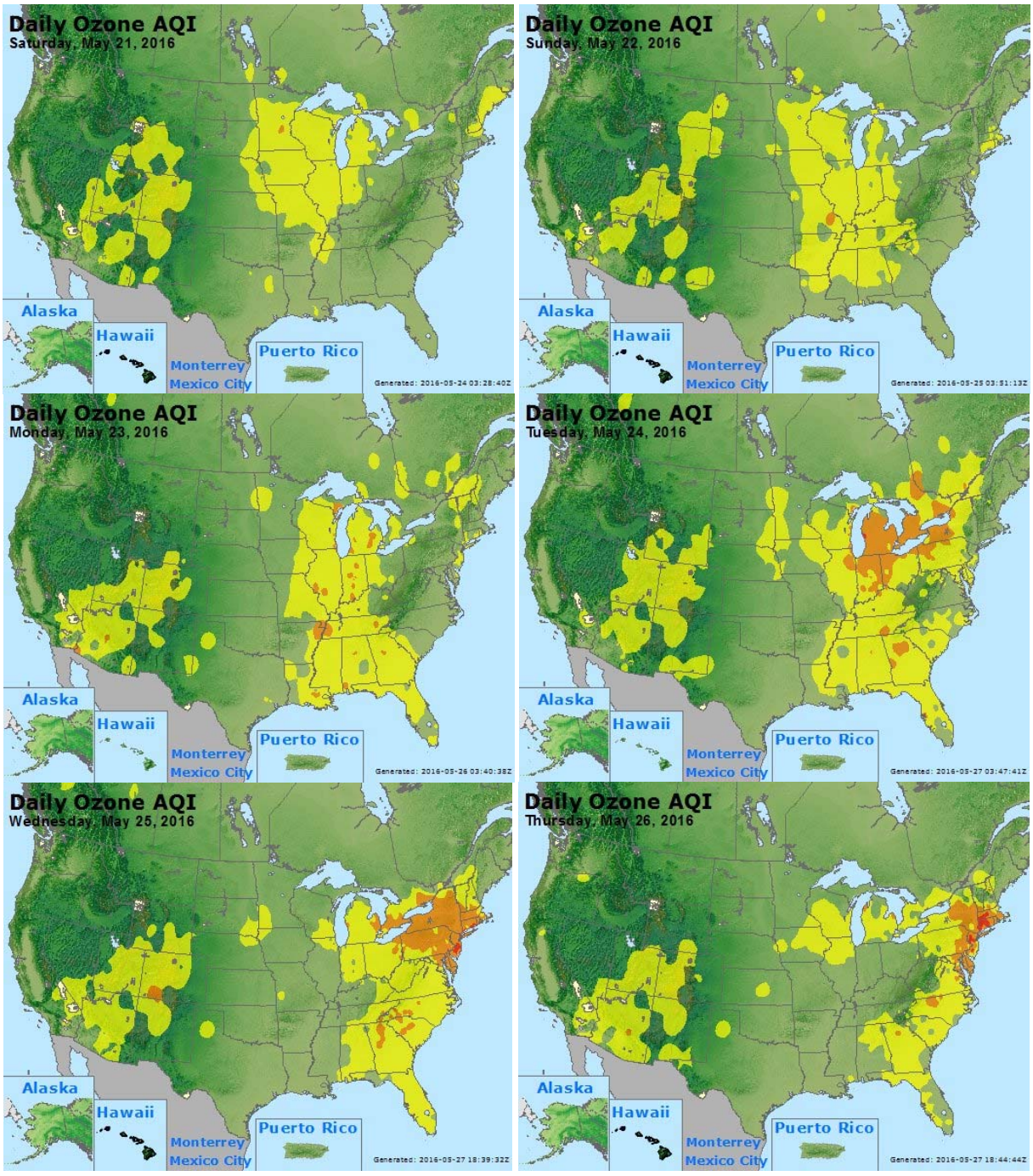

Figure 10. May 21 to 26, 2016 Ozone AQI

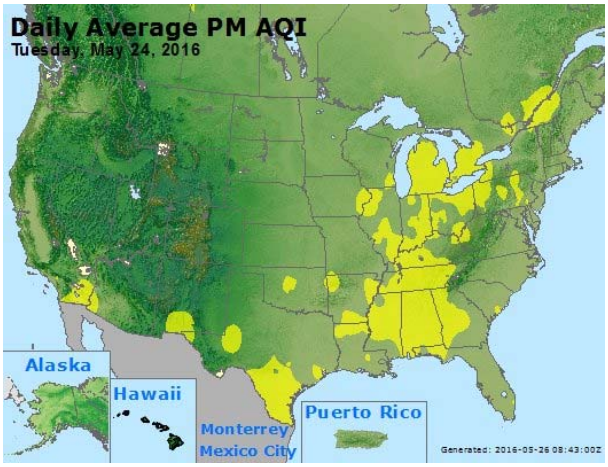

Figure 11. May 24, 2016 $PM_{2.5}$ AQI

Figure 12 shows the hourly ozone concentrations from May 21 to 28, 2016 at the monitors in the Cleveland area where data exclusion is requested. Increased ozone is evident on May 24 and 25, 2016. Likewise, Figure 13 shows an increase in ozone in the Cincinnati area on May 24, 2016. Figure 14 shows a marked increase in $PM_{2.5}$ on May 24, 2016 at the Harvard Yards monitor in the Cleveland area.

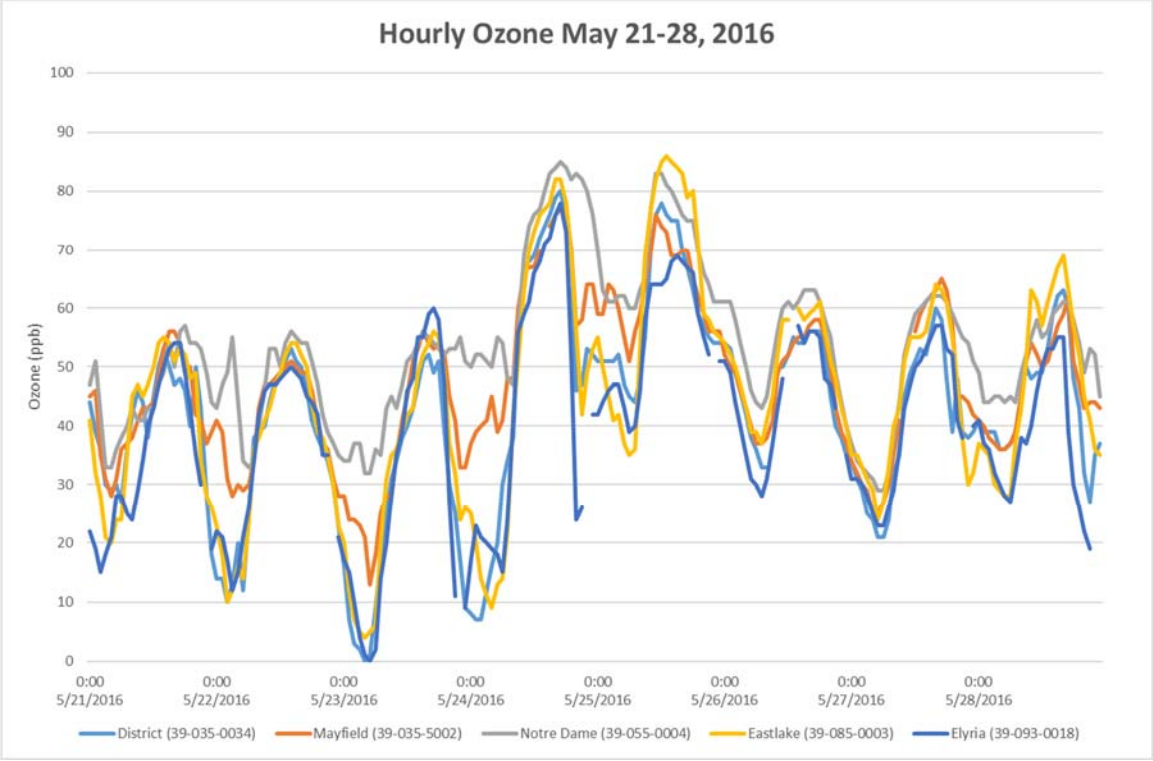

Figure 12. Hourly Ozone May 21-28, 2016 at Cleveland Area Monitors Requested for Data Exclusion

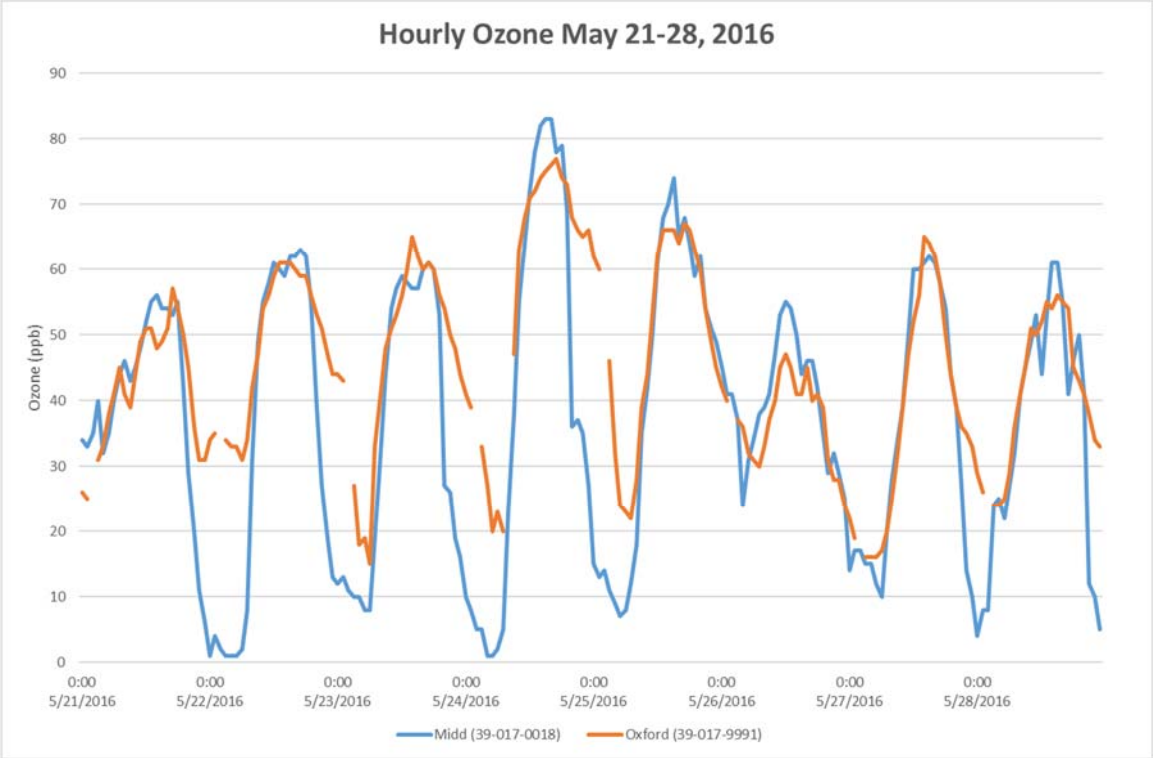

Figure 13. Hourly Ozone May 21-28, 2016 at Cincinnati Area Monitors Requested for Data Exclusion

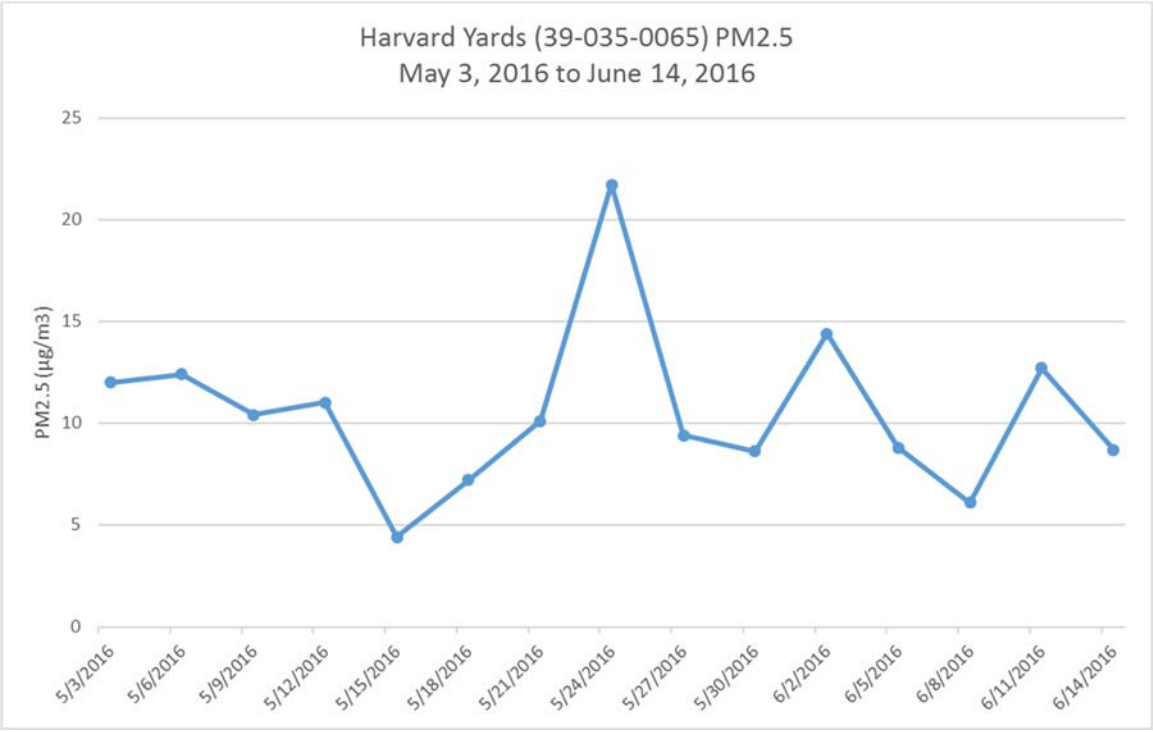

Figure 14. $PM_{2.5}$ May 3 to June 14, 2016 at Harvard Yards monitor (Cleveland area)

Meteorological Conditions Driving Smoke, Ozone and $PM_{2.5}$ Transport

Table 3 shows meteorological conditions at the Cleveland (KCLE) and Cincinnati (KCVG) airports from May 21 to 26, 2016. Upper air 700 millibar (mb) and 850 mb height maps[21], where long range transportation can occur, for May 21 through 26, 2016 are shown in Figures 15 to 20 (700 mb) and 21 to 26 (850 mb). Surface pressure maps[22] are provided in Figures 27 to 32. Soundings[23] from the upper air stations at the Buffalo (KBUF) and Wilmington (KILN) airports, representing Cleveland and Cincinnati upper air conditions respectively, are provided in Figures 33 to 38.

A comparison of meteorological conditions on typical ozone exceedance days to those on May 24 and 25, 2016 is provided in Table 4. This table shows average meteorological conditions at the KCLE airport during the hours of 9:00 am to 9:00 pm on days from 2012 to 2016 where the maximum daily 8-hour average exceeded 70 ppb at one or more ozone monitors for which data exclusion is requested in the Cleveland area, as compared to the averages on May 24 and 25, 2016. Where more than one monitor exceeded the standard on a given day, the ozone value for that day used in the analysis is the average of the monitors that exceeded. Likewise, the table shows average meteorological conditions at the KCVG airport during the hours of 9:00 am to 9:00 pm on days from 2012 to 2016 where the maximum daily 8-hour average exceeded 70 ppb at one or more ozone monitors for which data exclusion is requested in the Cincinnati area, as compared to the averages on May 24, 2016.

Figures 39 to 42 provide surface wind roses and pollution roses comparing the exceedances days to May 24 and 25, 2016, using the same conventions for averaging wind direction, wind speed and ozone concentration on exceedance days as used for the analysis presented in Table 4. These wind roses and pollution roses show the prevailing wind directions divided into sectors around the compass with due north at the top. The longer 'petals' of the rose represent sectors where the wind direction is more prominent. Overlaid on these petals are color bars representing specific ranges of wind speed (for the wind roses) or ozone concentrations (for pollution roses) for each wind direction sector.

Figures 43 to 46 provide upper air wind roses and pollution roses comparing the exceedances days to May 24 and 25, 2016. The upper air wind direction and speed were determined using upper air soundings at 700 mb through 850 mb pressures from KBUF and KILN, representative of Cleveland and Cincinnati respectively, for the 12z sounding on days from 2012 to 2016 where the maximum daily 8-hour average exceeded 70 ppb at one or more ozone monitors for which data exclusion is requested in the Cleveland and Cincinnati areas. Where more than one monitor exceeded the standard on a given day, the ozone value for that day used in the analysis is the average of the monitors that exceeded.

[21] Obtained from http://www.spc.noaa.gov/obswx/maps/
[22] Obtained from http://www.spc.noaa.gov/obswx/maps/
[23] Obtained from http://weather.uwyo.edu/upperair/sounding.html

Typically, most ozone exceedances occur on sunny, summer days with maximum surface temperatures averaging 87°F in Cleveland and 88°F in Cincinnati, surface winds from the southwest in the Cleveland area and southwest to southeast in the Cincinnati area (favorable for transport from the metropolitan areas) and aloft winds primarily from the west.

As shown in the HMS smoke analysis in Figure 9, smoke and smoke emissions were over the Ohio region on May 21 to 23, 2016 and over Michigan on May 21 to 24, 2016. The surface maps show a high pressure system dominated meteorological conditions during the event. Figures 15 to 32 show that upper air and surface winds likely transported pollutants from the wildfire plume into Ohio on May 22 and 23, which then became trapped in the boundary layer by a high pressure system as conditions became increasingly more conducive for ozone formation. Maximum temperature from May 21 to 23 was only 64 to 73°F in the Cleveland area and 66 to 77°F in the Cincinnati area. However, ozone formed on the days leading up to May 24, especially May 23 which was clear and warming, likely carried over under the high pressure system and contributed to the exceedances on May 24 and 25, 2016.

On May 24, upper air winds were generally from the northwest (rather than from the west as is typical for exceedance days), continuing transport of ozone precursors from the smoke plume into Ohio. The skies were clear and the temperature warmed to 82°F in Cleveland and 80°F in Cincinnati. Light surface winds on May 24 were a bit more towards the west in Cleveland than the southwest flow conditions typical for exceedance days. In Cincinnati, light winds were from the southwest as typical for exceedance days. Light winds at the surface are more favorable for ozone formation because this keeps air more stagnant, possibly causing ozone exceedances. In the soundings, there are strong temperature inversions on the 12Z run. A temperature inversion happens overnight when the ground cools quicker than the air above, and it acts as a cap to keep air from moving upward. Because of this, the pollution being carried into those areas becomes trapped, affecting the quality of the air for these days. Based on the 00Z soundings on May 24 and 25, the environmental lapse rate is between the moist adiabatic and the dry adiabatic lapse rates at the lower levels of the atmosphere, indicating that the atmosphere is conditionally unstable. A parcel can become unstable if it turns saturated, but this is not the case on this day, so the parcel is stable. Also, a high pressure system generally indicates a stable atmosphere. With this, air is more stagnant and susceptible to ozone formation.

Under typical daytime photochemistry, increased levels of wildfire-related precursor emissions resulted in enhanced levels of ozone throughout the region. Although the surface wind flow patterns would also have transported anthropogenic emissions to these monitors, the meteorological conditions (specifically, temperature) that existed during the event were likely not sufficient to have caused the ozone exceedances without the added burden of the additional wildfire-related precursor emissions. Only 6 out of 66 ozone exceedance days (9%) between 2012 and 2016 in the Cleveland area occurred at high temperatures of less than 82°F; only 3 out of 50 (6%) occurred at temperatures of less than 80°F in the Cincinnati area. As the smoke plume aged and

mixed with anthropogenic NOx (albeit the lowest NOx emissions in May since at least 2012), ozone concentrations accumulated to levels likely not possible without the smoke. This is reinforced by the fact that the Elyria monitor (39-093-0018) in Lorain County, which is located to monitor the upwind transport of ozone into Cleveland from the west and therefore should not be significantly affected by anthropogenic NOx from the Cleveland metropolitan area, was also affected by this event, although to a lesser degree than the other monitors in the Cleveland area which were likely influenced by both local anthropogenic emissions and transported wildfire emissions.

There was likely some pollutant carryover to May 25, until ozone levels decreased later in the day on May 25 and 26 with increased cloudiness and a change in upper air wind direction to the west and south, away from the smoke plume. Surface winds were from the southwest, typical of exceedance days. Upper air winds turned away from the smoke plume in the Cincinnati area during the afternoon of the May 24, earlier than they did in the Cleveland area on May 25. This supports the shorter, one-day event period in the Cincinnati area as compared to the two-day ozone event in the Cleveland area.

While the above analysis focuses primarily on ozone, it is also applicable to $PM_{2.5}$ formation and transport. As noted above, summertime conditions that are conducive to ozone (hot temperatures, stagnant air masses, and low wind speeds due to stationary high pressure systems) also frequently give rise to high $PM_{2.5}$. This is due to stagnation and limited mixing causing $PM_{2.5}$ to accumulate as well as higher emissions of, and conversion of, precursors. Wind direction is another strong determinant of $PM_{2.5}$, as air transported from polluted source regions has higher concentrations. Similar to ozone, the $PM_{2.5}$ concentration spike on May 24, 2016 correlates with transport from the smoke plume, stagnant air masses and low winds speeds due to the high pressure system, and the $PM_{2.5}$ concentration returns to typical levels as meteorological conditions changed.

Table 3. Meteorological Conditions May 21 to 26, 2016

Area	Variable	5/21/16	5/22/16	5/23/16	5/24/16	5/25/16	5/26/16
Cleveland (KCLE)	Maximum Temperature (F)	64	69	73	82	86	84
	Surface Wind Direction (deg)	NE	NNW	N	WSW	SSW	SSW
	Wind Speed (m/s)	3	4	2	3	4	5
	Sky	Overcast /rain	Partly cloudy	Clear	Clear	Mostly cloudy	Mostly cloudy
Cincinnati (KCVG)	Maximum Temperature (F)	66	79	77	80	82	79
	Surface Wind Direction (deg)	N	NNW	ENE	SSW	S	SSW
	Wind Speed (m/s)	4	4	2	2	4	4
	Sky	Overcast /rain	Partly cloudy	Clear/ partly cloudy	Clear/ partly cloudy	Mostly cloudy	Mostly cloudy/ rain

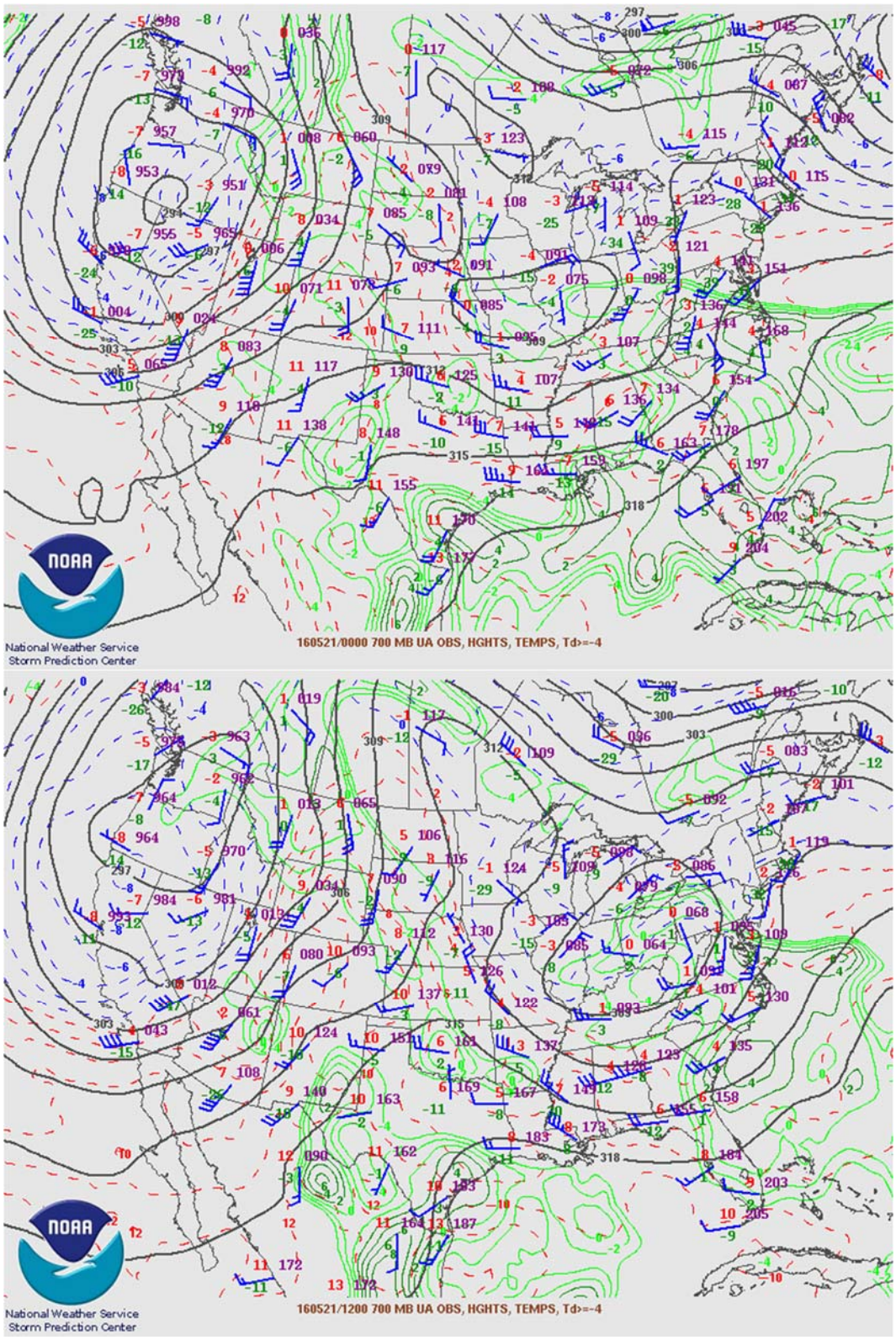

Figure 15. 700 mb Pressure Pattern with Winds for May 21, 2016 (00:00 top; 12:00 bottom)

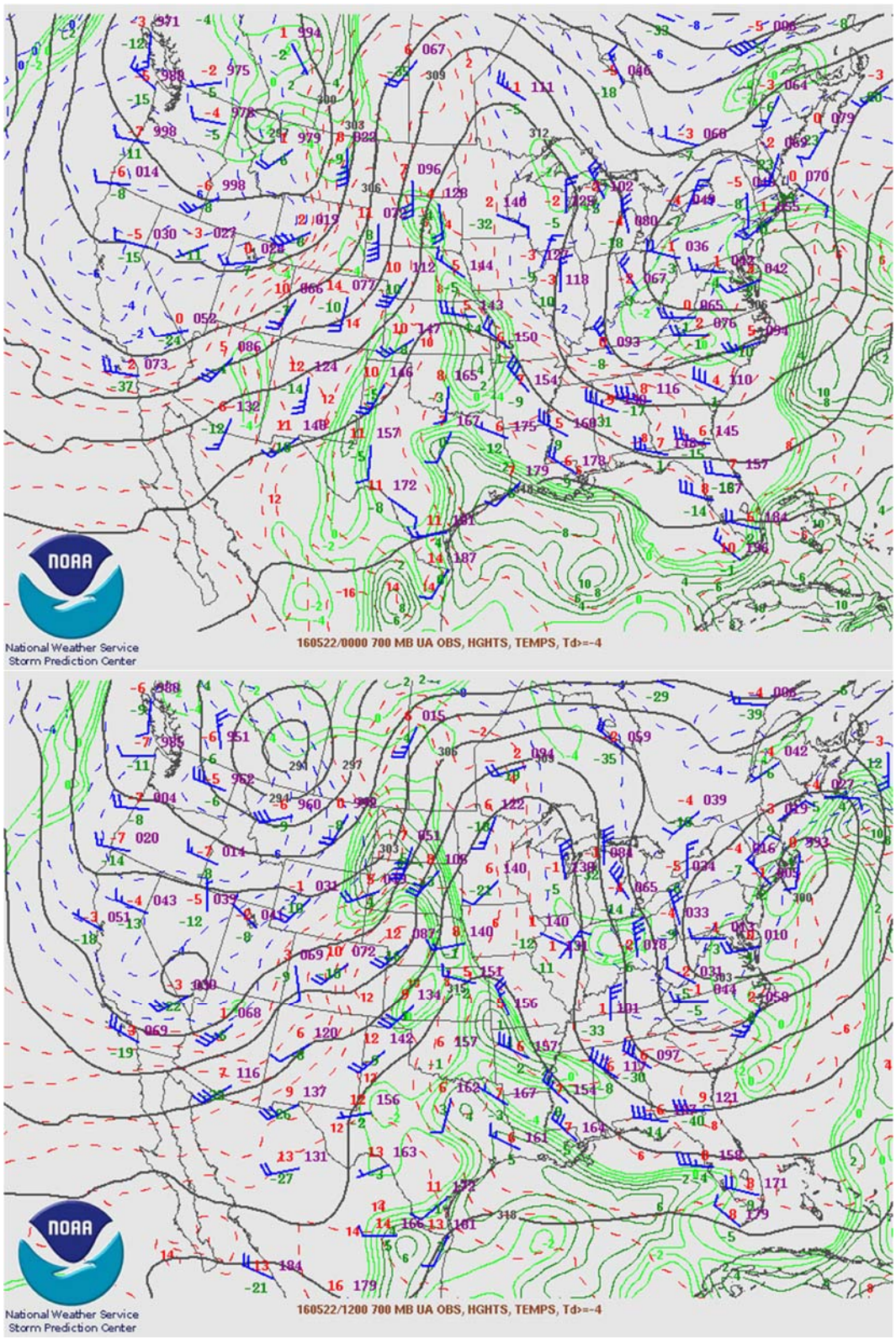

Figure 16. 700 mb Pressure Pattern with Winds for May 22, 2016 (00:00 top; 12:00 bottom)

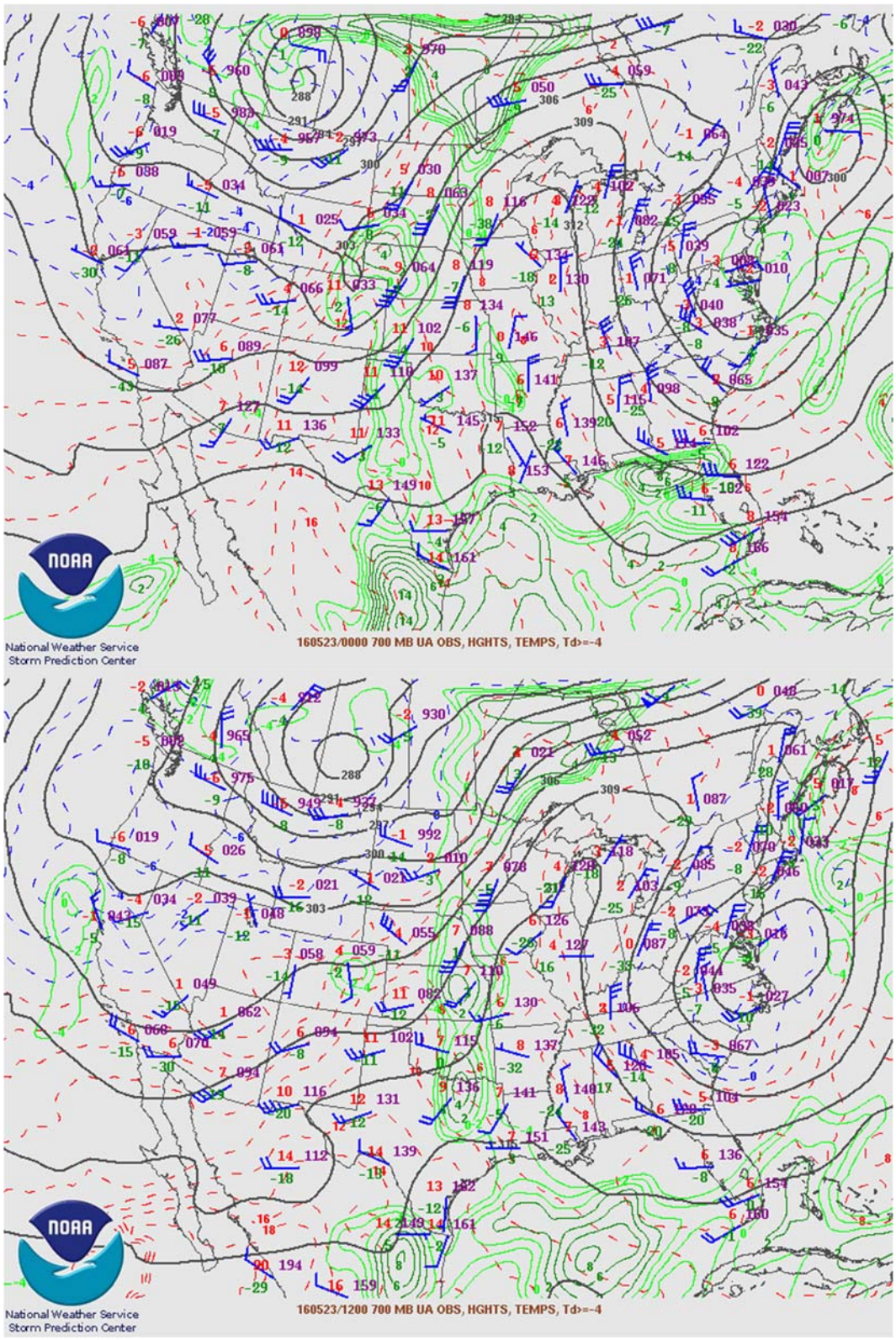

Figure 17. 700 mb Pressure Pattern with Winds for May 23, 2016 (00:00 top; 12:00 bottom)

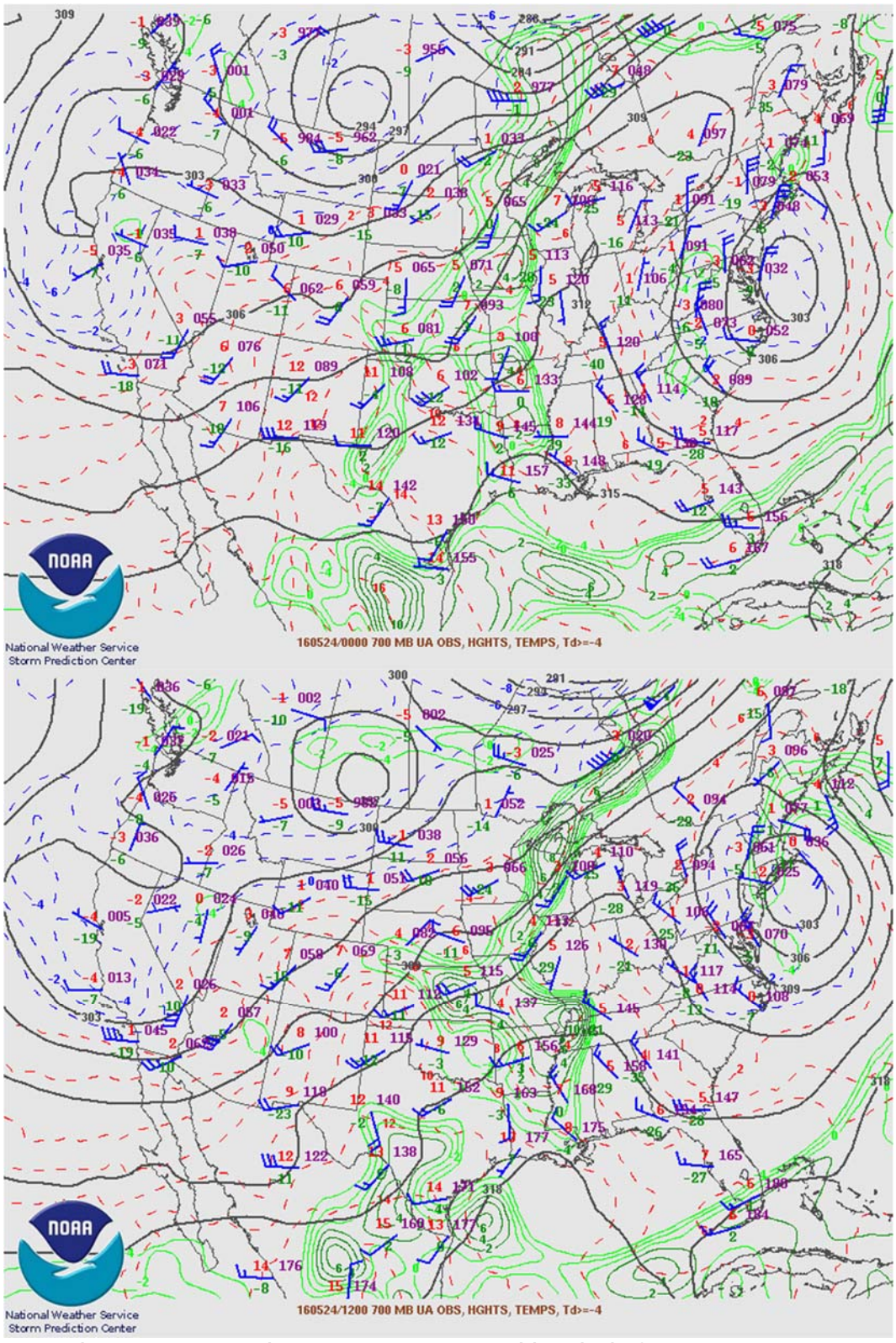

Figure 18. 700 mb Pressure Pattern with Winds for May 24, 2016 (00:00 top; 12:00 bottom)

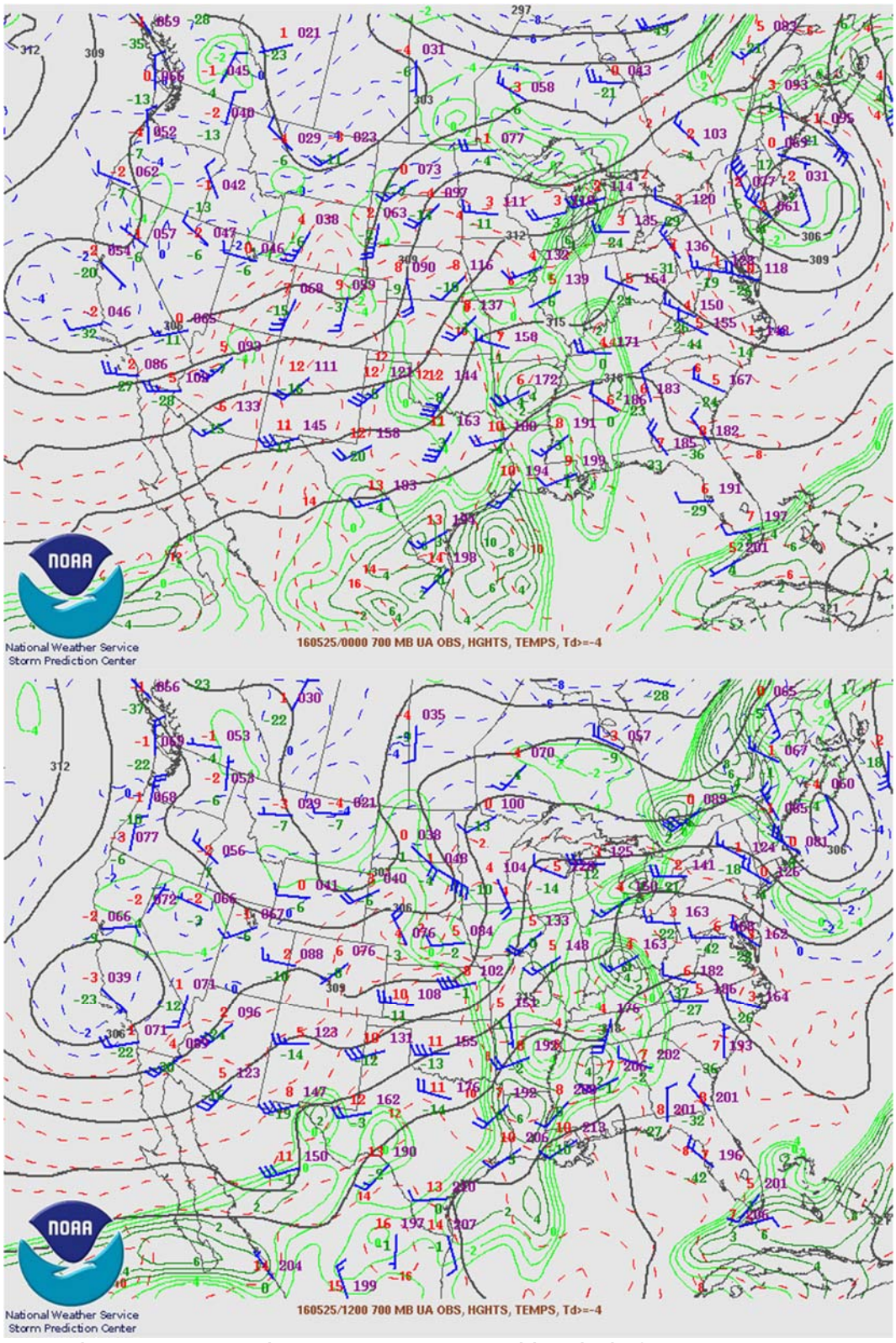

Figure 19. 700 mb Pressure Pattern with Winds for May 25, 2016 (00:00 top; 12:00 bottom)

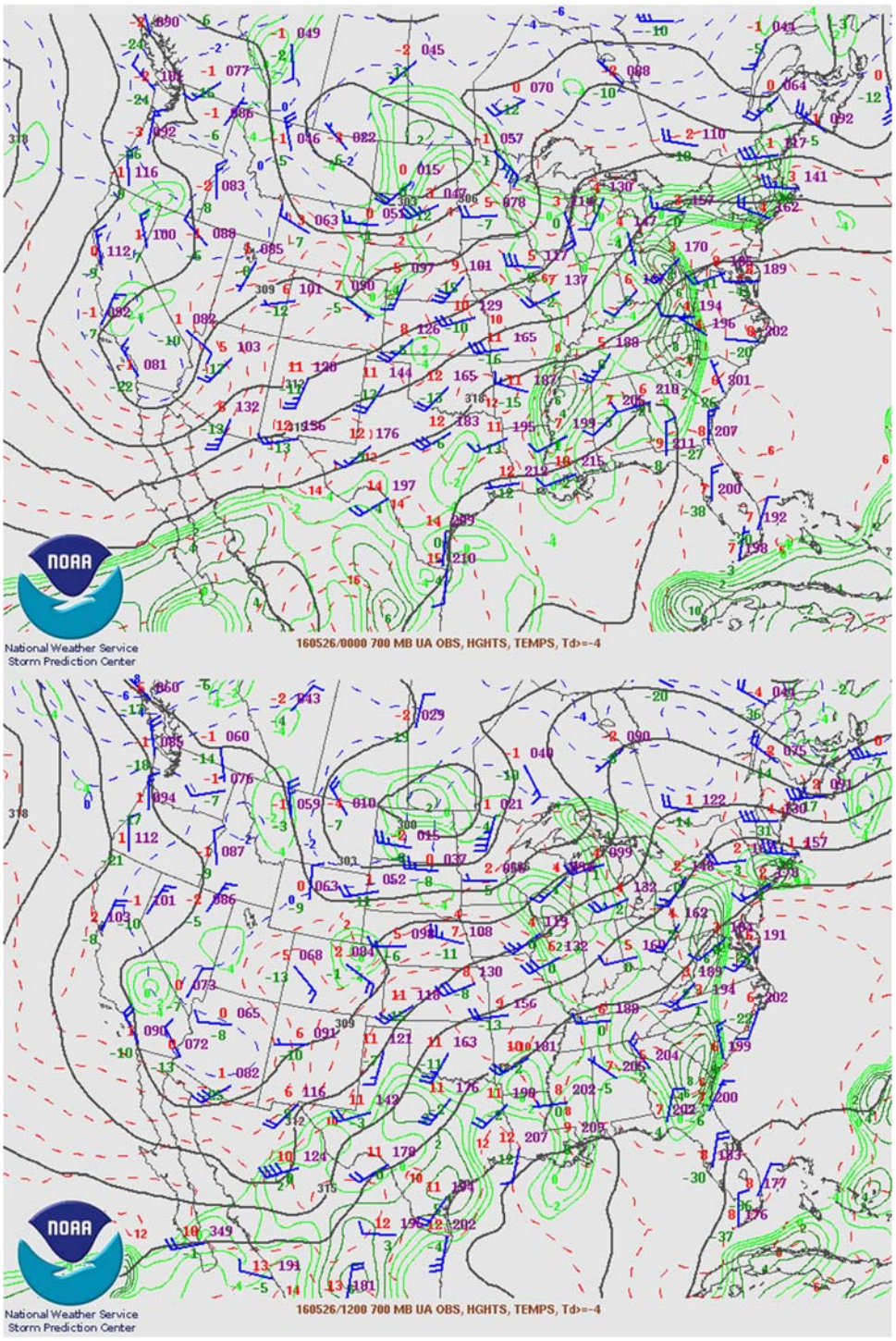

Figure 20. 700 mb Pressure Pattern with Winds for May 26, 2016 (00:00 top; 12:00 bottom)

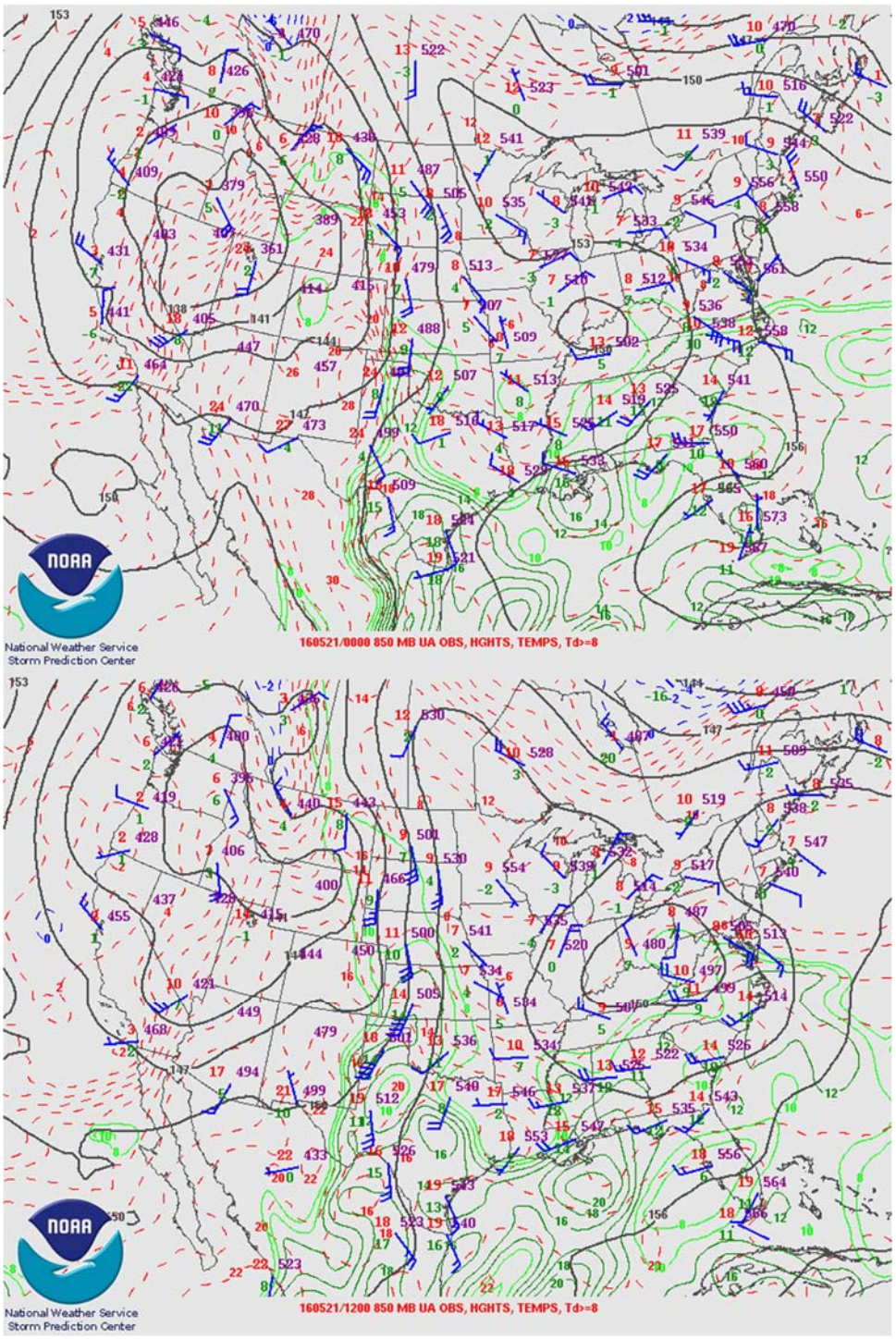

Figure 21. 850 mb Pressure Pattern with Winds for May 21, 2016 (00:00 top; 12:00 bottom)

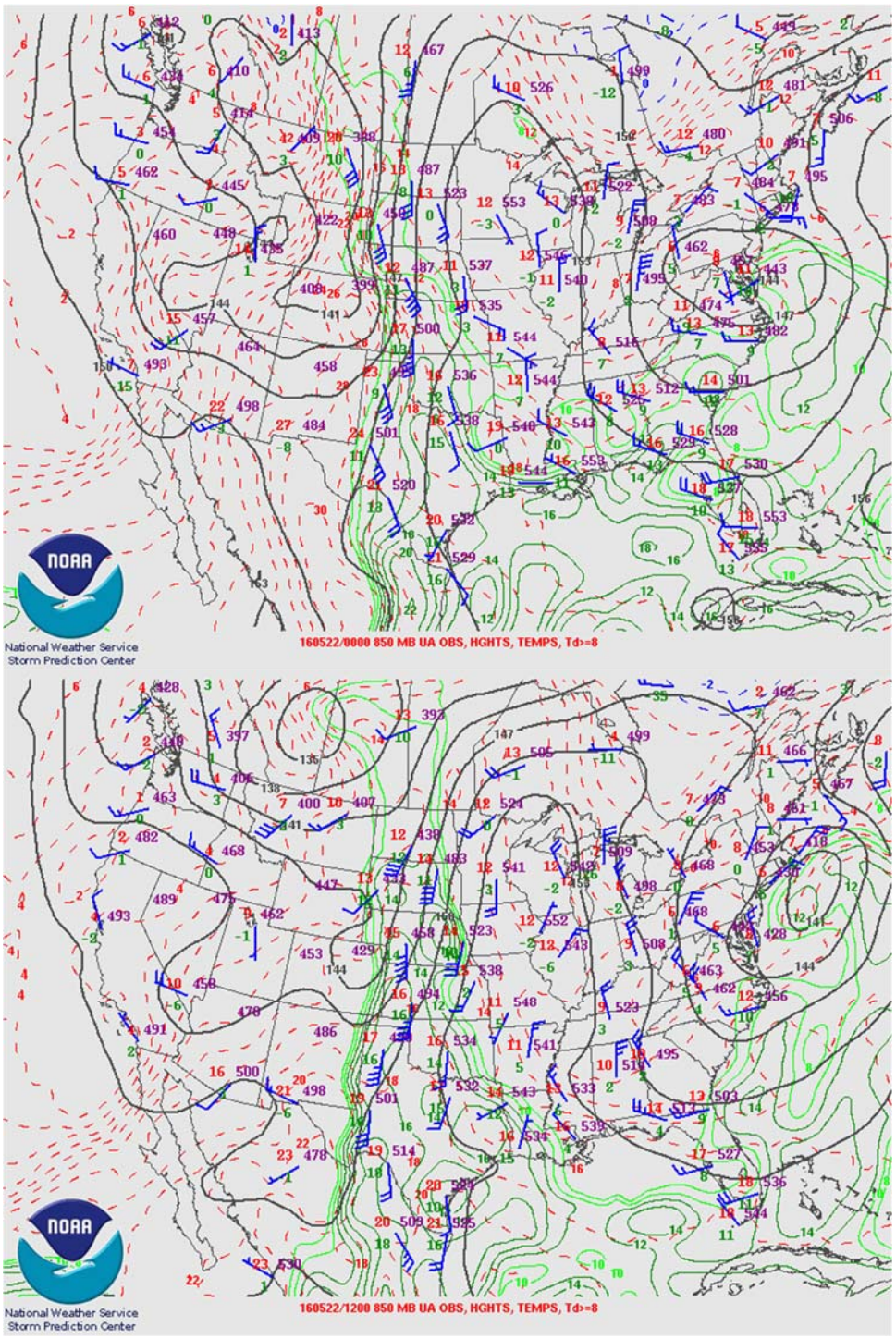

Figure 22. 850 mb Pressure Pattern with Winds for May 22, 2016 (00:00 top; 12:00 bottom)

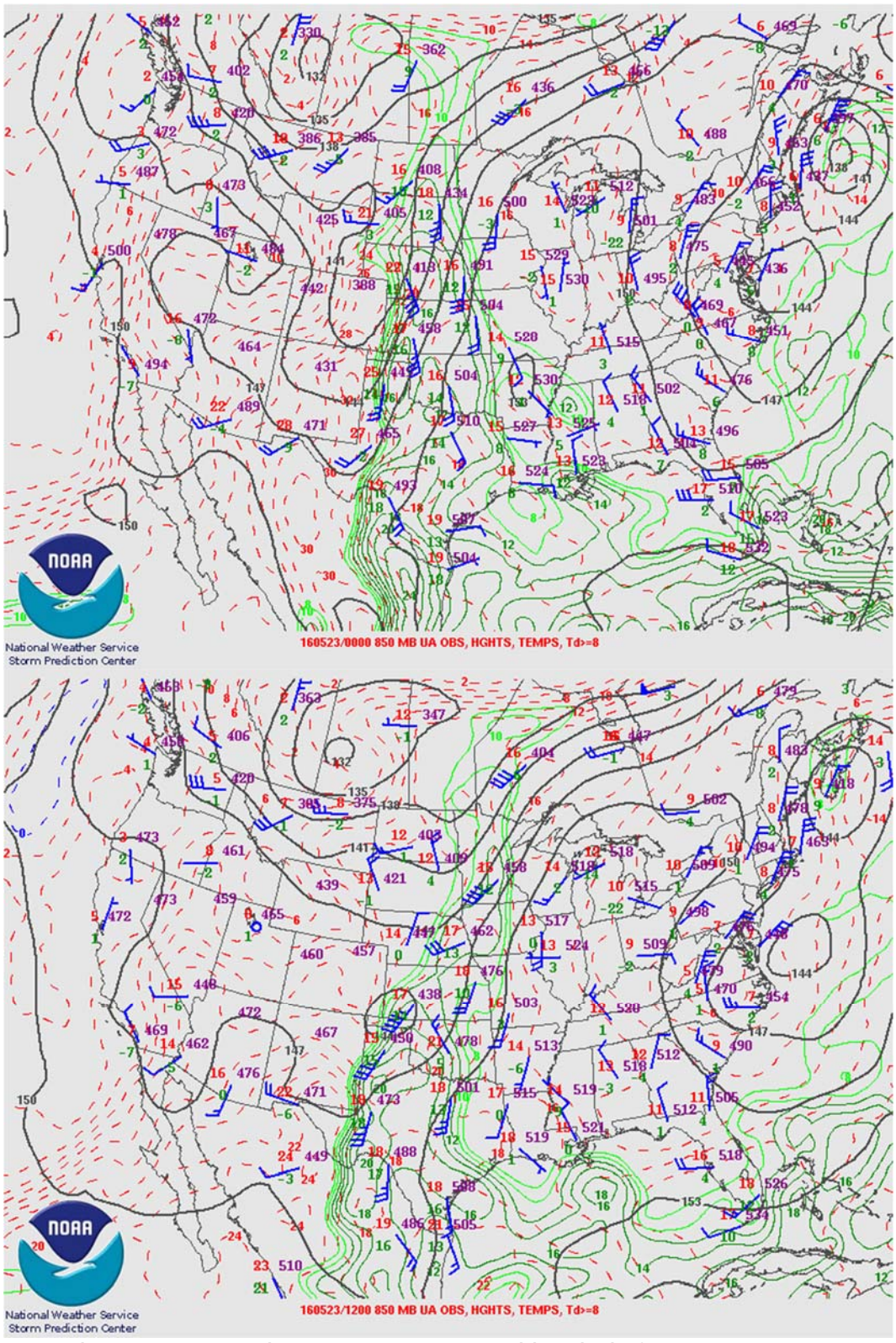

Figure 23. 850 mb Pressure Pattern with Winds for May 23, 2016 (00:00 top; 12:00 bottom)

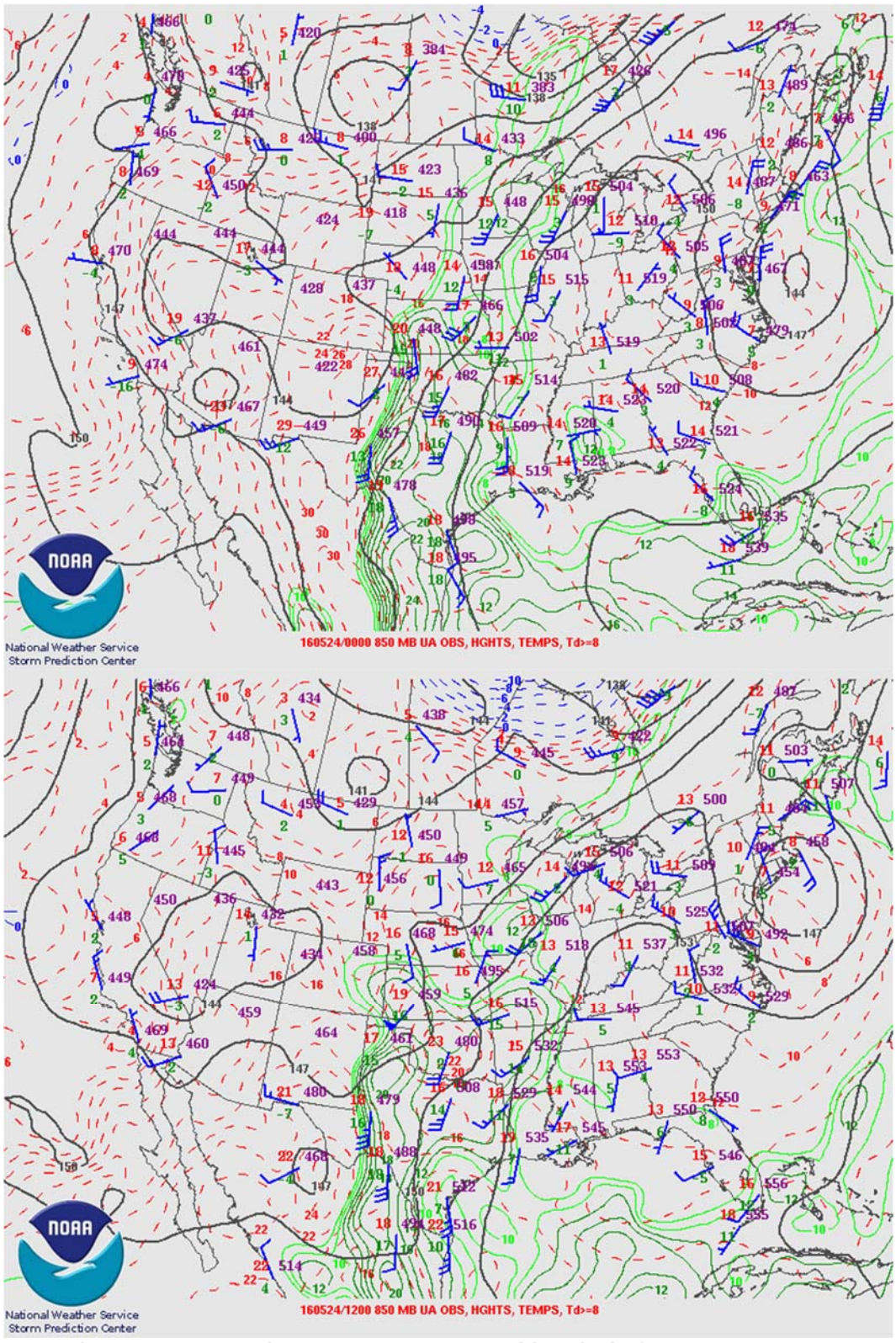

Figure 24. 850 mb Pressure Pattern with Winds for May 24, 2016 (00:00 top; 12:00 bottom)

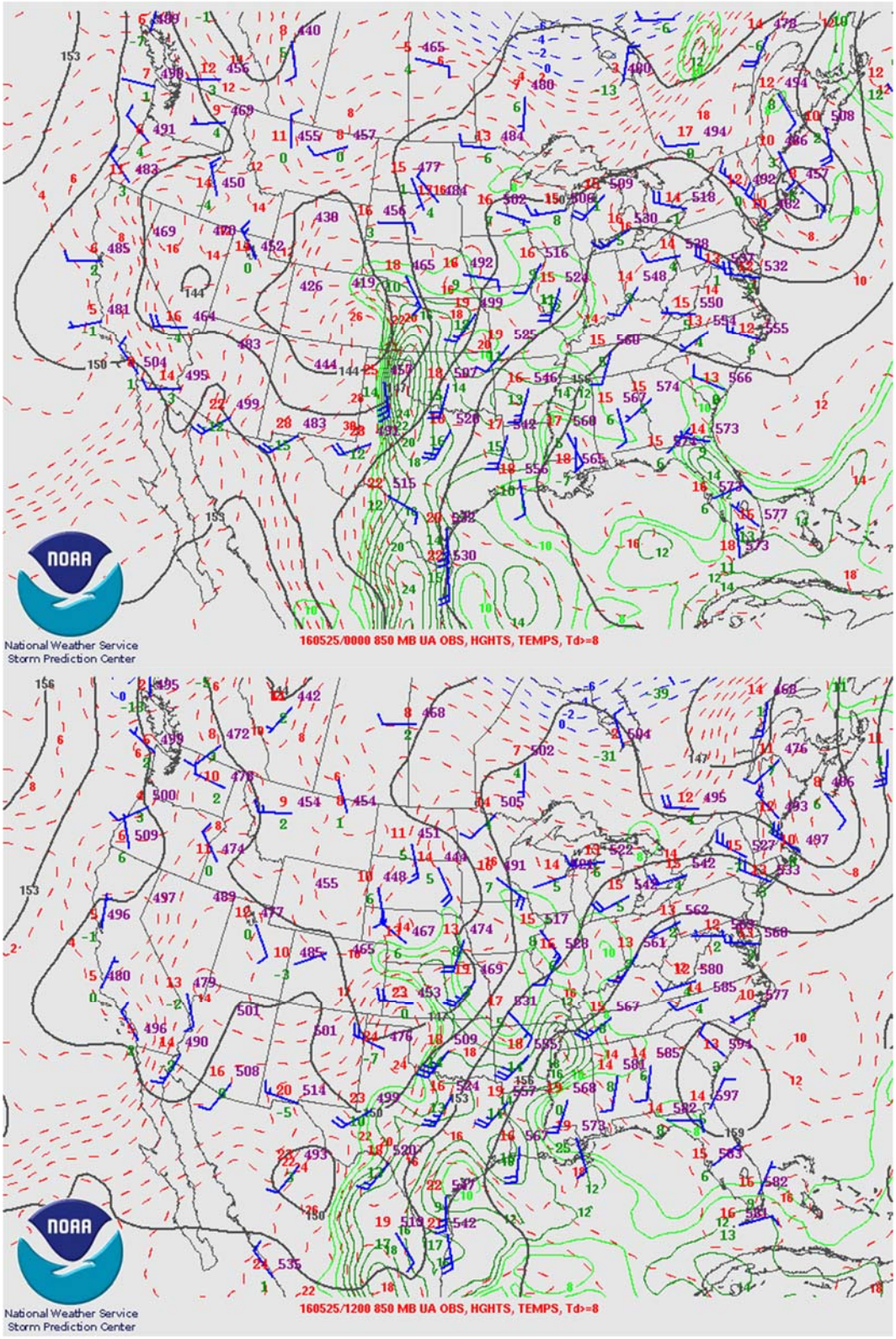

Figure 25. 850 mb Pressure Pattern with Winds for May 25, 2016 (00:00 top; 12:00 bottom)

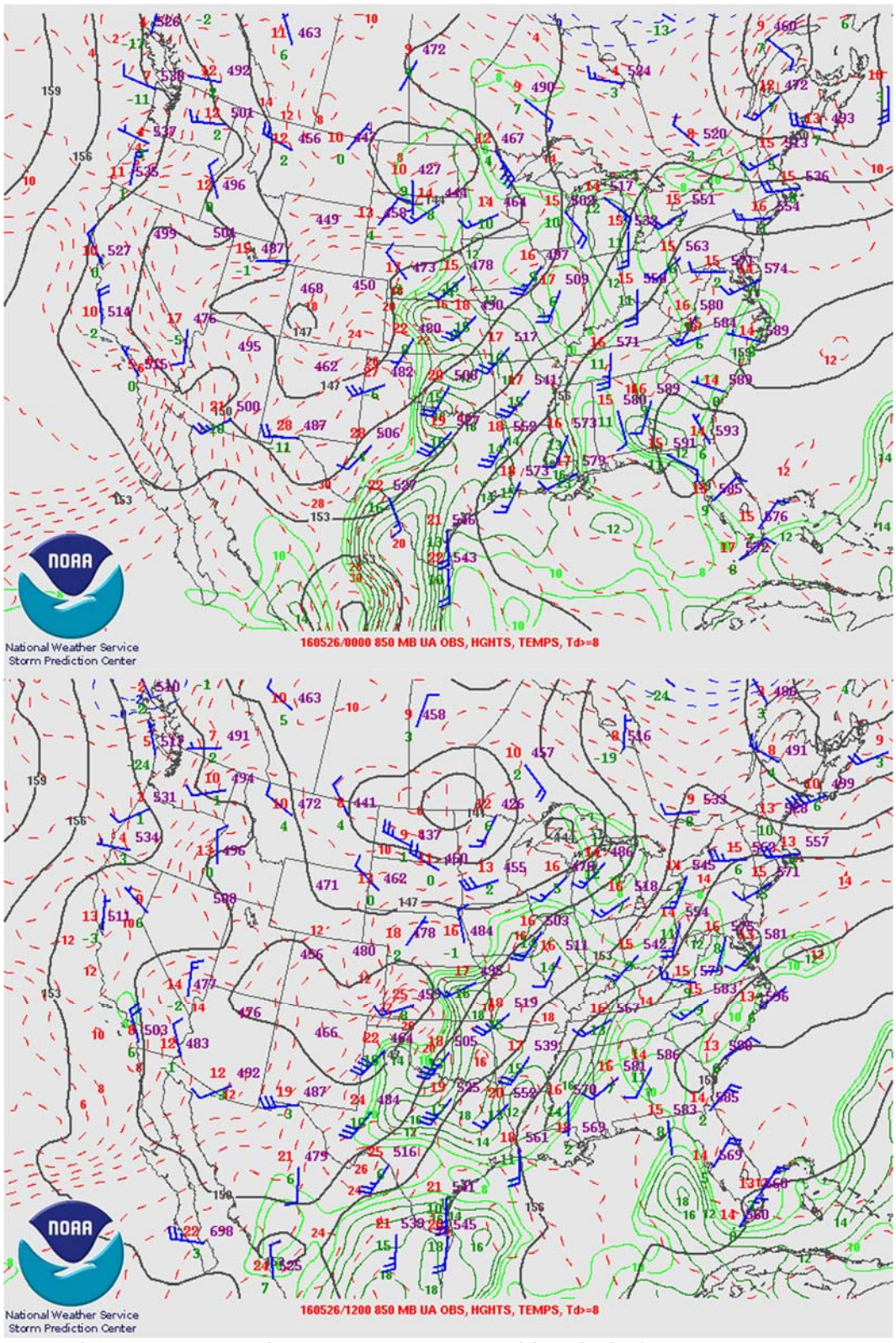

Figure 26. 850 mb Pressure Pattern with Winds for May 26, 2016 (00:00 top; 12:00 bottom)

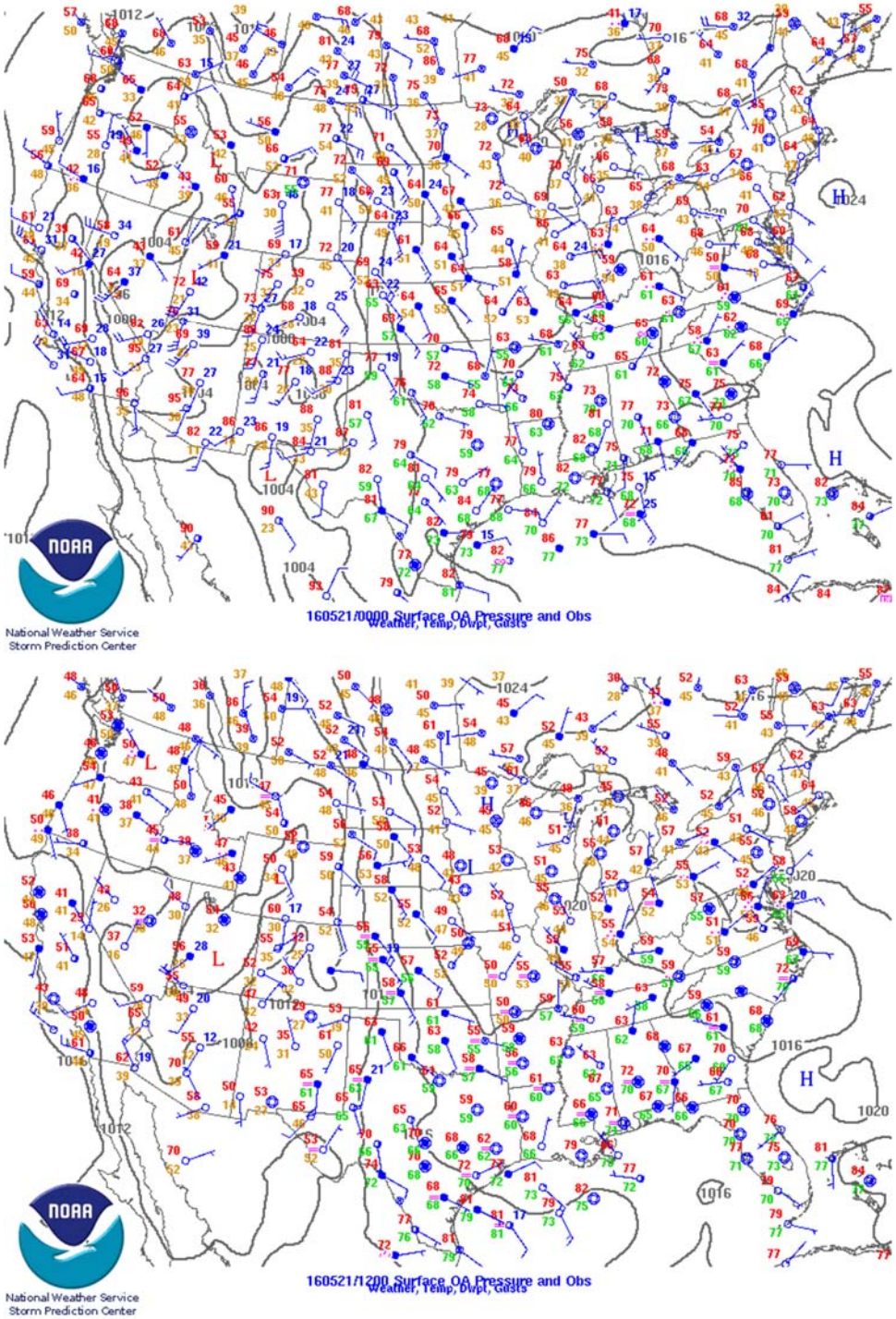

Figure 27. Surface Pressure Pattern with Winds for May 21, 2016 (00:00 top; 12:00 bottom)

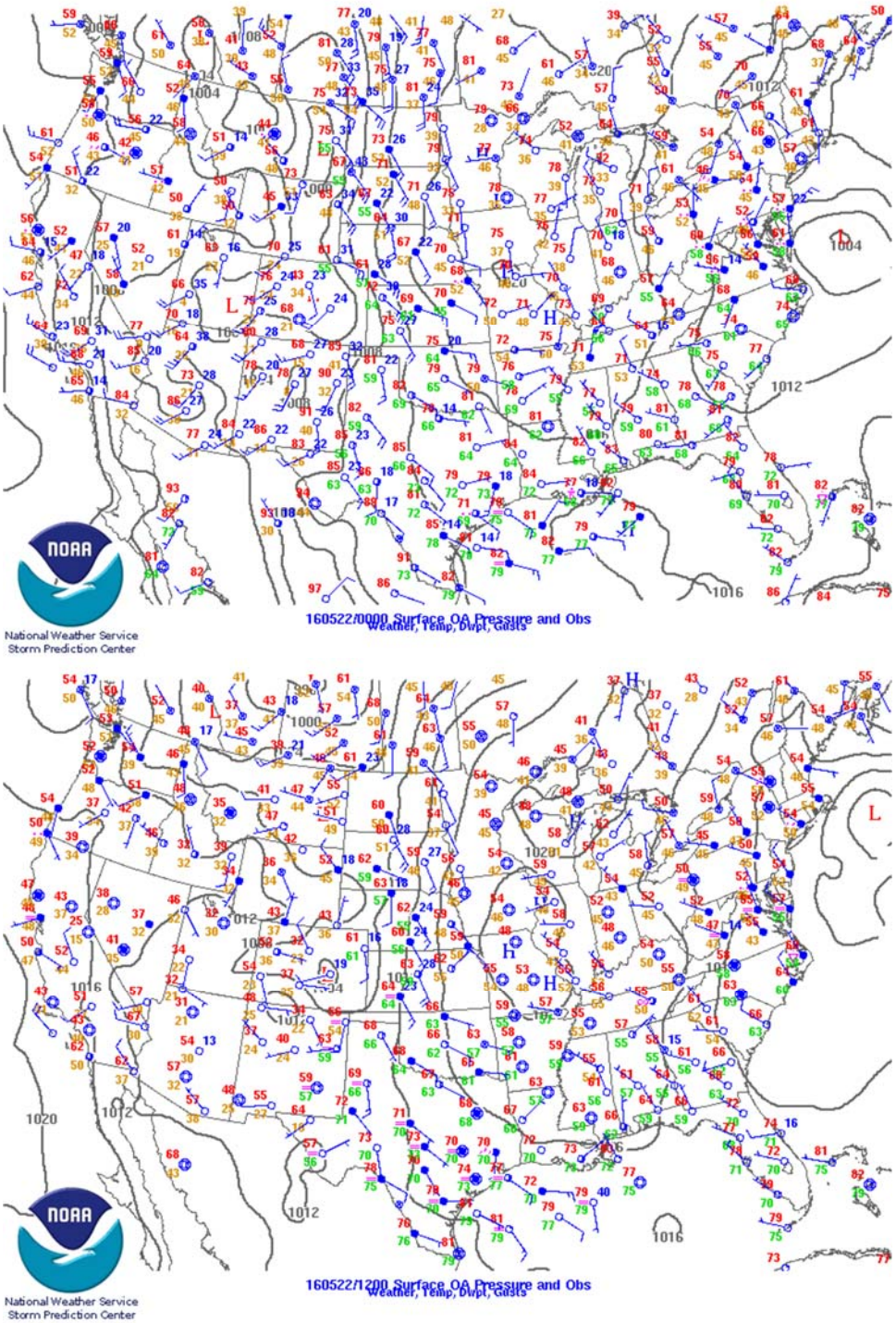

Figure 28. Surface Pressure Pattern with Winds for May 22, 2016 (00:00 top; 12:00 bottom)

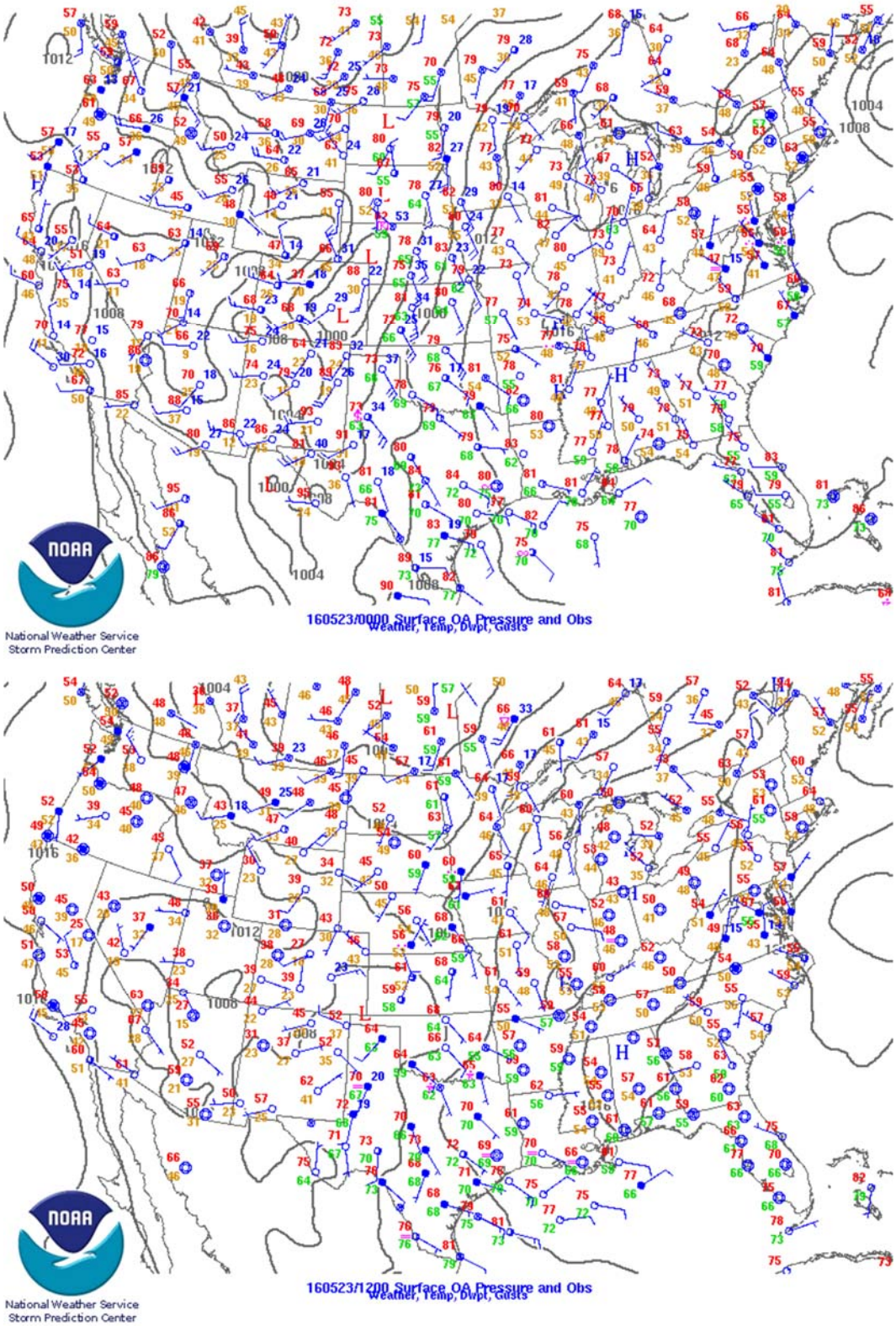

Figure 29. Surface Pressure Pattern with Winds for May 23, 2016 (00:00 top; 12:00 bottom)

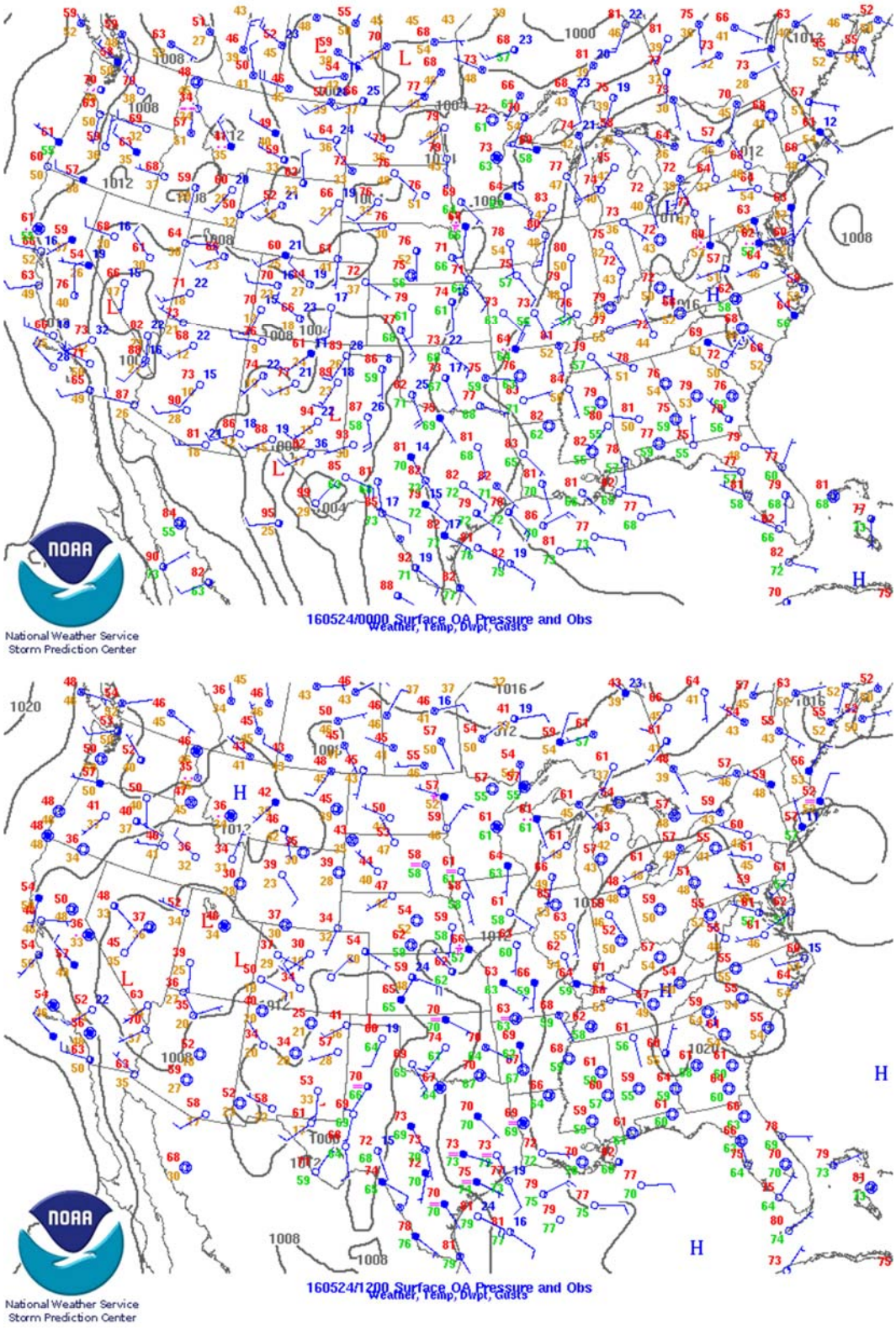

Figure 30. Surface Pressure Pattern with Winds for May 24, 2016 (00:00 top; 12:00 bottom)

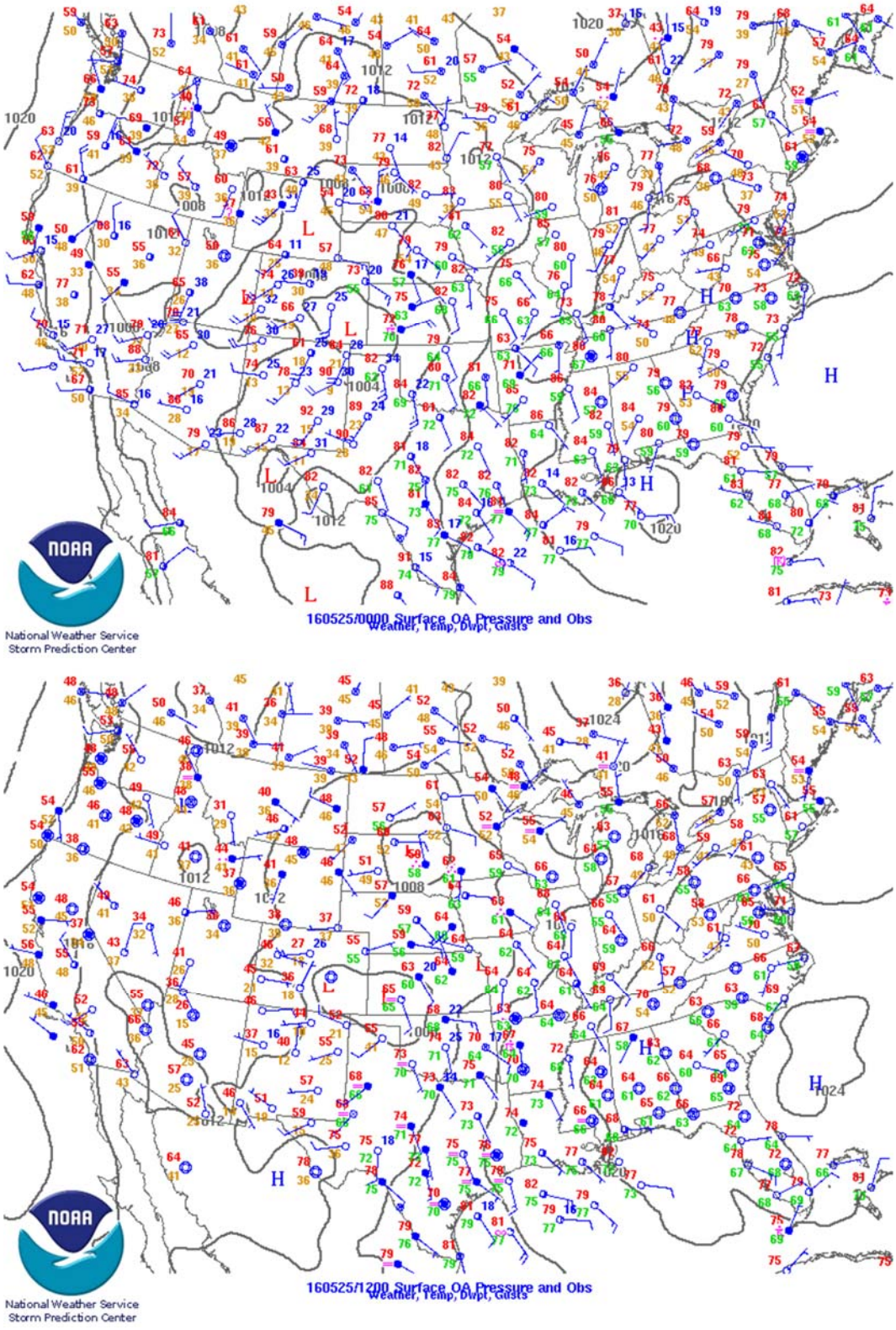

Figure 31. Surface Pressure Pattern with Winds for May 25, 2016 (00:00 top; 12:00 bottom)

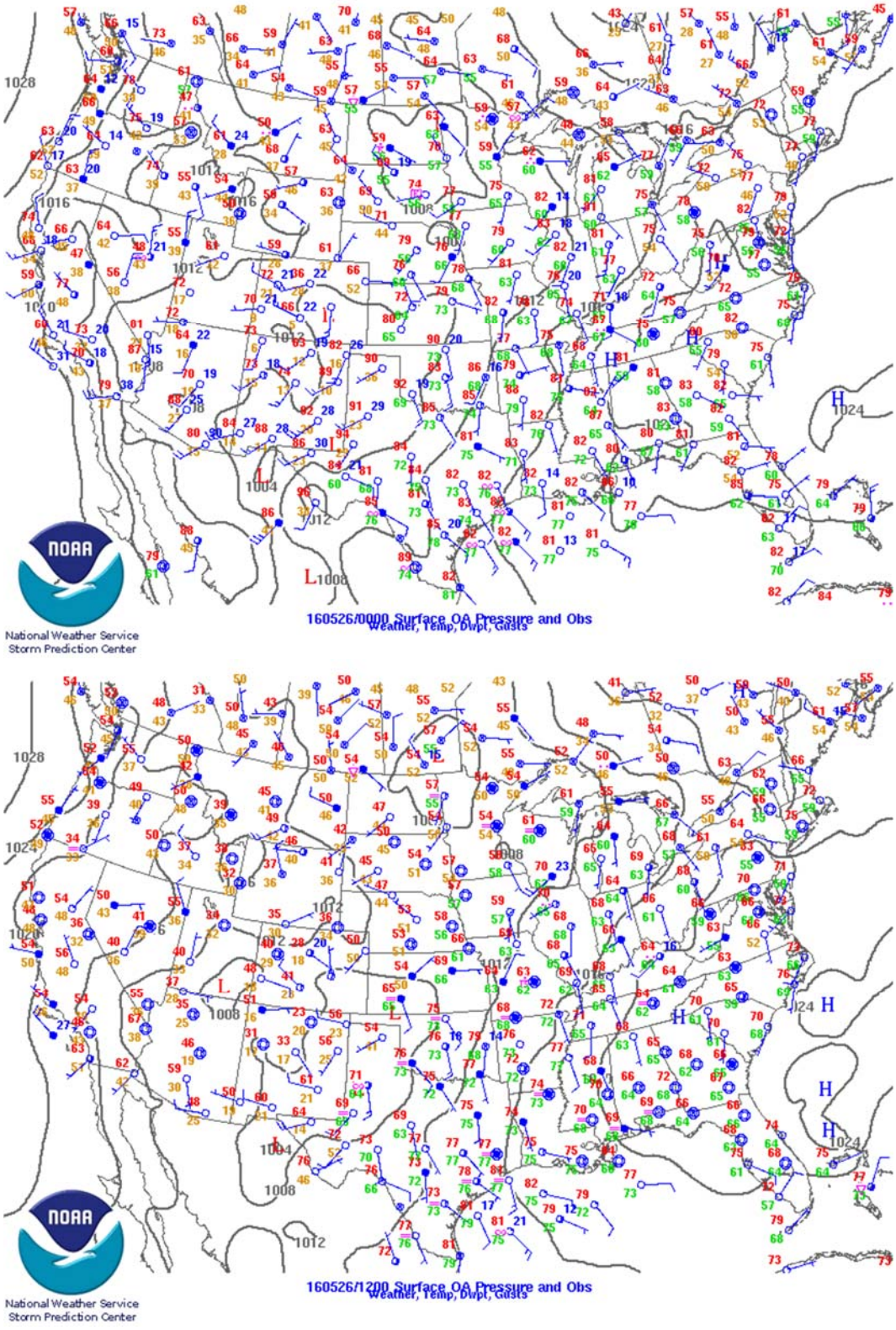

Figure 32. Surface Pressure Pattern with Winds for May 26, 2016 (00:00 top; 12:00 bottom)

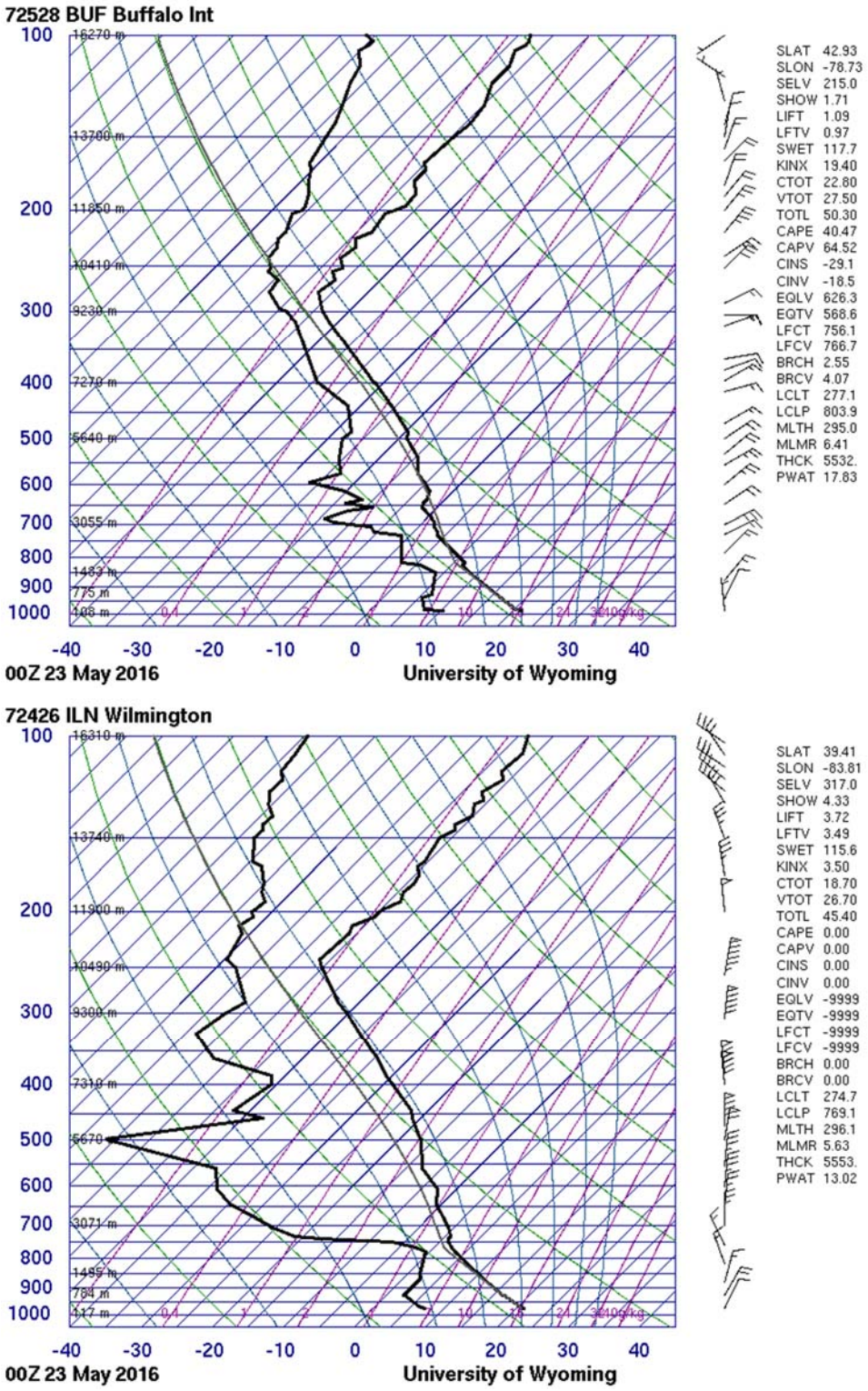

Figure 33. 00Z Soundings for May 23, 2016 (KBUF top; KILN bottom)

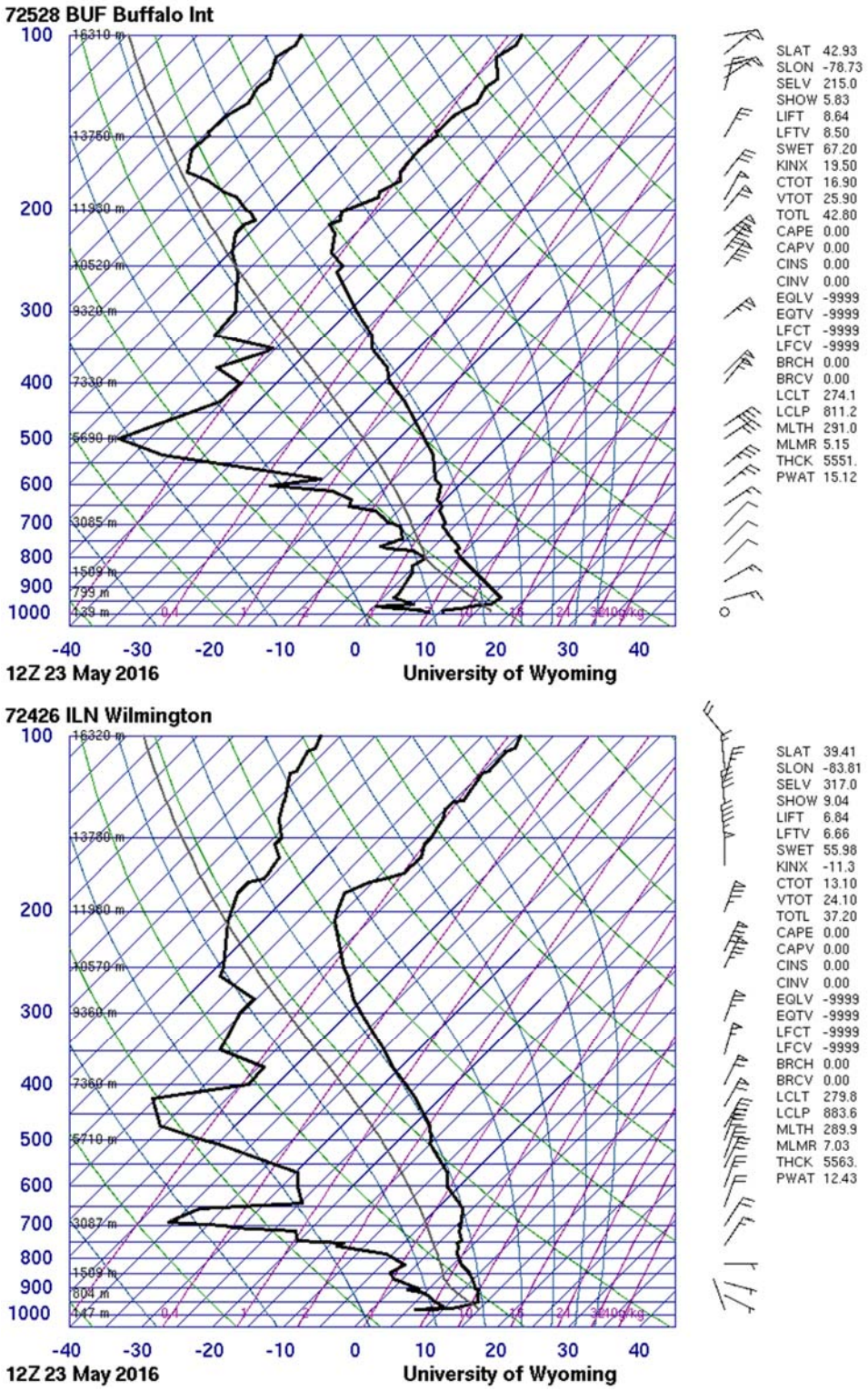

Figure 34. 12Z Soundings for May 23, 2016 (KBUF top; KILN bottom)

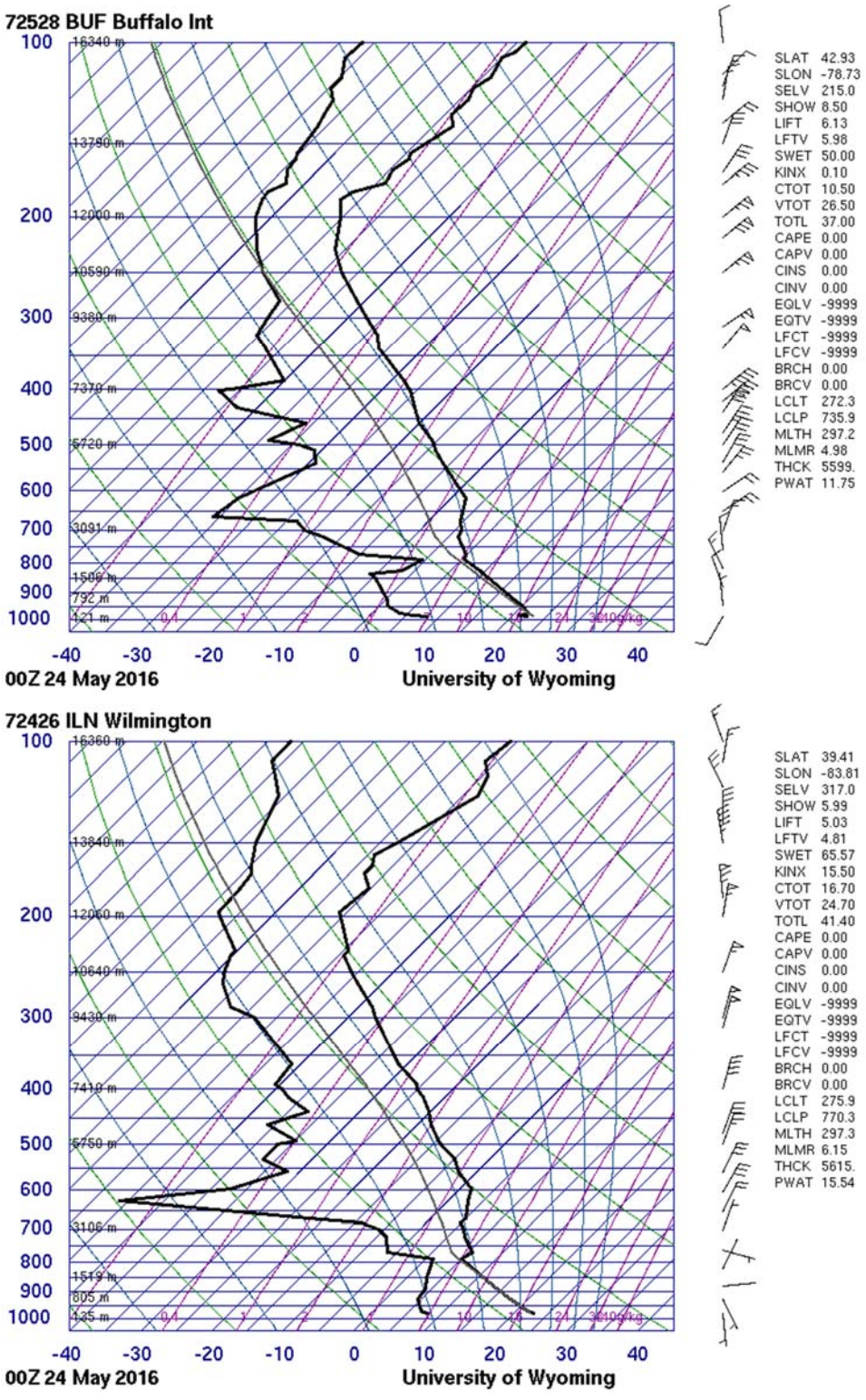

Figure 35. 00Z Soundings for May 24, 2016 (KBUF top; KILN bottom)

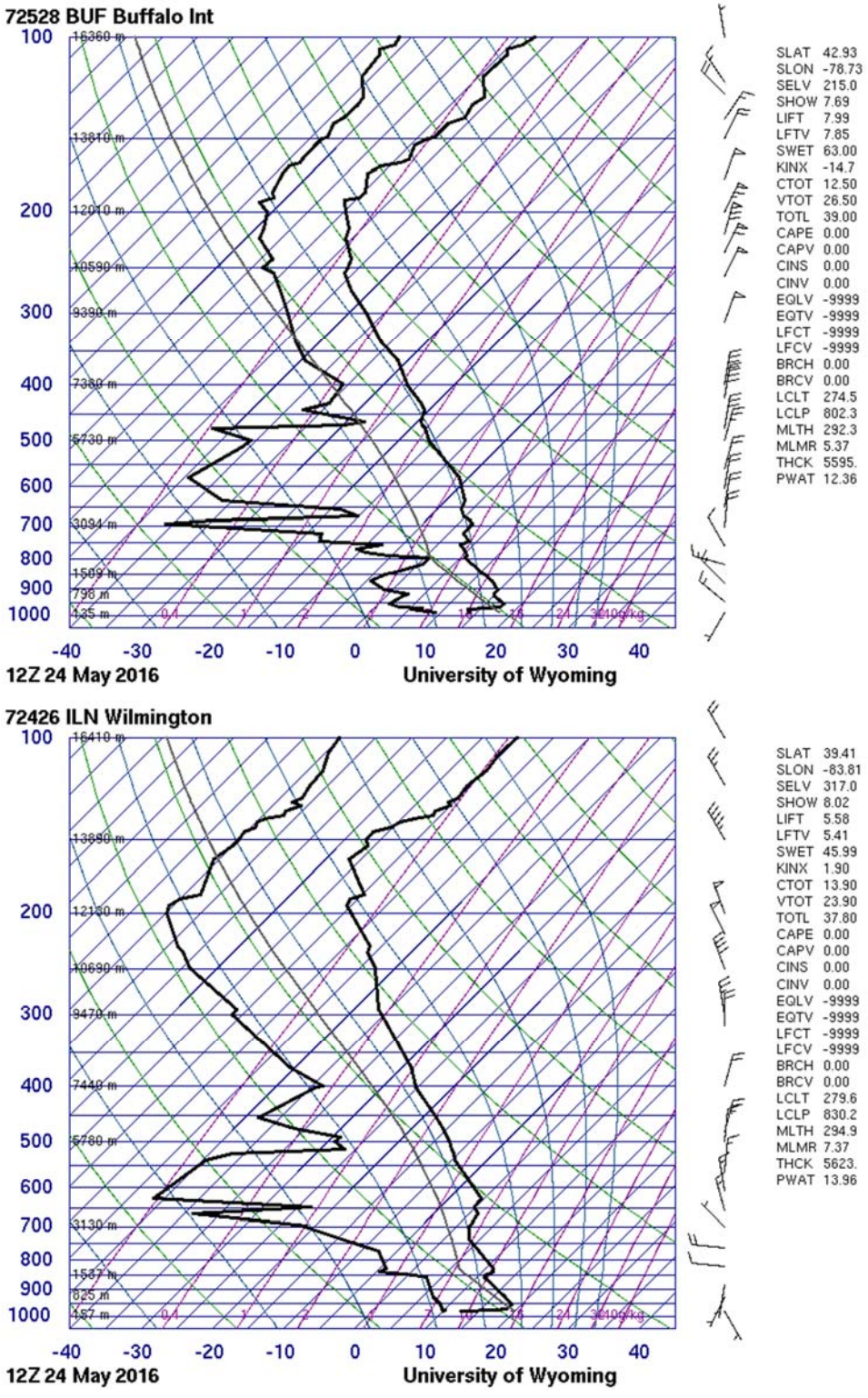

Figure 36. 12Z Soundings for May 24, 2016 (KBUF top; KILN bottom)

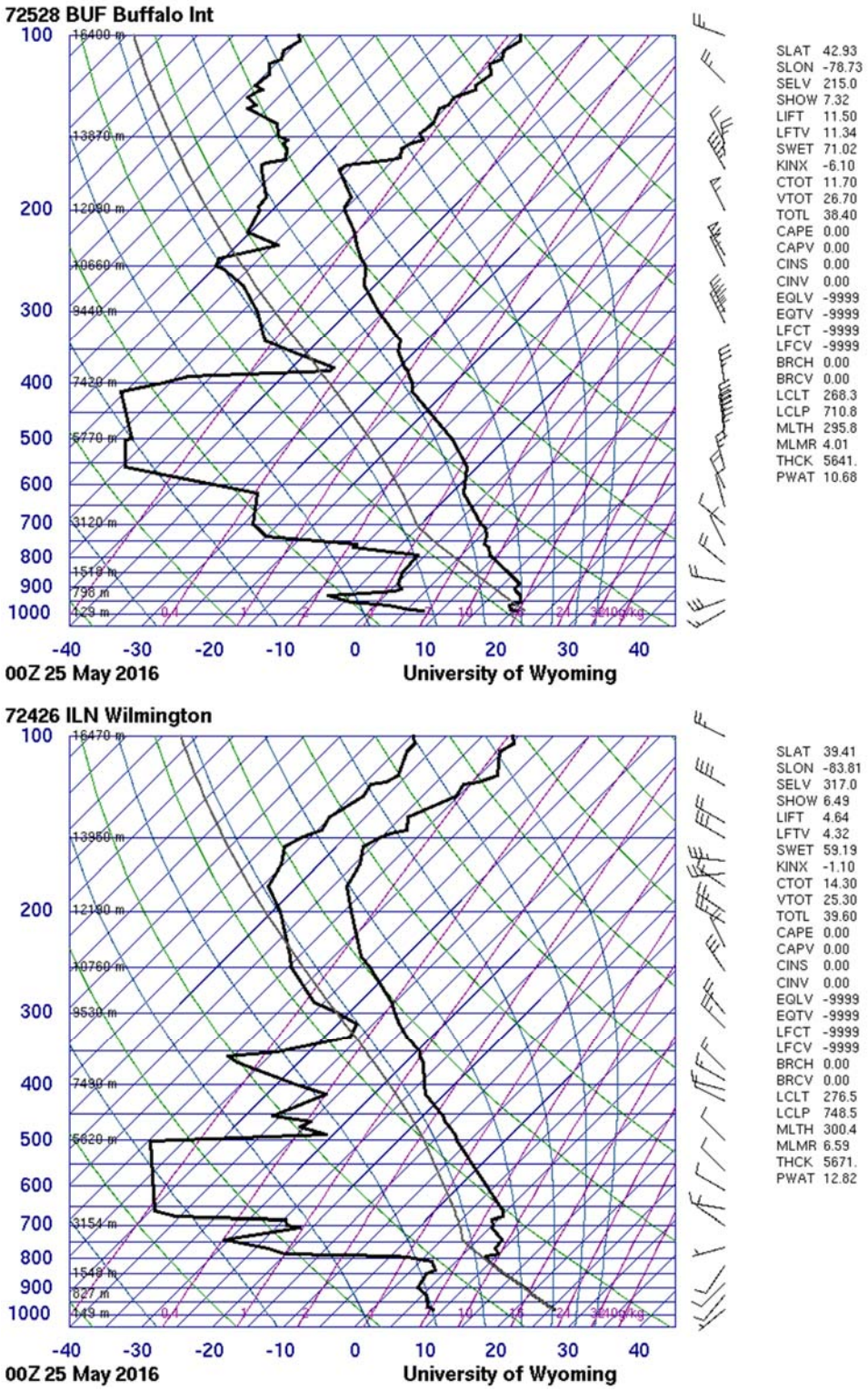

Figure 37. 00Z Soundings for May 25, 2016 (KBUF top; KILN bottom)

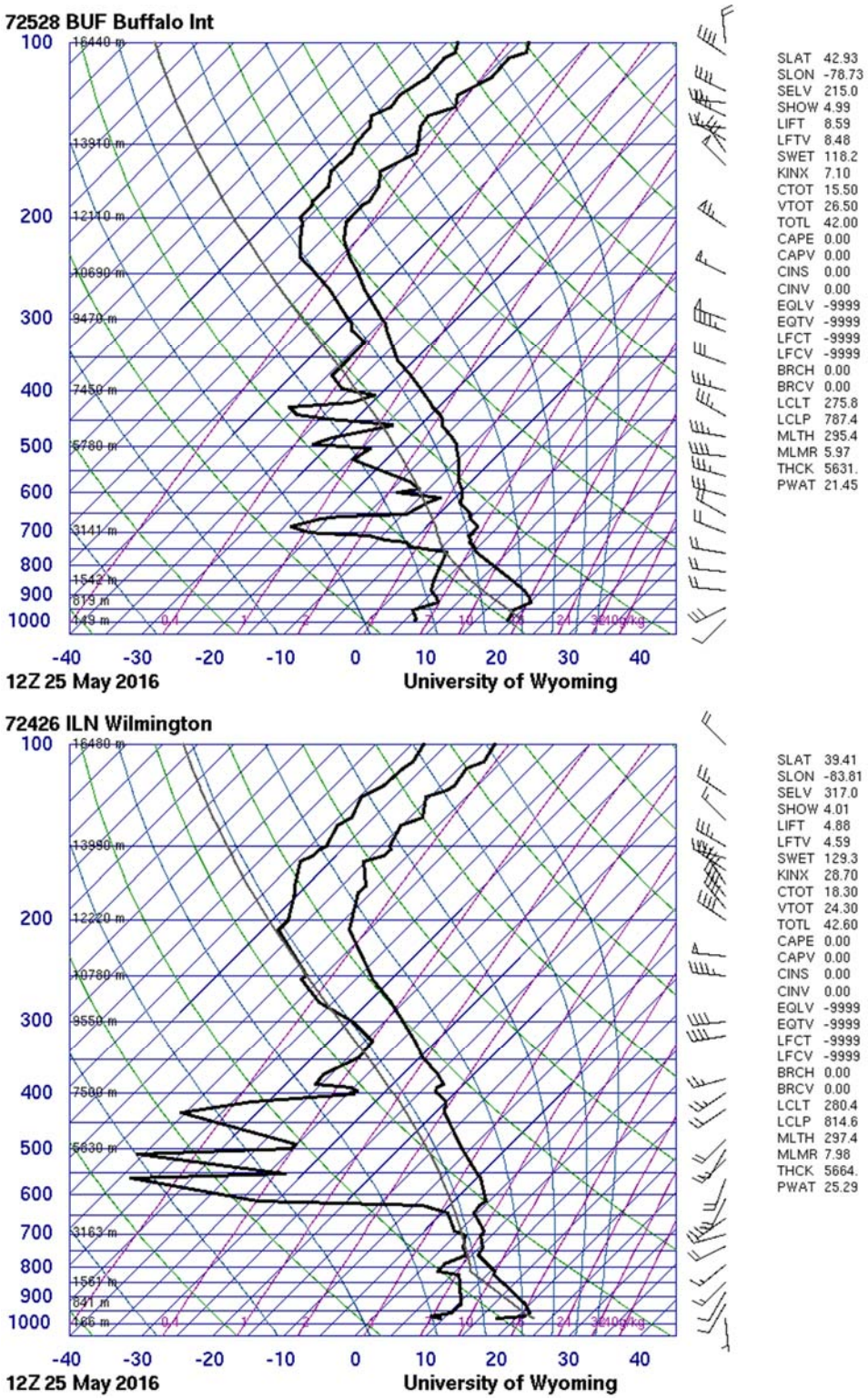

Figure 38. 12Z Soundings for May 25, 2016 (KBUF top; KILN bottom)

Table 4. Average Meteorological Conditions on Ozone Exceedance Days (2012-2016)

Variable	Cleveland (KCLE)			Cincinnati (KCVG)	
	Exceedance Day Averages	5/24/16	5/25/16	Exceedance Day Averages	5/24/16
Maximum Temperature (F)	87	82	86	88	80
Average Temperature (F)	76	68	74	75	67
Dew Point Temperature (F)	58	47	52	57	50
Sea Level Pressure (hPa)	1017.61	1018.08	1019.51	1017.06	1018.43
Surface Wind Direction (deg)	215.89	247.47	214.61	164.01	201.79
Surface Wind Speed (m/s)	3.17	2.89	3.92	2.19	1.83
Sky Coverage Code	3.13	0.00	4.50	2.49	2.73
Relative Humidity	56.42	50.92	46.32	55.54	60.54
Ozone (ppb)	75.79	77.00	76.00	75.40	76.00

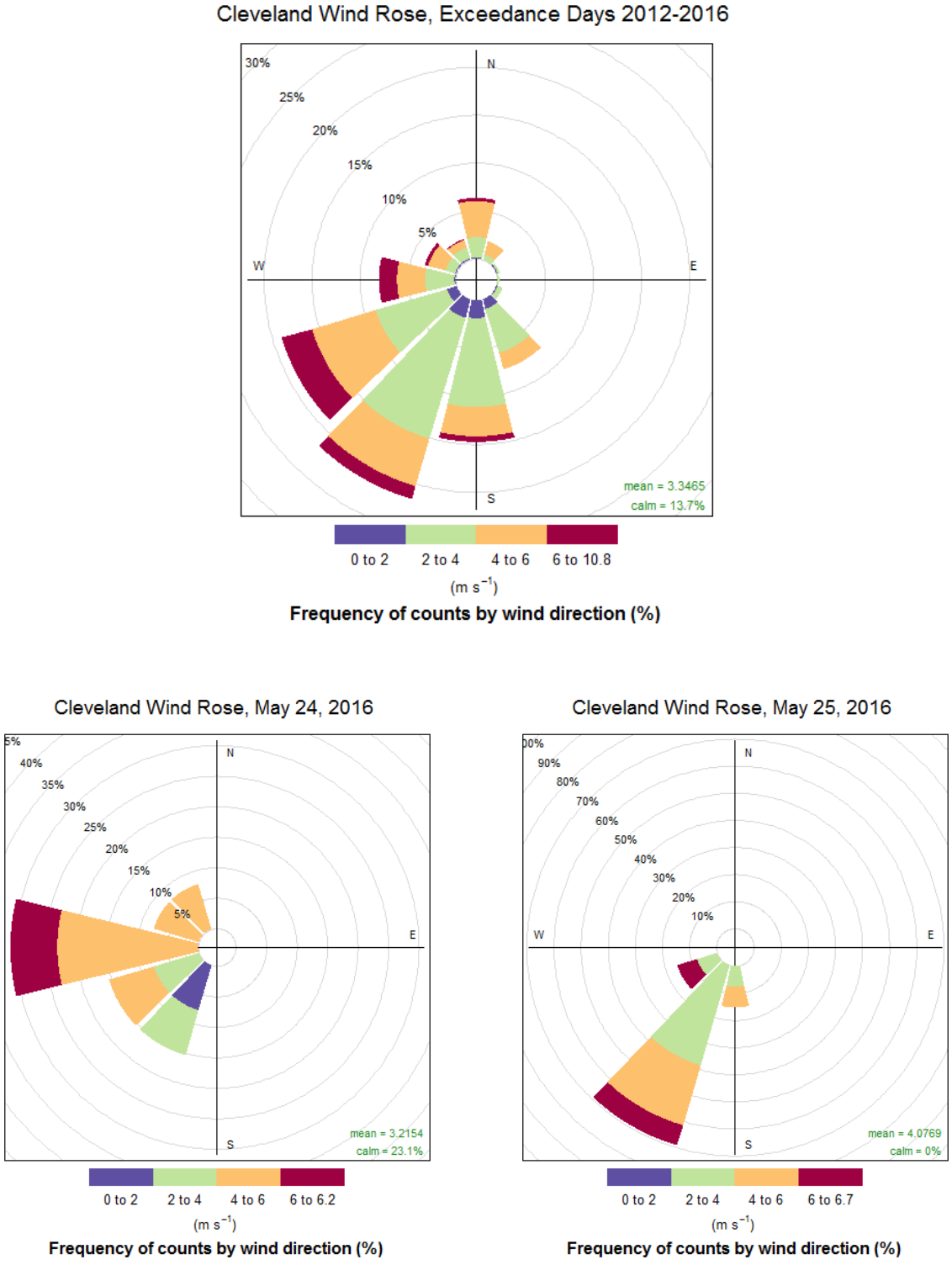

Figure 39. Cleveland Wind Roses

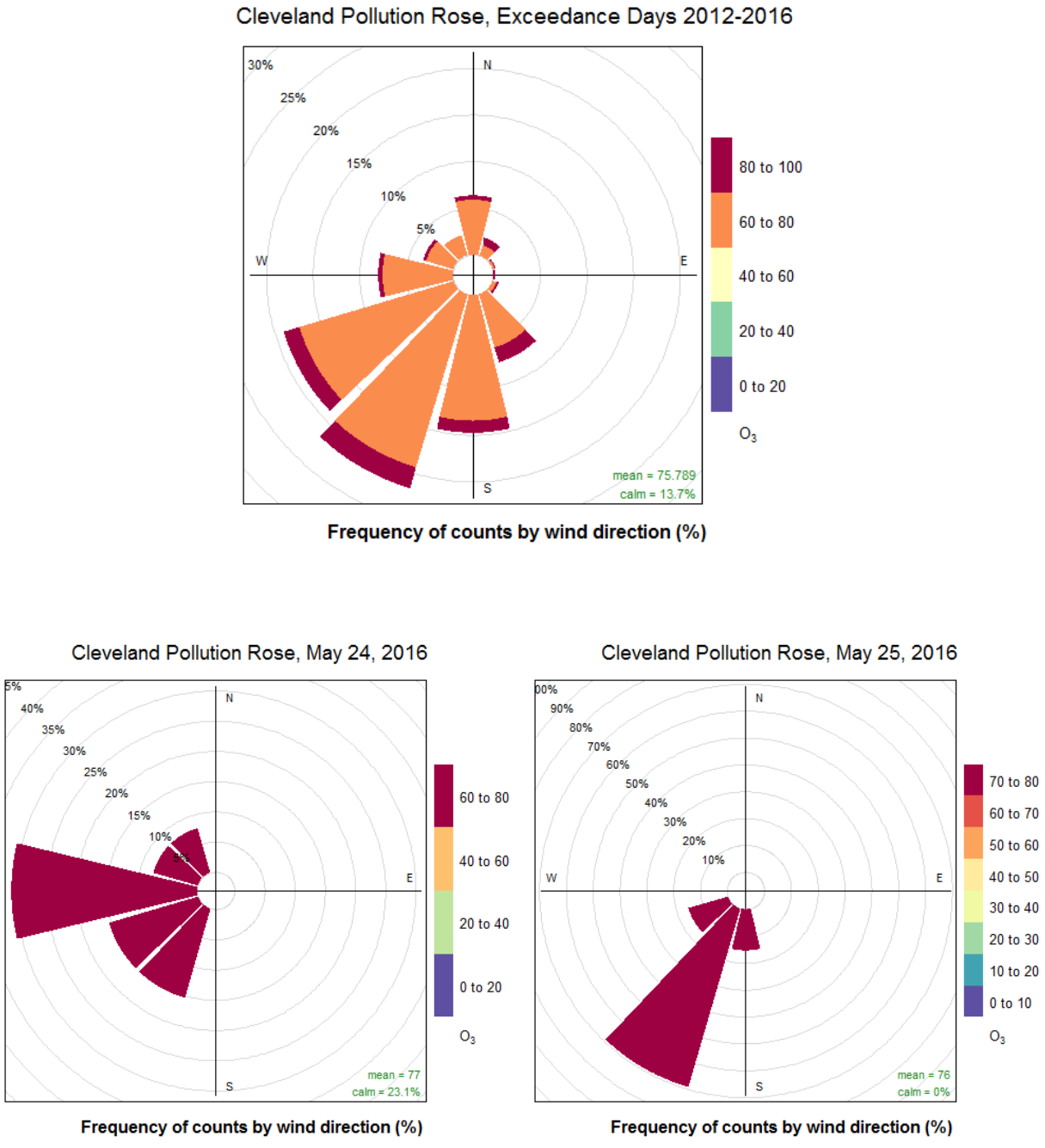

Figure 40. Cleveland Pollution Roses

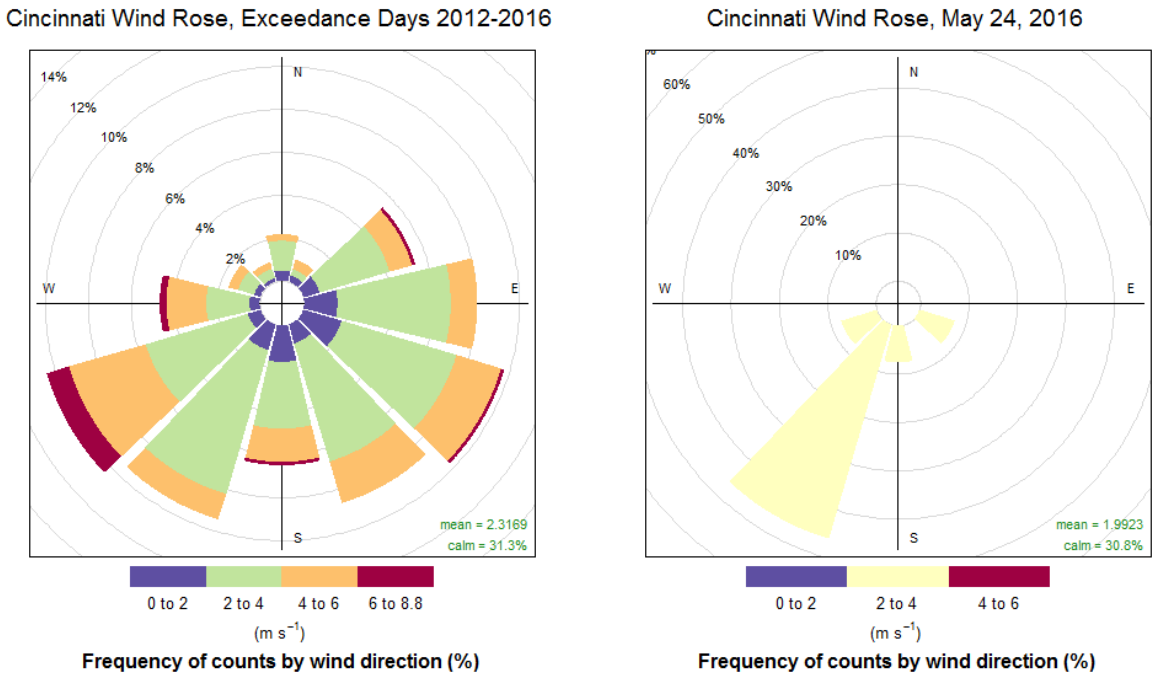

Figure 41. Cincinnati Wind Roses

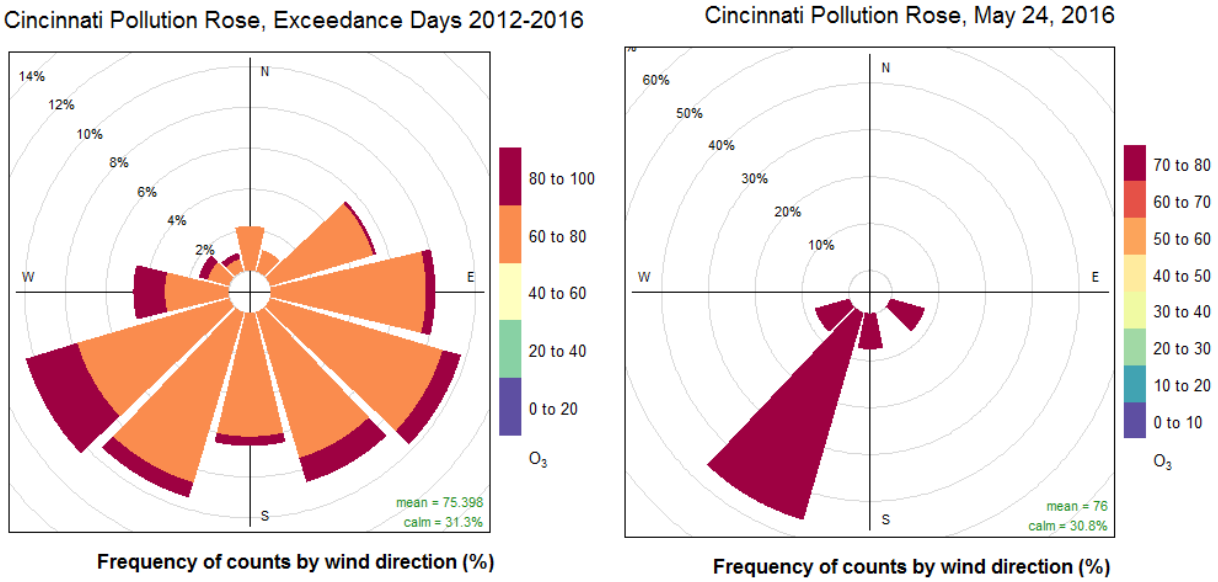

Figure 42. Cincinnati Pollution Roses

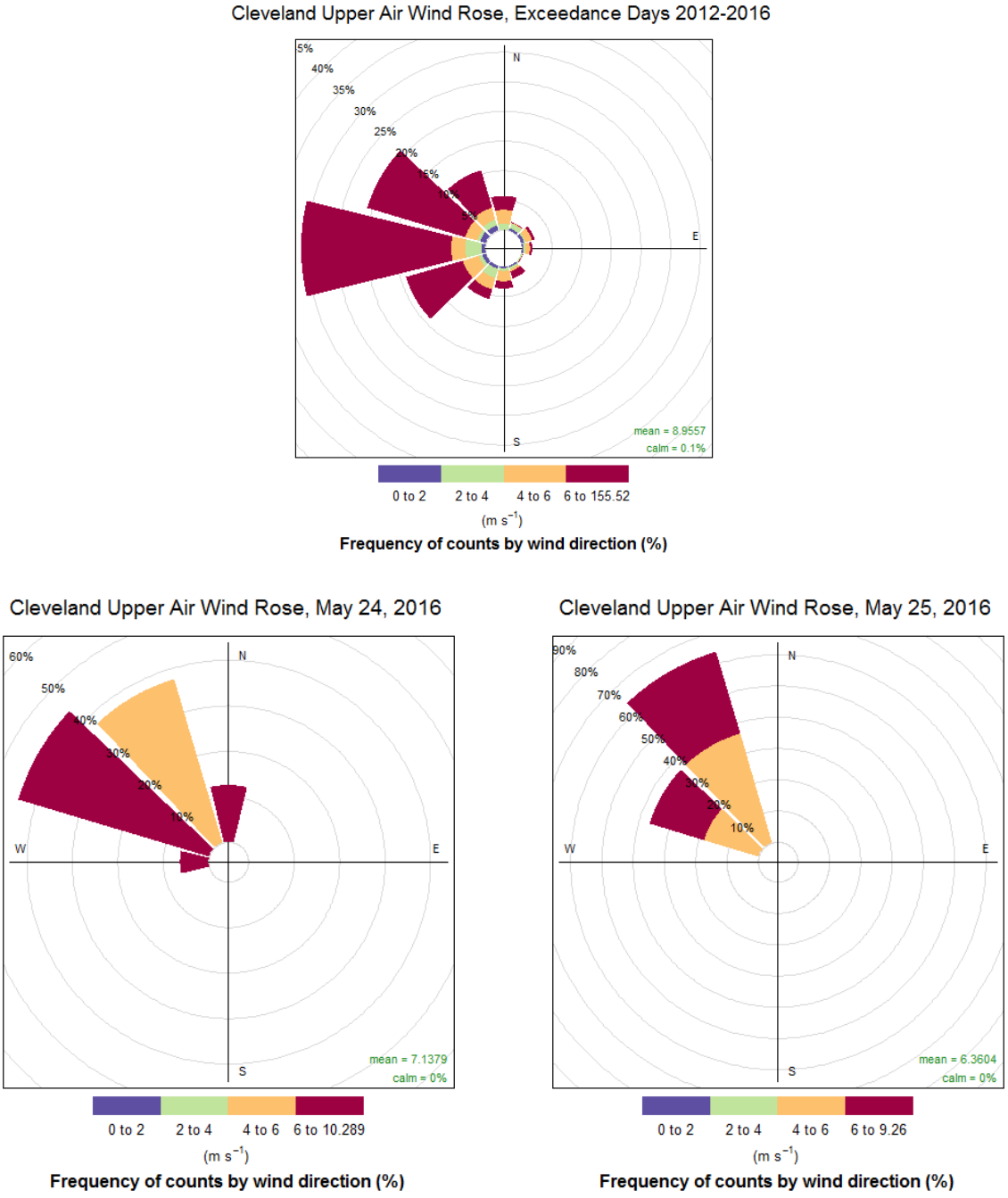

Figure 43. Cleveland Upper Air (700-850 mb) Wind Roses

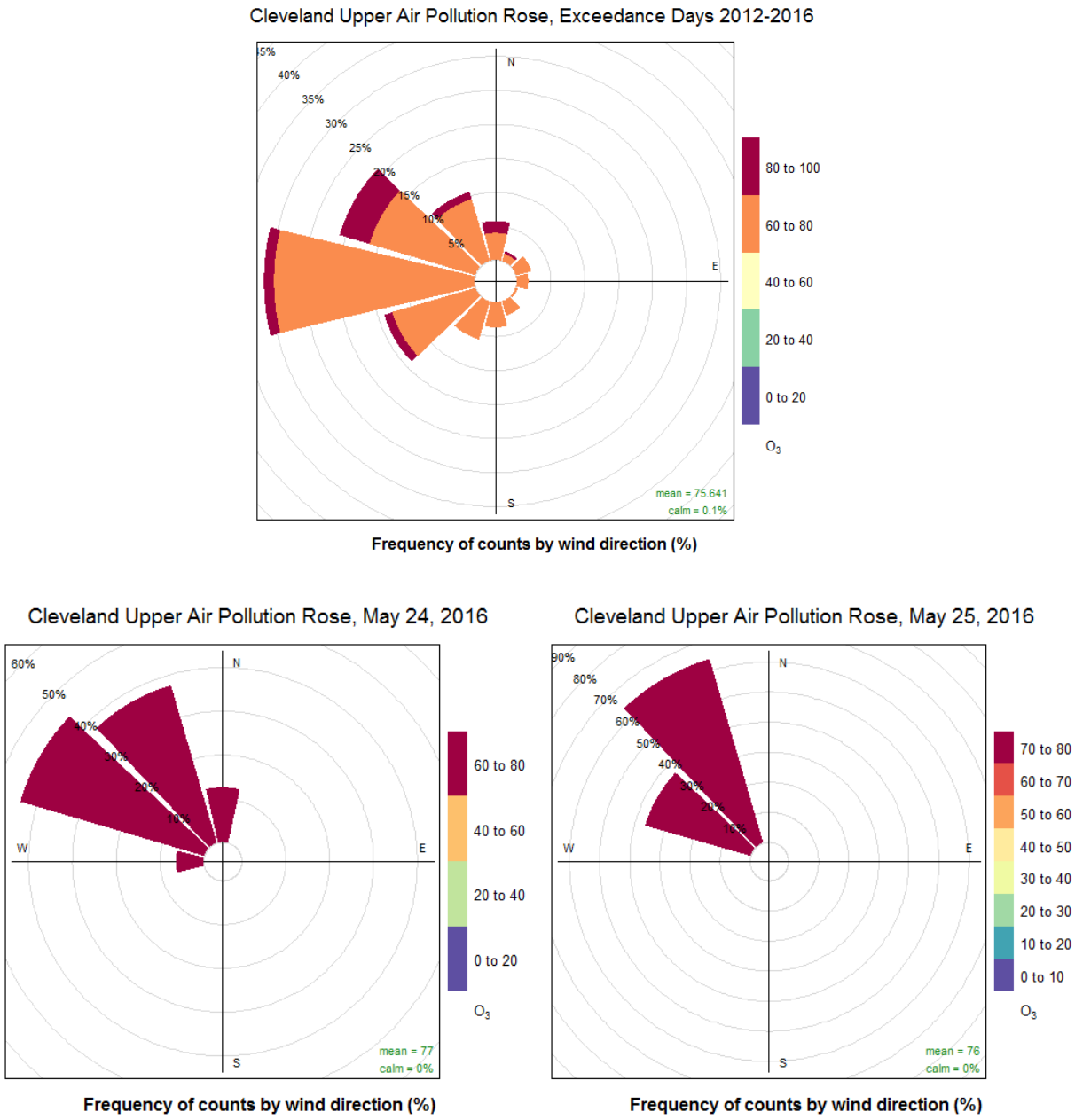

Figure 44. Cleveland Upper Air (700-850 mb) Pollution Roses

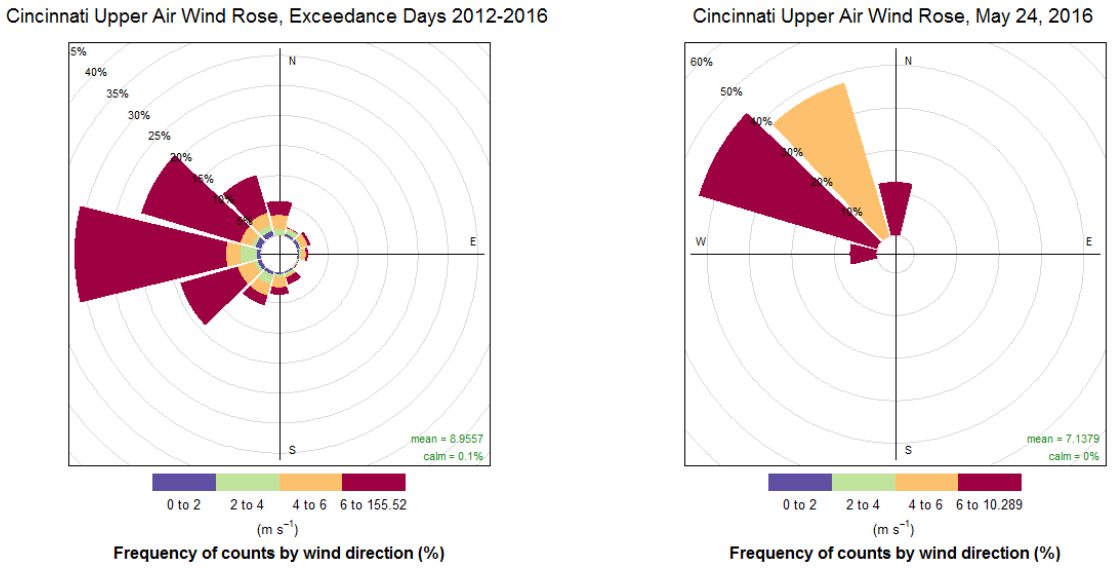

Figure 45. Cincinnati Upper Air (700-850 mb) Wind Roses

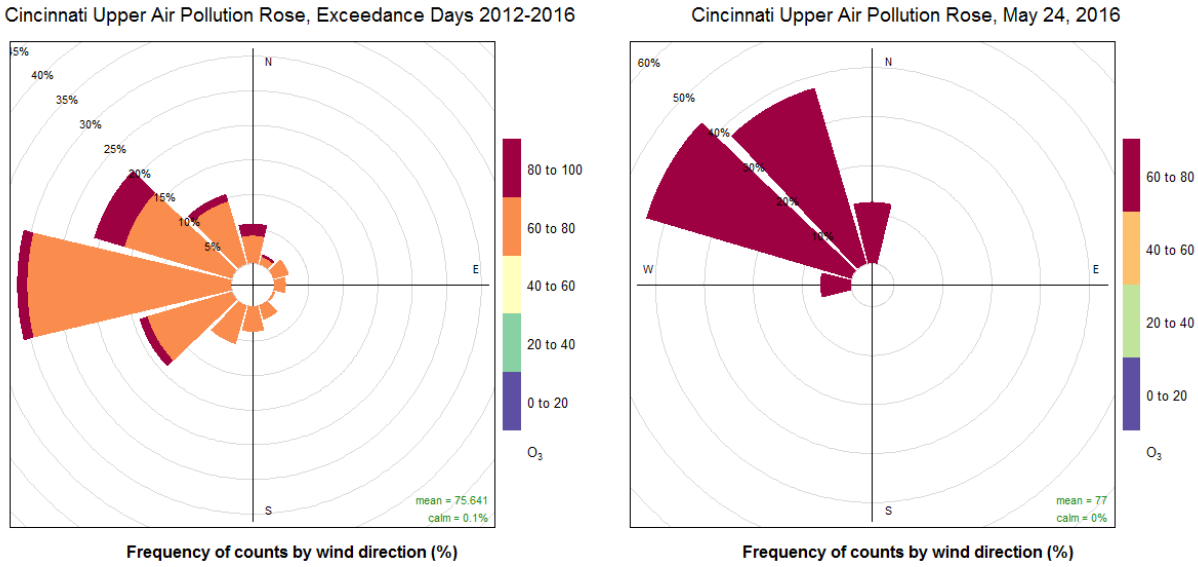

Figure 46. Cincinnati Upper Air (700-850 mb) Pollution Roses

C. Clear Causal Relationship and Supporting Analyses

U.S. EPA's Exceptional Event Guidance outlines a three-tiered approach for the clear causal relationship analysis, along with examples of supporting documentation for each tier.

A Tier 1 demonstration requires the least amount of evidence, and is appropriate for wildfires that clearly influenced monitored concentrations, either during a time of year that typically has no exceedances or is clearly distinguishable from non-event concentrations. The May 24-25, 2016 event occurred during Ohio's typical ozone season and, though concentrations were higher than normal for that time of year, they were not unprecedented. Therefore, a Tier 1 demonstration is not appropriate in this case.

A Tier 2 analysis is necessary when the wildfire impacts are less clear, and includes a comparison of the fire emissions to the fire's distance to the monitor (Q/d analysis). Ohio EPA has adapted the Q/d analysis performed by the CT DEEP as part of their Exceptional Event demonstration for the Fort McMurray Wildfire (Appendix B). Using CT DEEP's estimated value of 2,293 tons per day (tpd) for daily fire emissions (Q) and a distance (d) of 2,718 km to the Cleveland monitors and 2,764 km to the Cincinnati monitors, Q/d is 0.84 tpd/km for the Cleveland monitors and 0.83 tpd/km for the Cincinnati monitors. These values are well below the U.S. EPA recommended level of 100 tpd/km indicating a clear causal relationship. Using CT DEEP's less conservative estimates of Q for the maximum extent of the burn area over the life of the fire, the result would be 49.3 tpd/km for the Cleveland monitors and 48.5 tpd/km for the Cincinnati monitors. As the Q/d analysis for this area does not satisfy the criteria for clear causality under a Tier 2 demonstration, Ohio EPA has provided additional evidence below for a Tier 3 analysis to establish a clear causal relationship.

Comparison of Fire-Influenced Exceedances with Historical Concentrations

U.S. EPA's Exceptional Events Guidance indicates a clear-causal demonstration should include a comparison of the event-related exceedance with historical concentrations measures at each monitor requested for data exclusion. Examples of supporting documentation include time-series plots overlaying 5 years of data, and 5-year percentiles. The Exceptional Events Guidance indicates that if the flagged data is above the 99th or higher percentile of the 5-year distribution of ozone monitoring data, or is one of the four highest ozone concentrations within 1 year, these data can be considered outliers and provide strong evidence for the event.

Figures 47 through 52 show time-series plots of ozone concentrations at the Cleveland and Cincinnati monitors for the ozone season overlaying ozone monitoring data from 2012 through April 2017. Figure 53 also shows a time-series plot of ozone concentrations at one of the Cincinnati monitors; however, as this monitor operates year-round, this figure overlays all annual data from 2012 through March 2017.

Figures 54 through 59 show distribution plots of ozone season concentrations at the Cleveland and Cincinnati monitors for 2012 through 2016. Figure 60 shows a distribution of annual ozone season concentrations at the year-round Cincinnati monitor for 2012 through 2016. Table 5 shows the maximum 8-hour daily ozone and $PM_{2.5}$ levels observed at the monitors on May 24, 2016 and May 25, 2016 compared with the 99^{th} percentile ranked 8-hour ozone and $PM_{2.5}$ levels observed during the last five years.

As shown in these figures and table, the May 24 and 25, 2016 ozone data is among the higher concentrations, but does not appear to be unprecedented. Among the 11 dates for which ozone data exclusion is requested (as specified in Table 1), all were above the 97^{th} percentile and 5 of the 11 dates were above the 99^{th} percentile. All were among the four highest ozone concentrations in 2016, thereby meeting the criteria for considering these data outliers. Of particular interest is the Notre Dame monitor (39-055-0004) in Geauga County, where May 24 and 25, 2016 were the two highest ozone concentrations in 2016, and May 24, 2016 was one of the four highest ozone concentrations since 2012. As noted previously, exclusion of this data may influence boundary recommendations under the 2015 ozone standard.

When viewed in the context of the declining concentrations over the 5-year period as shown in the time-series plots in Figures 61 through 67, it becomes clear that May 24 and 25, 2016 were unusually high given recent trends. As shown previously, May 2016 had lower NOx emissions than any other year since at least 2012. Therefore, higher ozone concentrations on May 24 and 25, 2016 represented substantially more ozone generated from available NOx than in 2012, when emissions were substantially higher. This is exceptionally evident in the Cincinnati area, where the May 24, 2016 values were the highest recorded since 2012 at the Midd monitor (39-017-0018), and since 2013 at the Oxford monitor (39-017-9991). Between 2012 and 2016, only eight days were higher at the Midd monitor, all of which occurred in 2012. Only 13 days were higher at the Oxford monitor, all but one of which were in 2012 (the other in 2013).

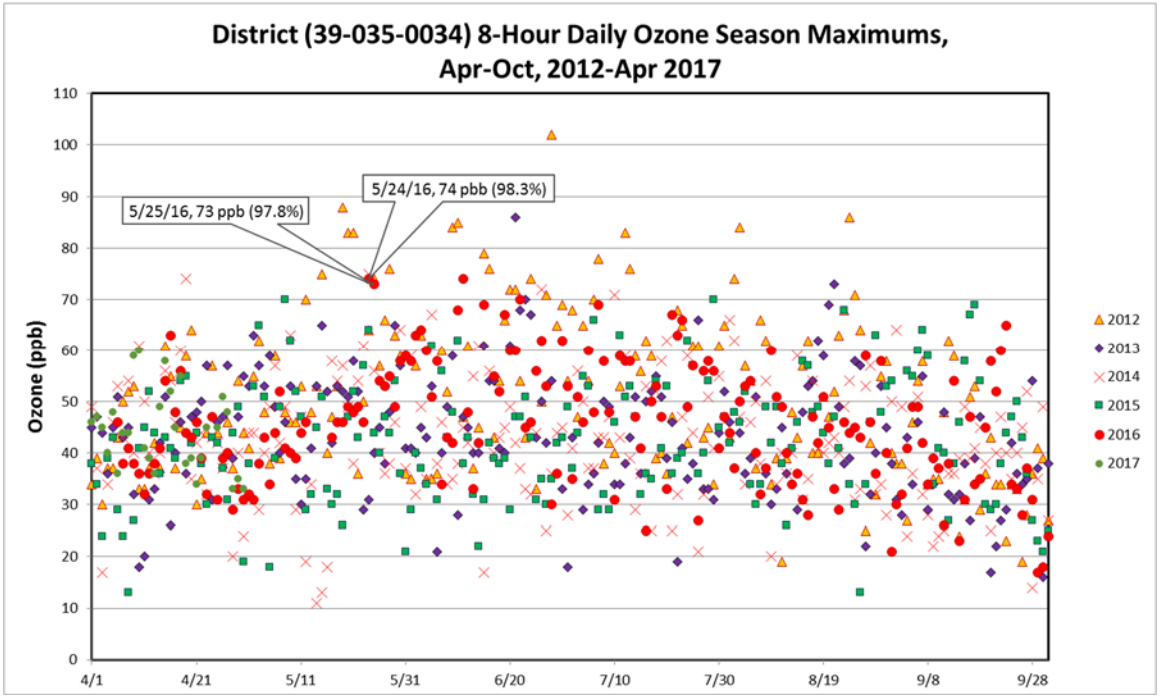

Figure 47. District (39-035-0034) Daily Ozone Season Maximums 2012-Apr 2017

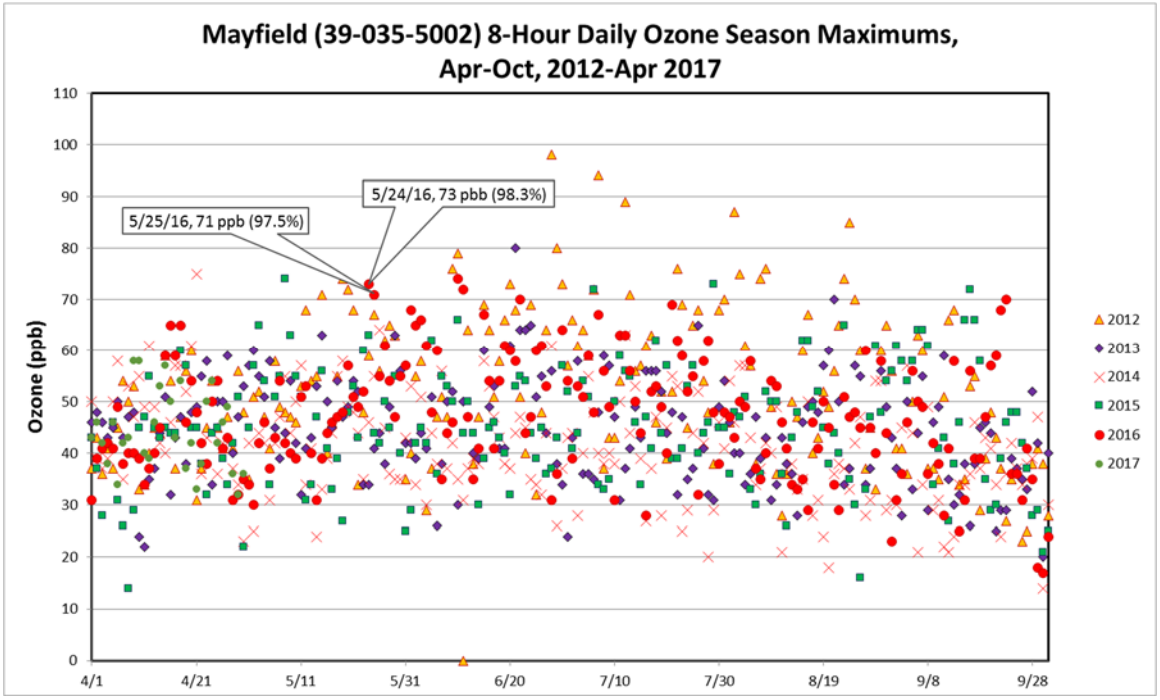

Figure 48. Mayfield (39-035-5002) Daily Ozone Season Maximums 2012-Apr 2017

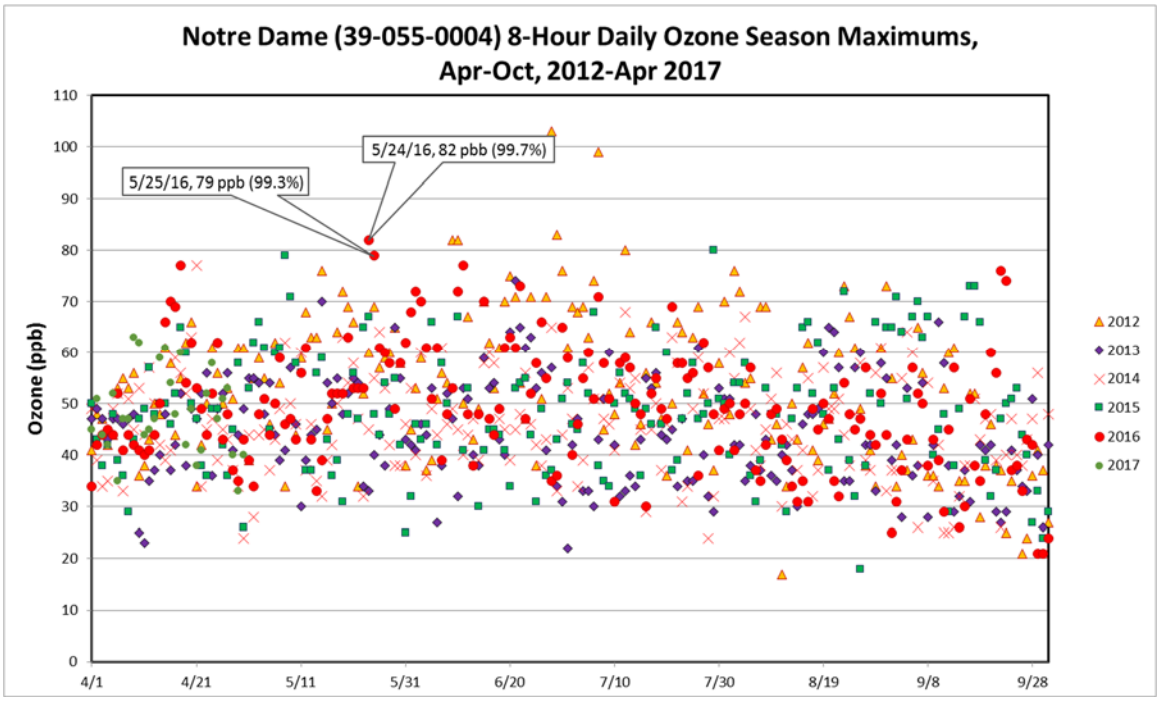

Figure 49. Notre Dame (39-055-0004) Daily Ozone Season Maximums 2012-Apr 2017

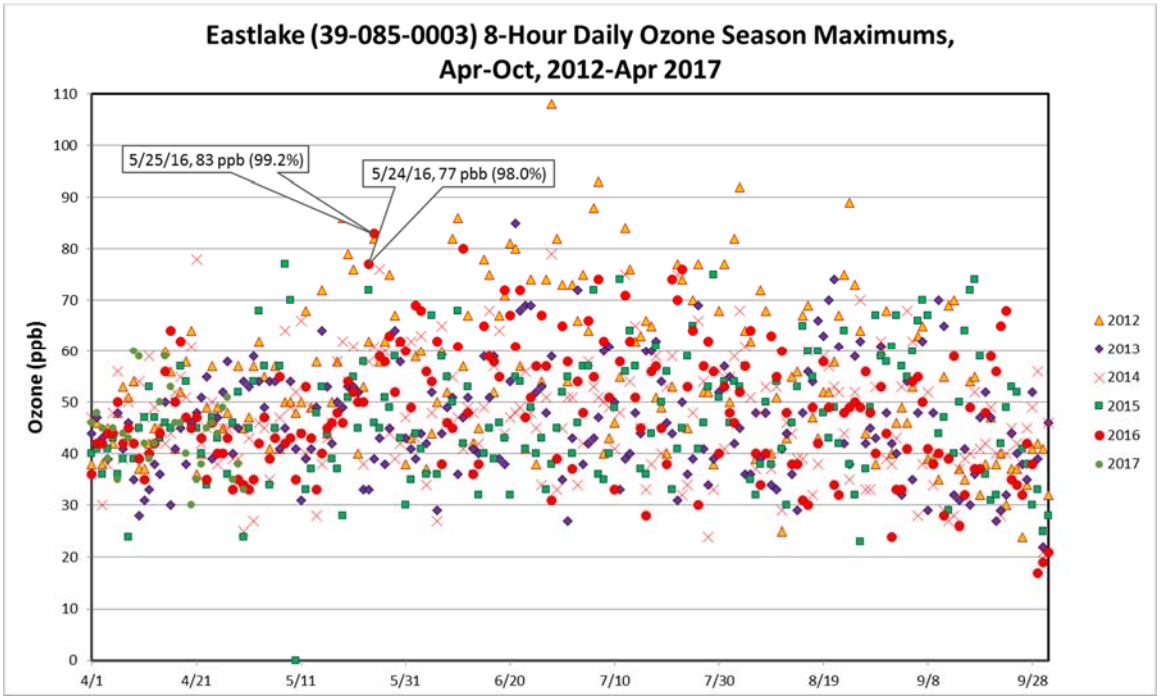

Figure 50. Eastlake (39-085-0003) Daily Ozone Season Maximums 2012-Apr 2017

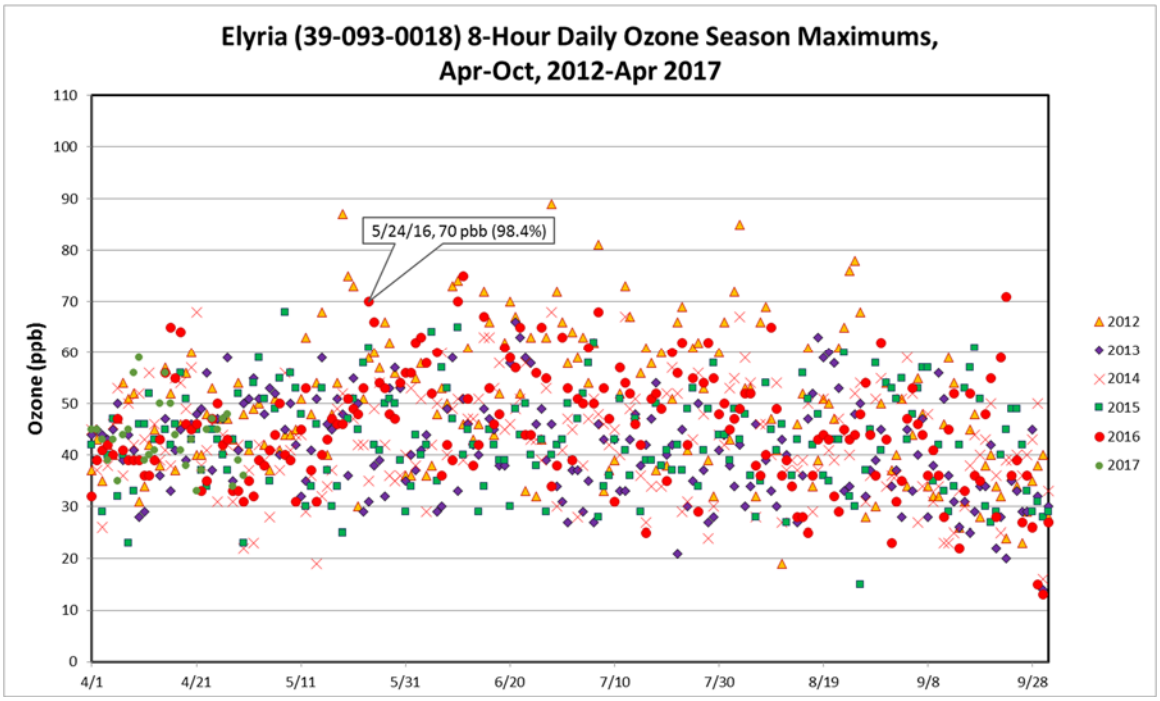

Figure 51. Elyria (39-093-0018) Daily Ozone Season Maximums 2012-Apr 2017

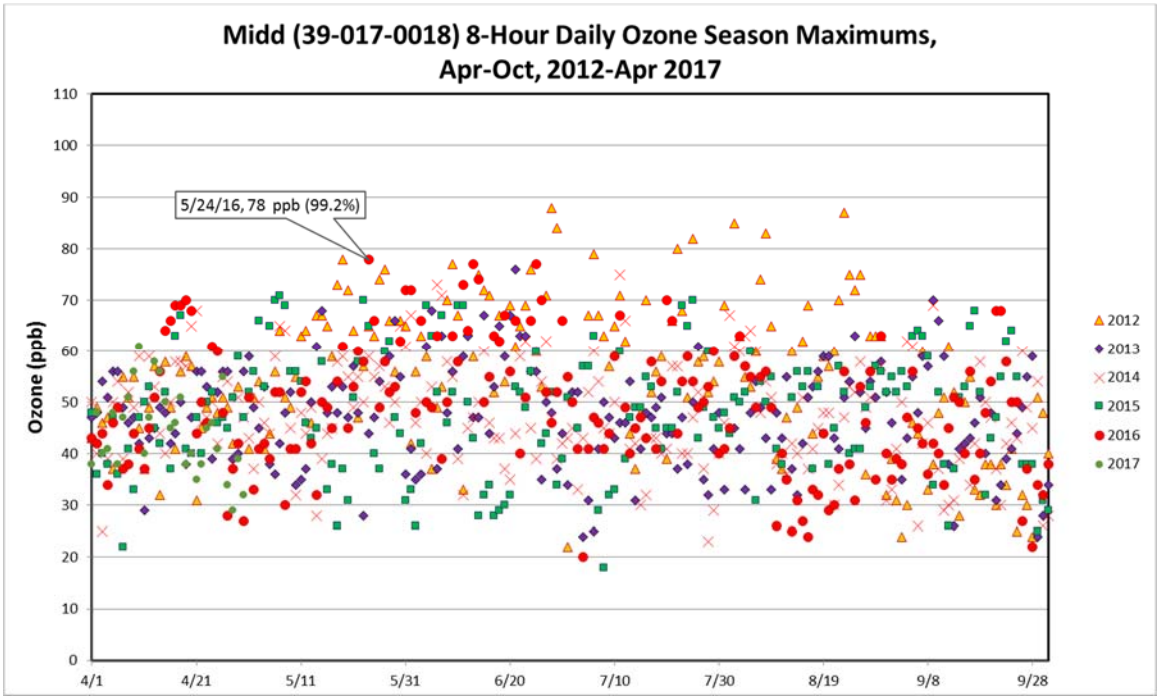

Figure 52. Midd (39-017-0018) Daily Ozone Season Maximums 2012-Apr 2017

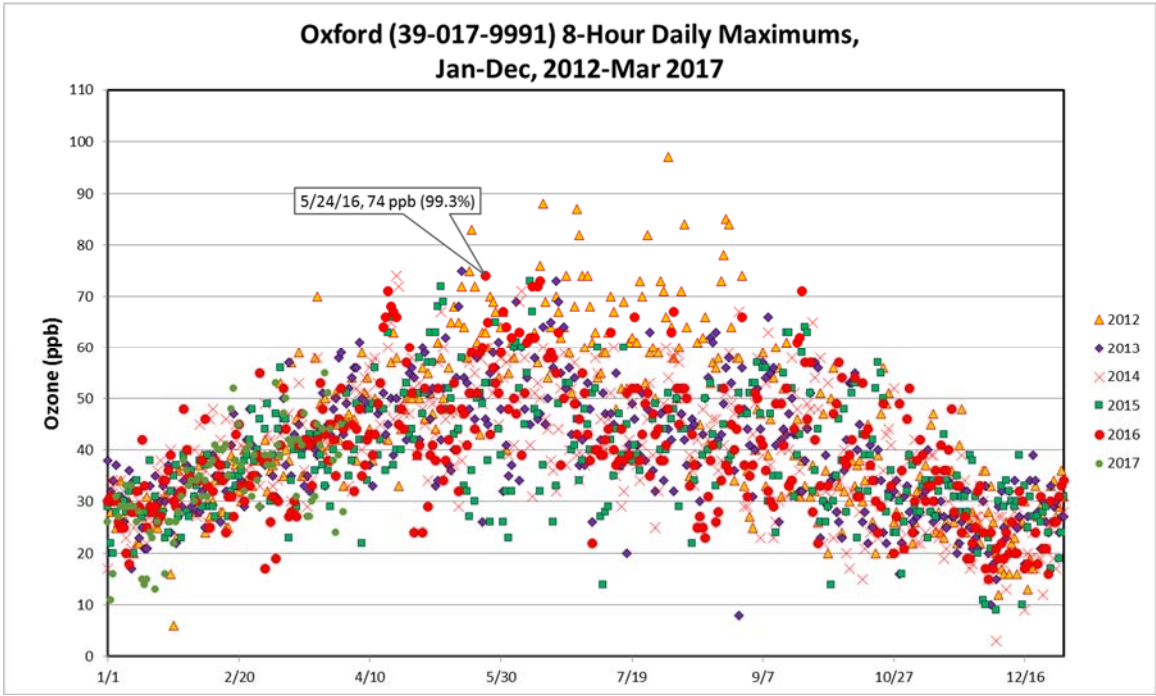

Figure 53. Oxford (39-017-9991) Daily Maximums 2012-Mar 2017

Table 5. 5-year (2012 to 2016) 99th Percentile Comparison

Parameter	Area	Monitor ID	Site Name	County	Maximum 8-hr Avg Ozone (ppb)/ $PM_{2.5}$ (µg/m³)		99th Percentile
					5/24/16	5/25/16	
Ozone	Cleveland	39-035-0034	District	Cuyahoga	74	73	78
		39-035-5002	Mayfield	Cuyahoga	73	71	75
		39-055-0004	Notre Dame	Geauga	82	79	77
		39-085-0003	Eastlake	Lake	77	83	82
		39-093-0018	Elyria	Lorain	70	66*	73
	Cincinnati	39-017-0018	Midd	Butler	78	66*	77
		39-017-9991	Oxford	Butler	74	65*	74
$PM_{2.5}$	Cleveland	39-035-0065	Harvard Yards	Cuyahoga	21.7	Not Measured	26.4

* Not requested for data exclusion

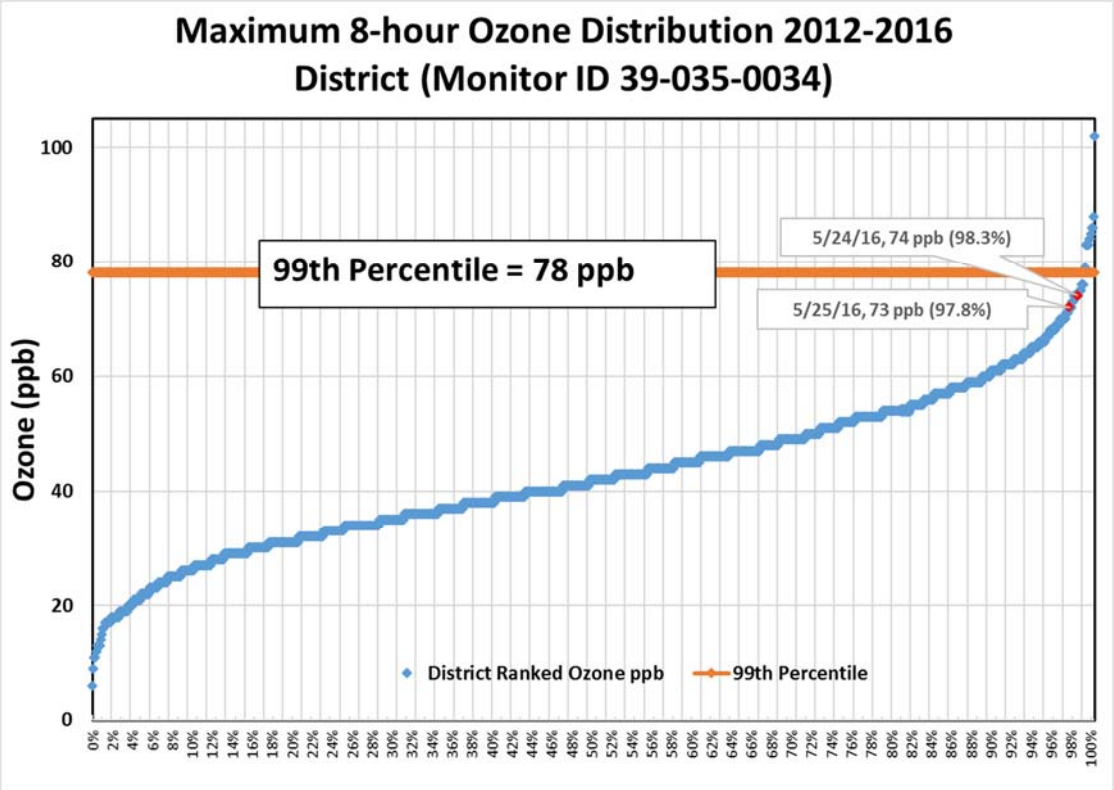

Figure 54. District (39-035-0034) Ranked 8-hour Ozone Distribution 2012-2016

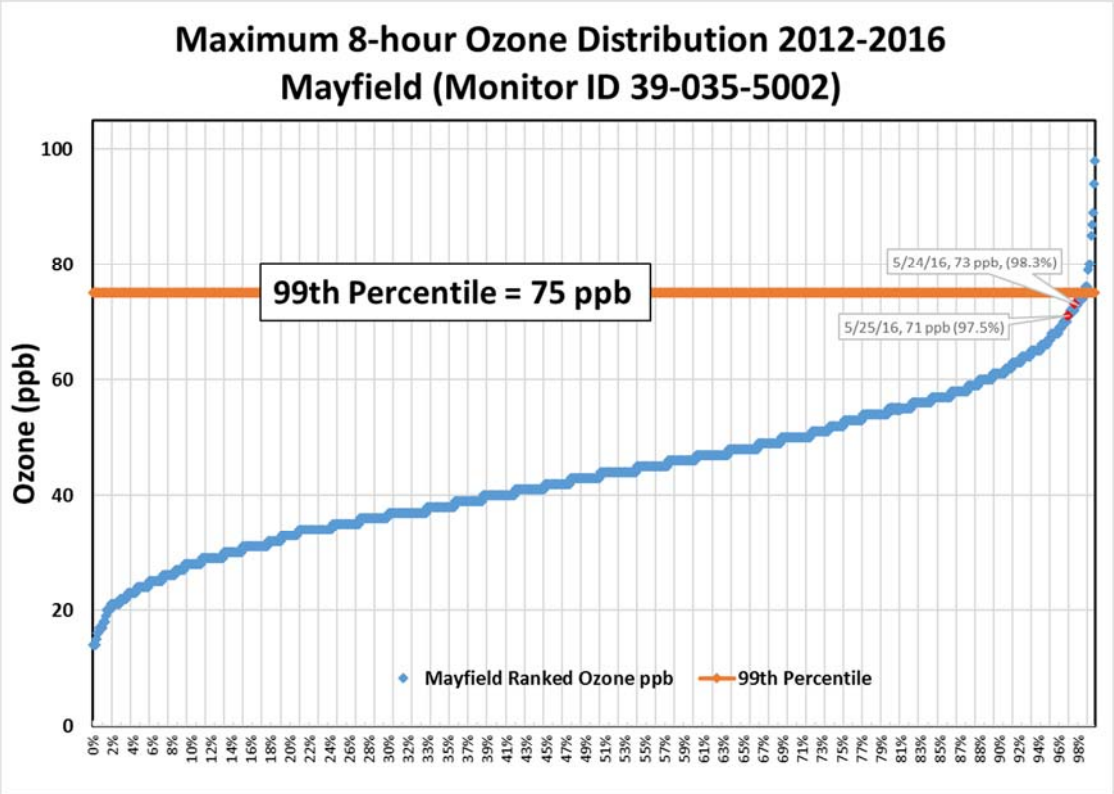

Figure 55. Mayfield (39-035-5002) Ranked 8-hour Ozone Distribution 2012-2016

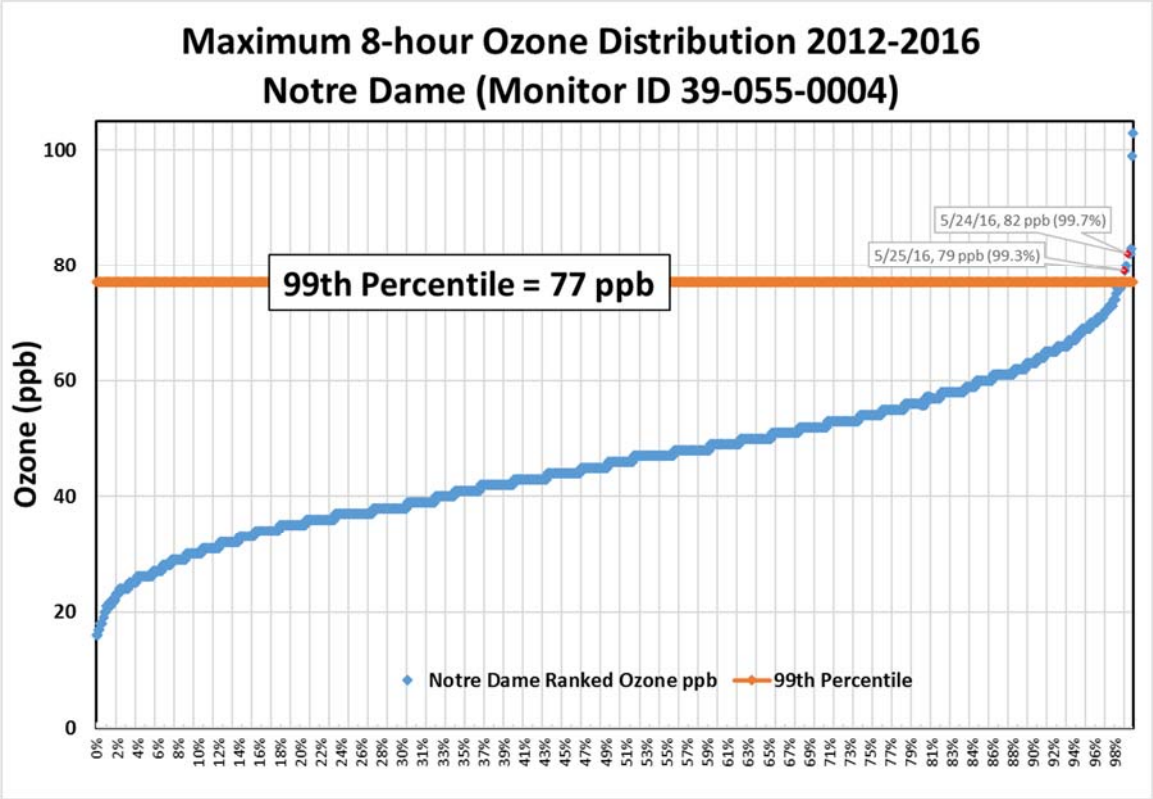

Figure 56. Notre Dame (39-055-0004) Ranked 8-hour Ozone Distribution 2012-2016

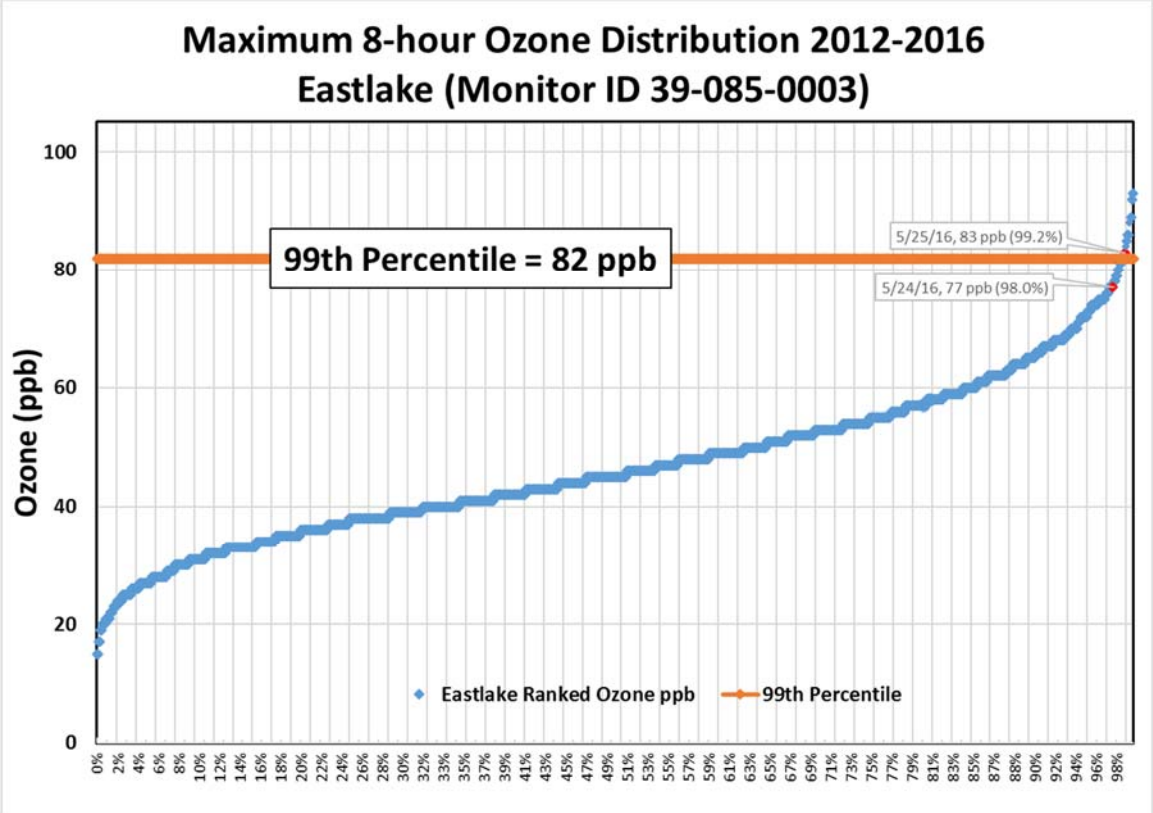

Figure 57. Eastlake (39-085-0003) Ranked 8-hour Ozone Distribution 2012-2016

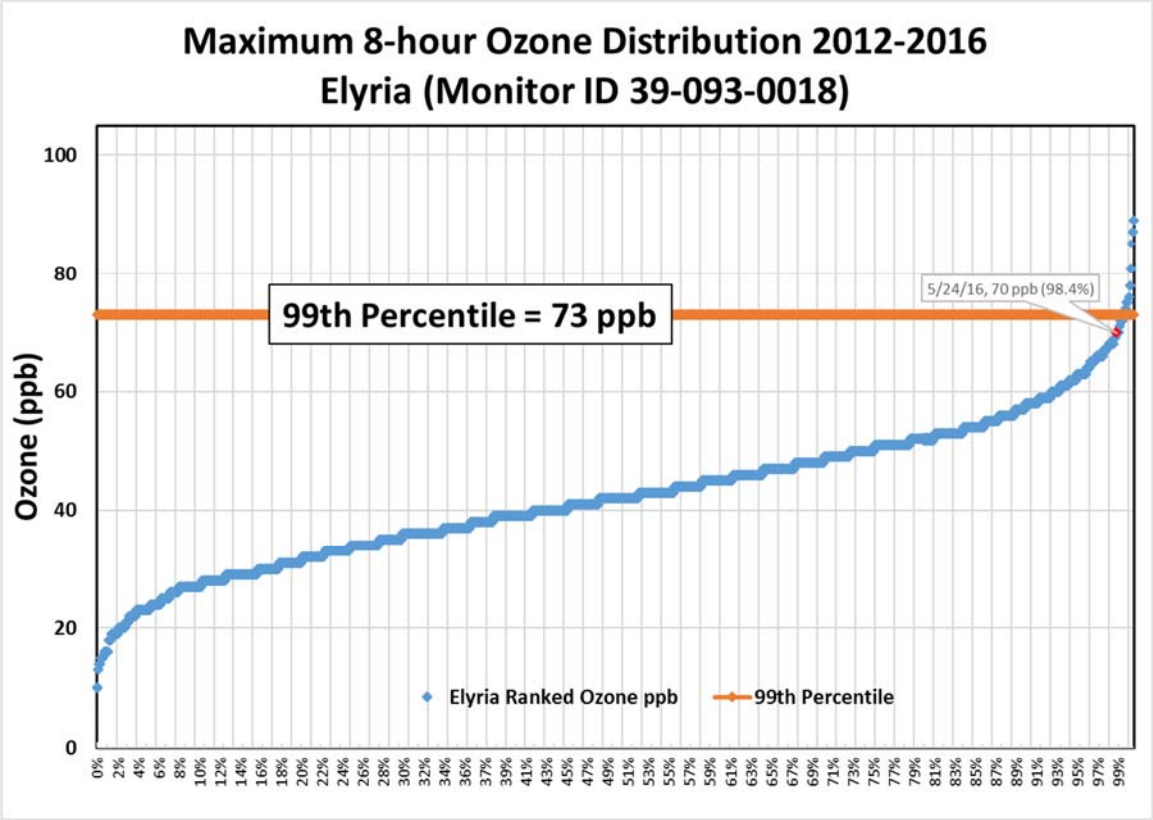

Figure 58. Elyria (39-093-0018) Ranked 8-hour Ozone Distribution 2012-2016

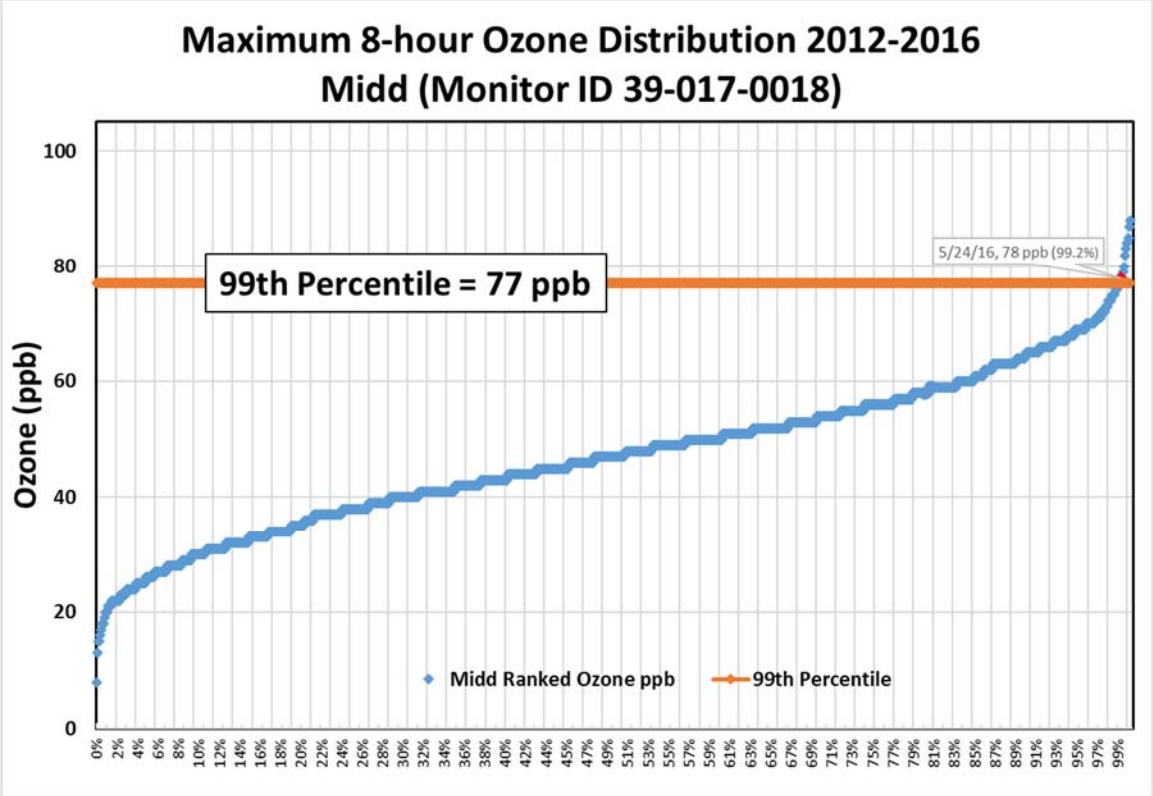

Figure 59. Midd (39-017-0018) Ranked 8-hour Ozone Distribution 2012-2016

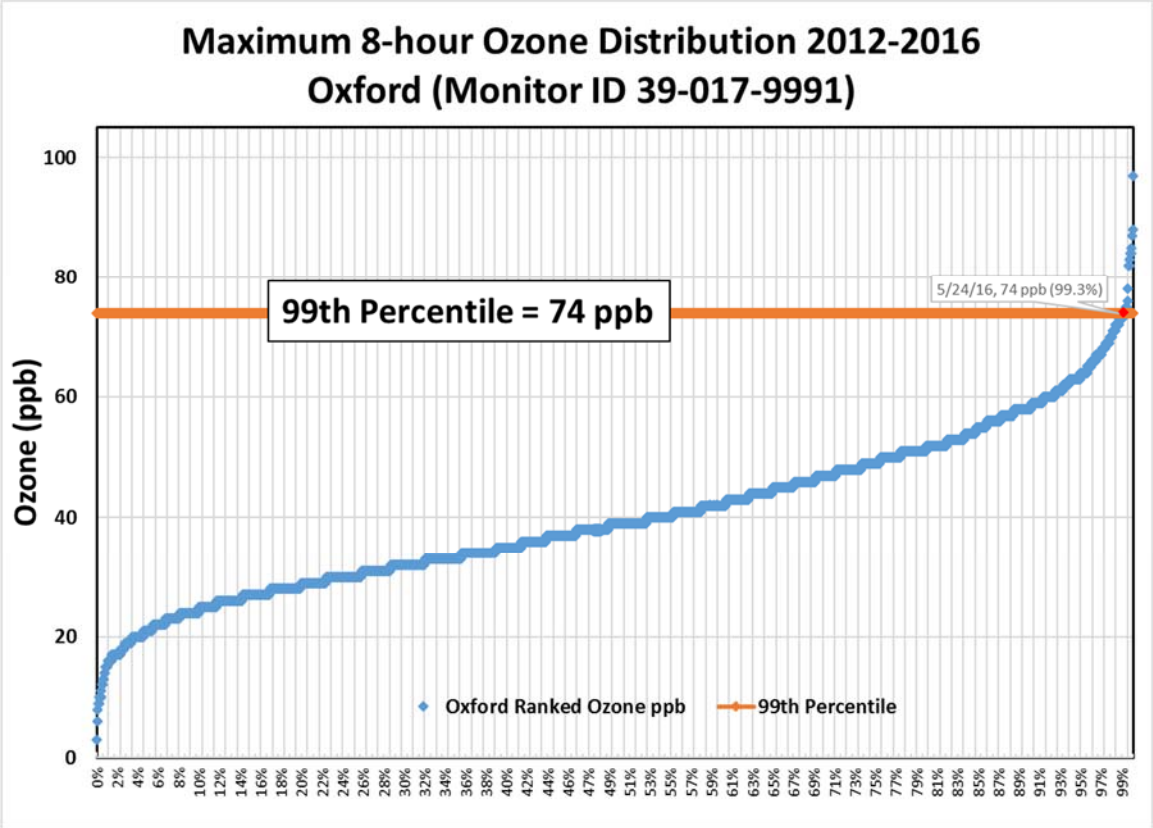

Figure 60. Oxford (39-017-9991) Ranked 8-hour Ozone Distribution 2012-2016

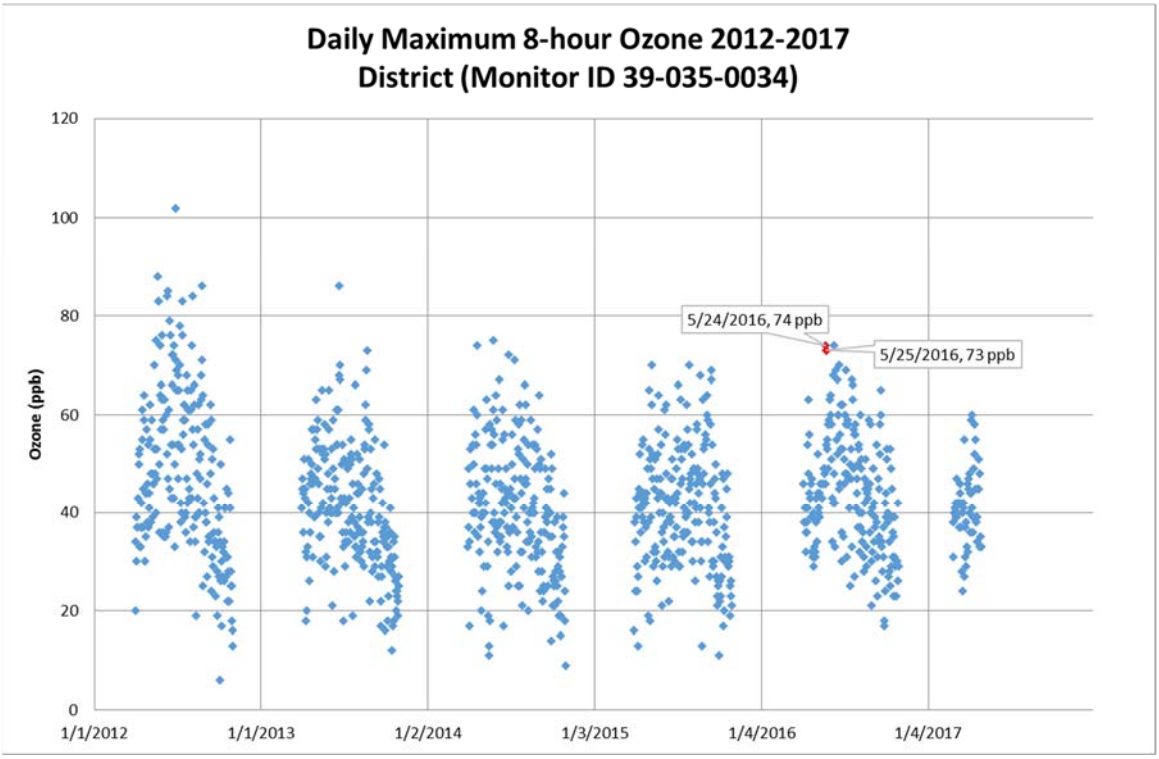

Figure 61. District (39-035-0034) Daily Maximum 8-hour Ozone 2012-Apr 2017

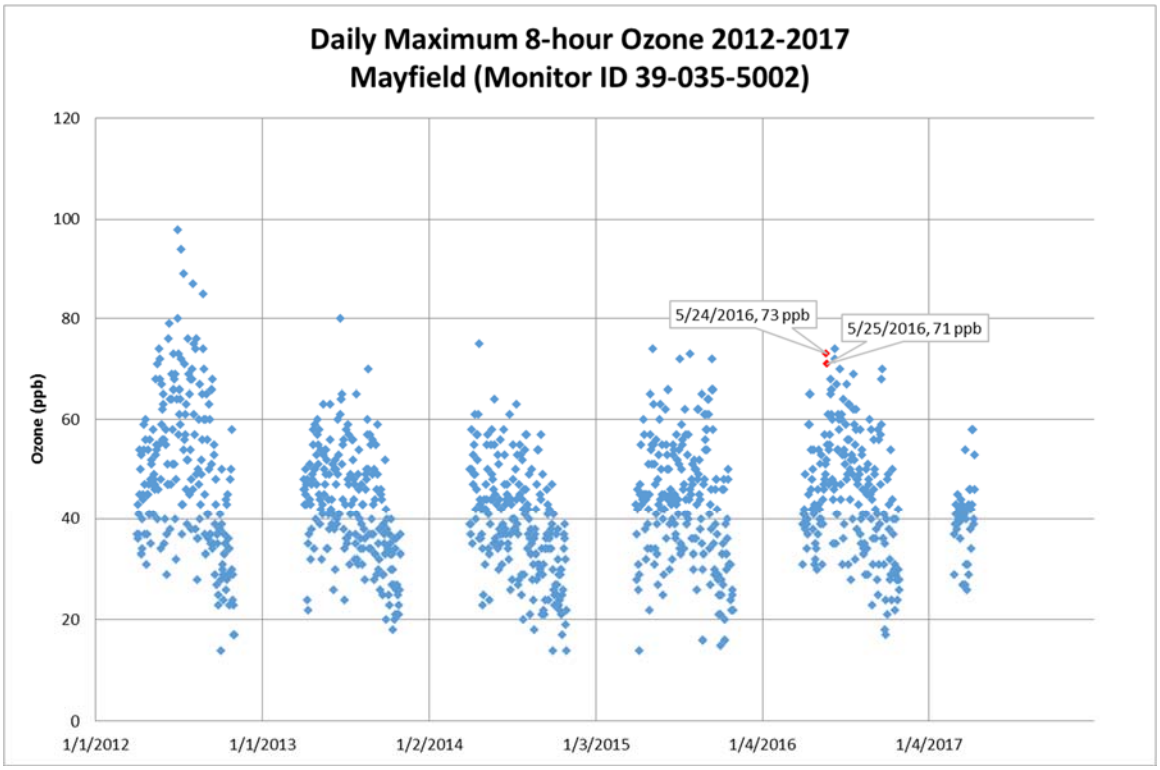

Figure 62. Mayfield (39-035-5002) Daily Maximum 8-hour Ozone 2012-Apr 2017

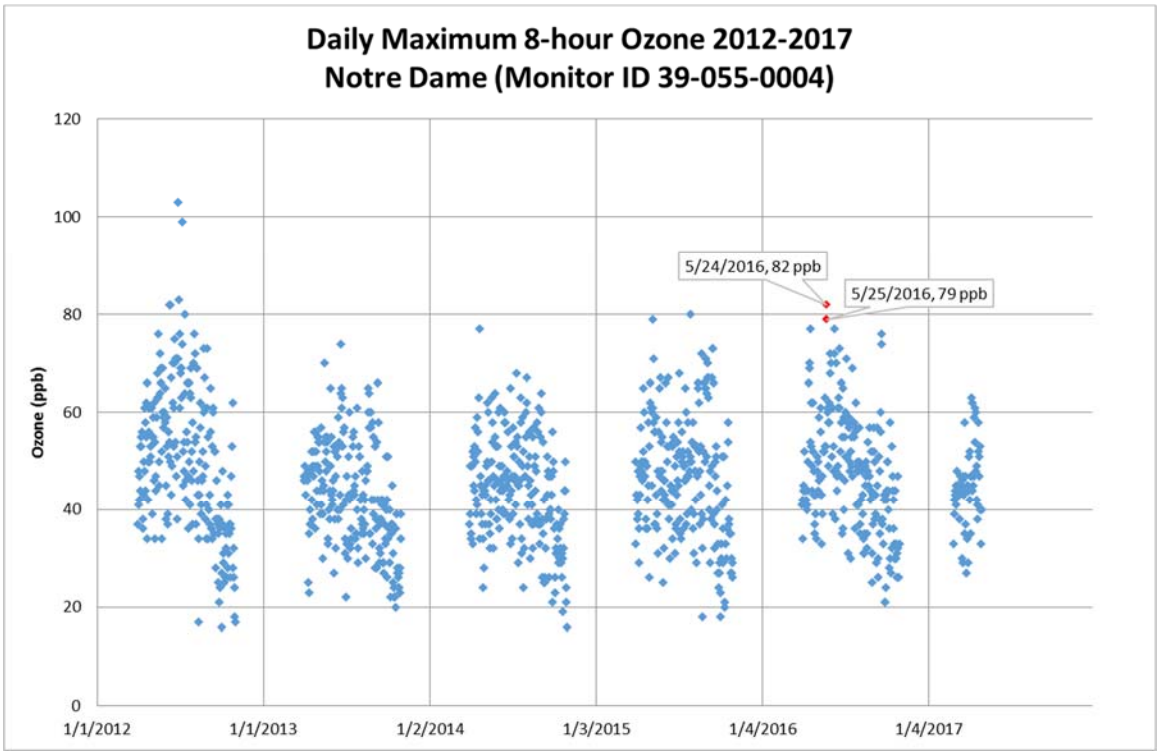

Figure 63. Notre Dame (39-055-0004) Daily Maximum 8-hour Ozone 2012-Apr 2017

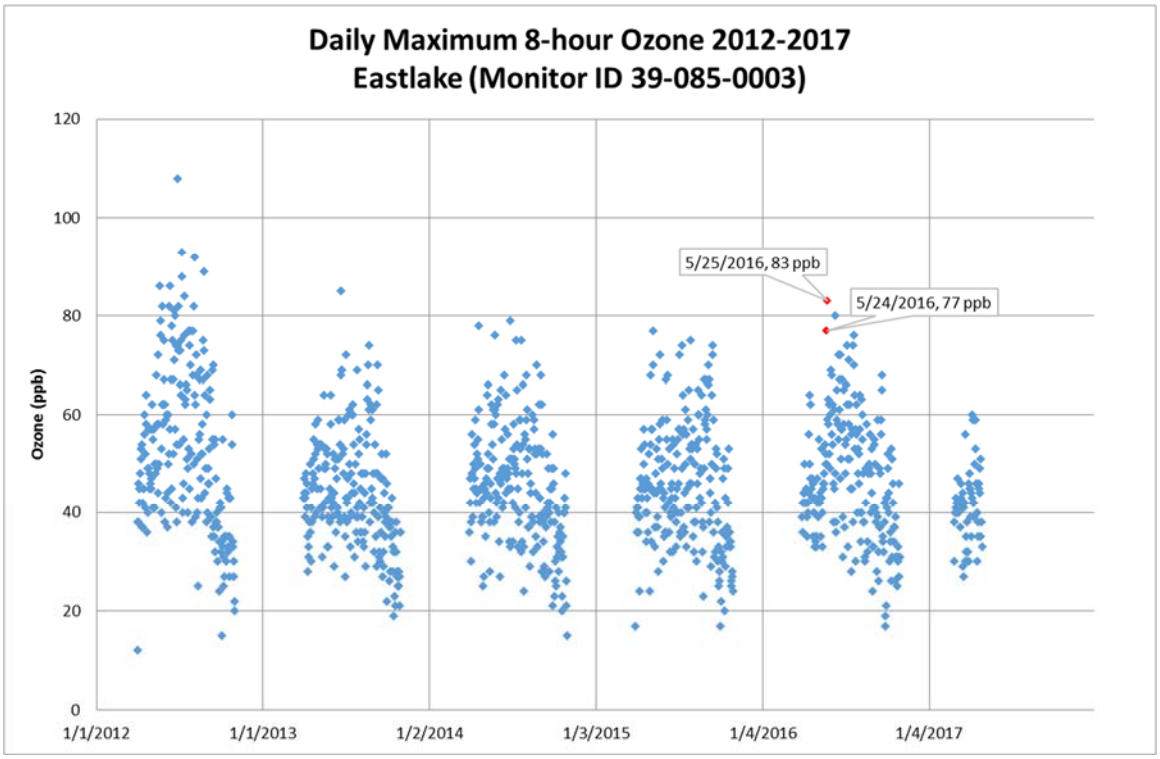

Figure 64. Eastlake (39-085-0003) Daily Maximum 8-hour Ozone 2012-Apr 2017

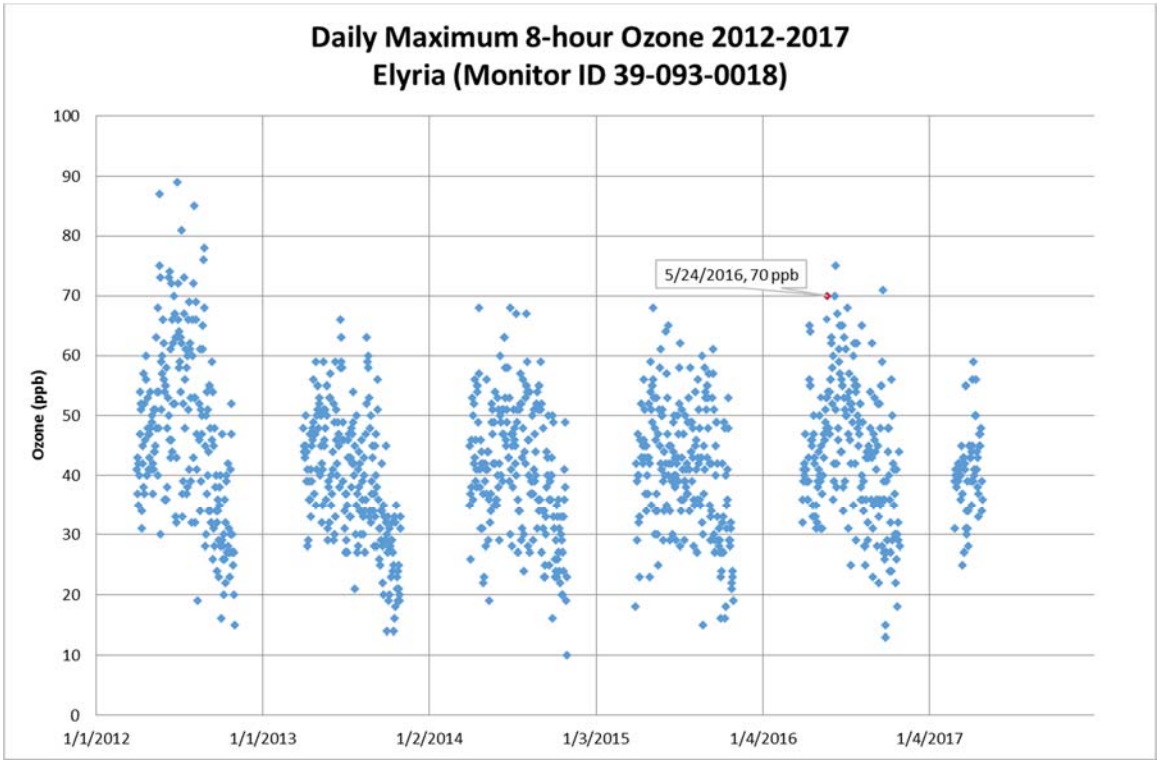

Figure 65. Elyria (39-093-0018) Daily Maximum 8-hour Ozone 2012-Apr 2017

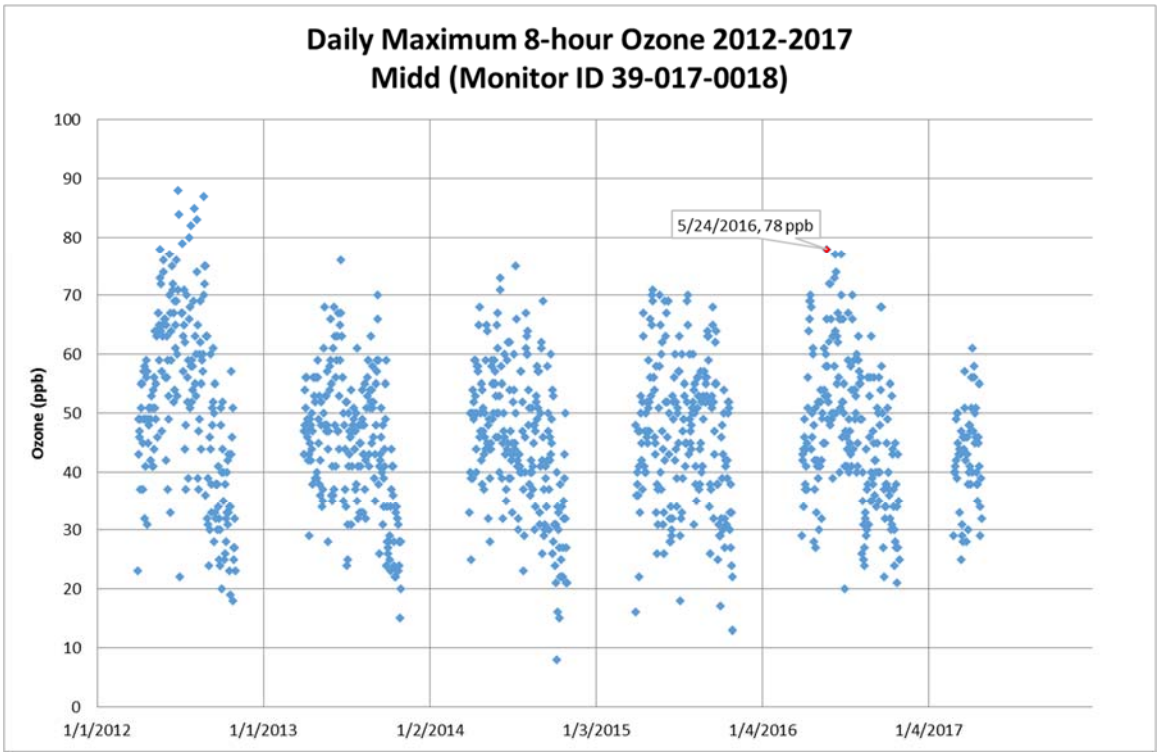

Figure 66. Midd (39-017-0018) Daily Maximum 8-hour Ozone 2012-Apr 2017

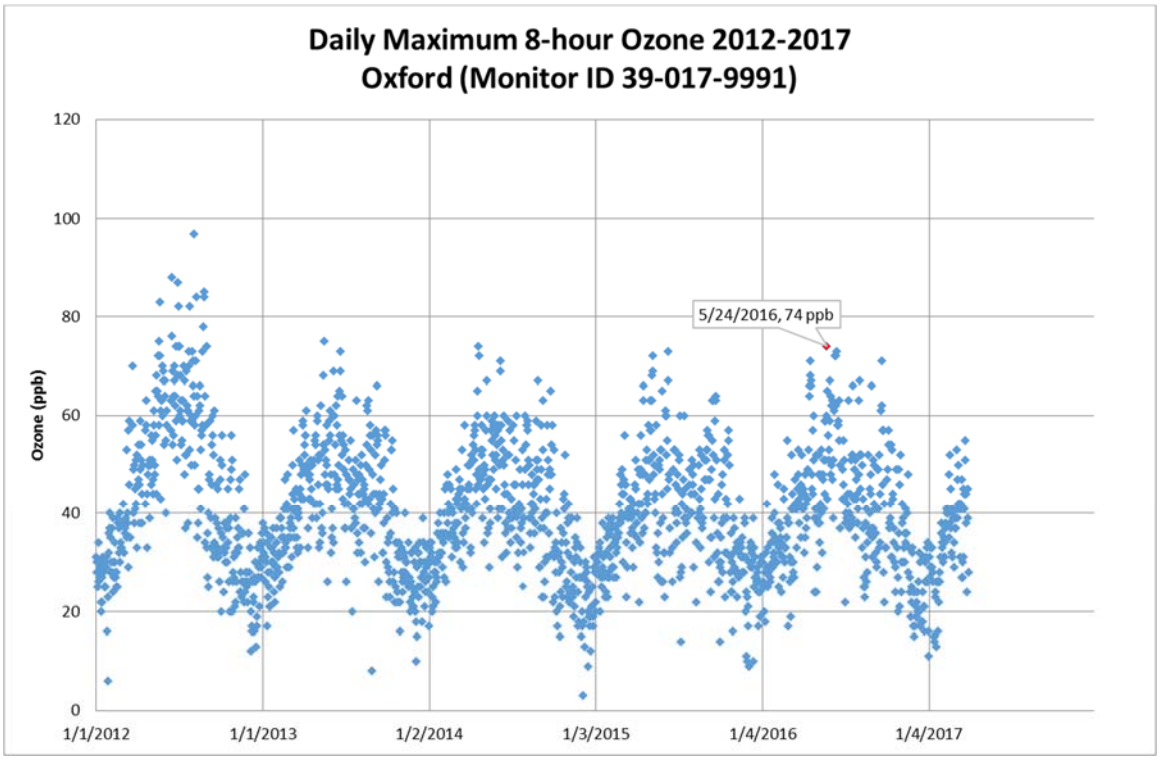

Figure 67. Oxford (39-017-9991) Daily Maximum 8-hour Ozone 2012-Mar 2017

Figure 68 shows a time-series plot of $PM_{2.5}$ concentrations at the Harvard Yards monitor in Cleveland overlaying $PM_{2.5}$ monitoring data from 2012 through April 2017. Figure 69 shows a distribution plot of $PM_{2.5}$ concentrations at this monitor for 2012 through 2016. Figure 70 shows a chronological time series plot of $PM_{2.5}$ at this monitor from 2012 through April 2017. The May 24, 2016 data was among the higher concentrations at the 94th percentile amongst 2012 to 2016 data. In 2016, May 24 was the third highest value at a percentile of 98.3.

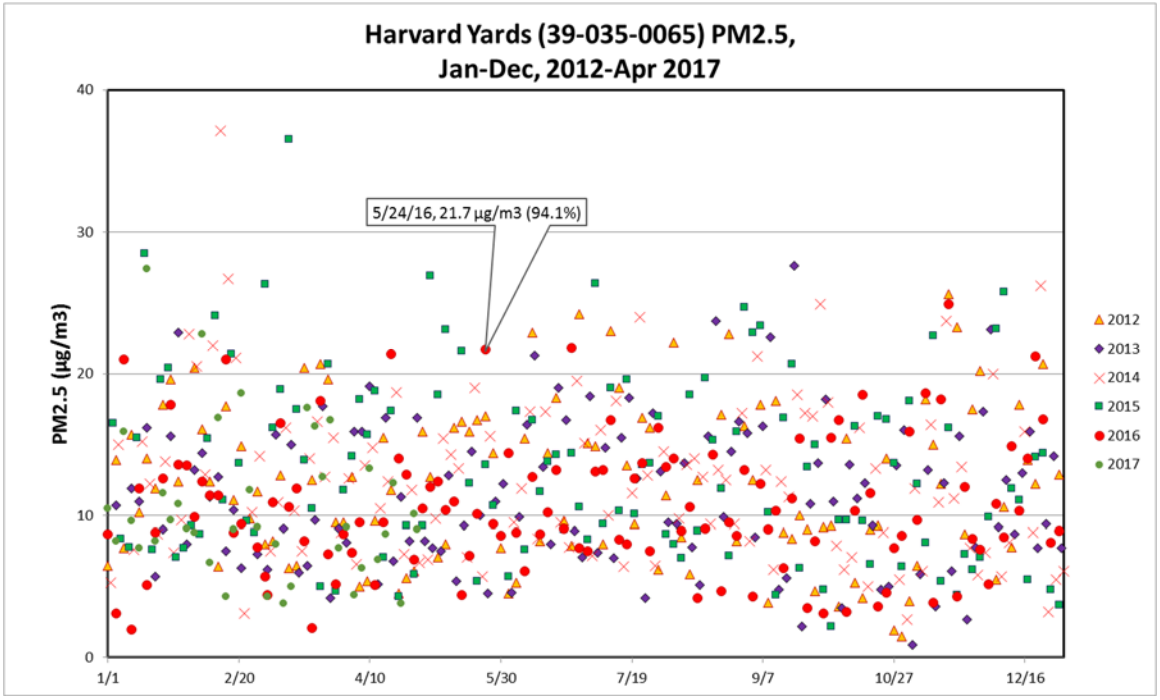

Figure 68. Harvard Yards (39-035-0065) $PM_{2.5}$ Jan-Dec, 2012-Apr 2017

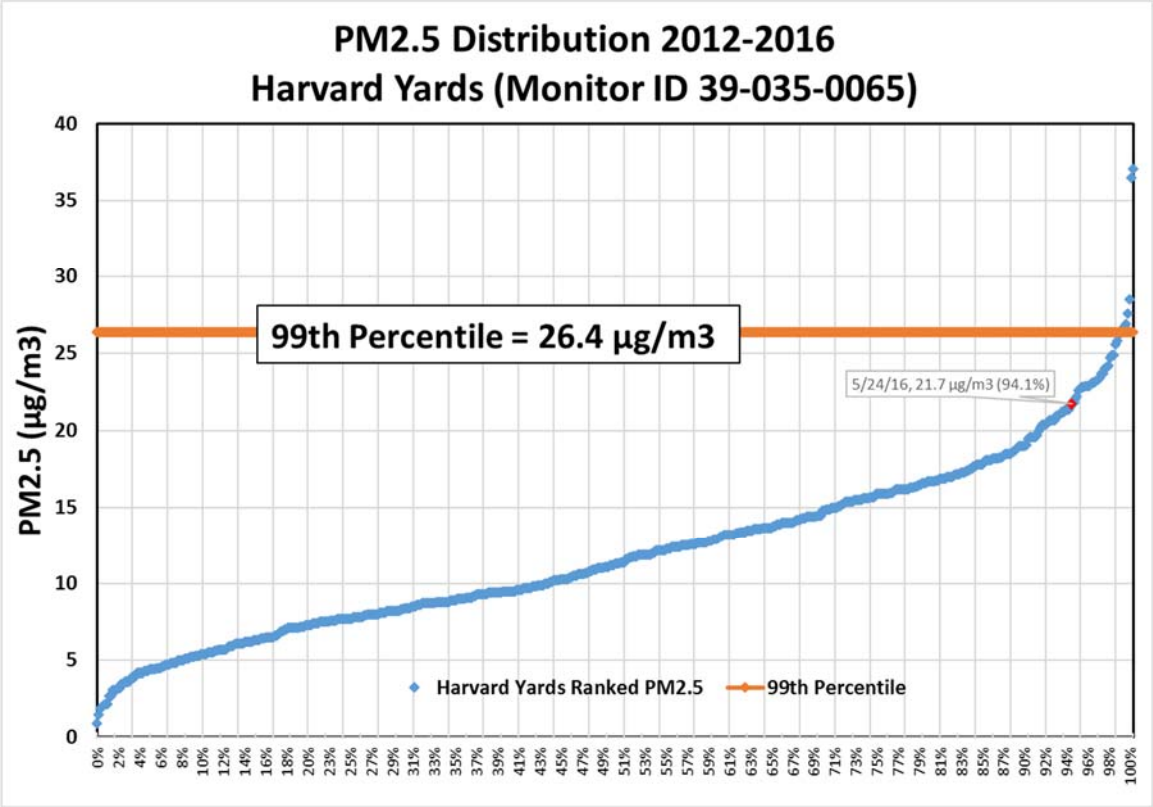

Figure 69. Harvard Yards (39-035-0065) Ranked $PM_{2.5}$ Distribution 2012-2016

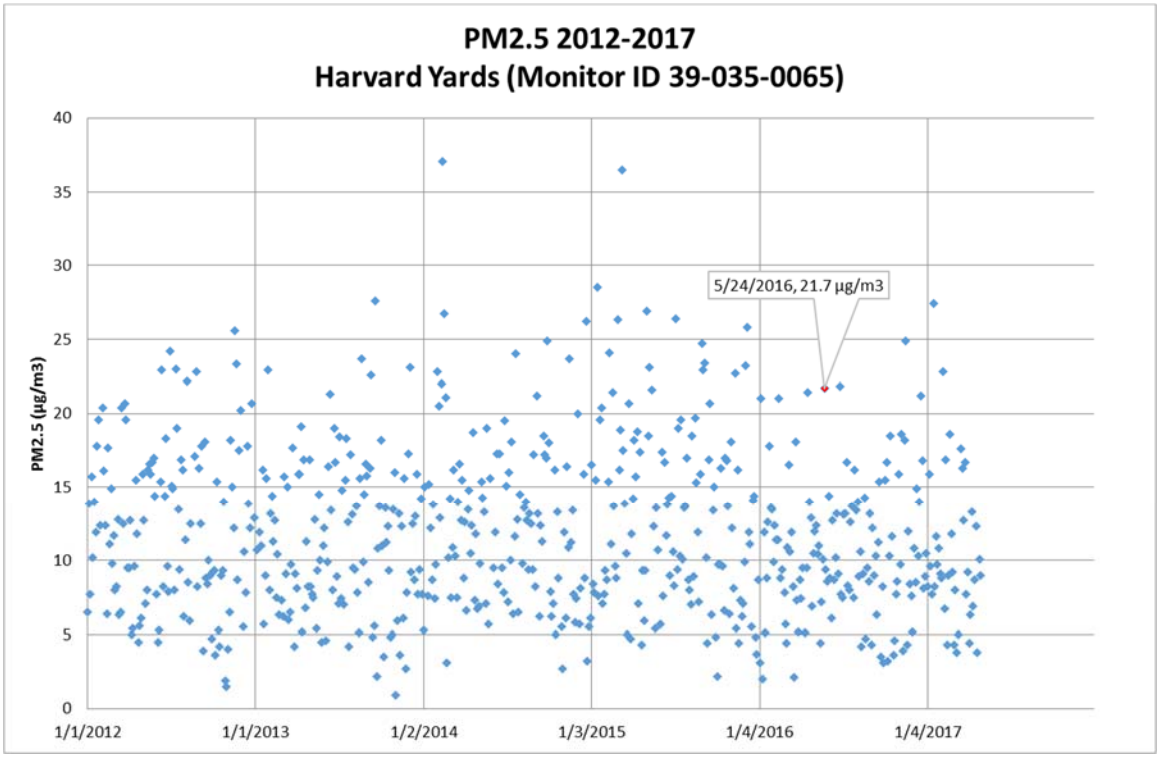

Figure 70. Harvard Yards (39-035-0065) $PM_{2.5}$ 2012-Apr 2017

Evidence of Transport of Fire Emissions from the Fire to the Monitor

HYSPLIT Trajectory Analysis

To demonstrate that the Fort McMurray wildfire emissions were transported to the Ohio ozone network, the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model[24] was used to calculate forward trajectories originating from within the smoke plume at the fire sites and backward trajectories from Cleveland, Ohio and Cincinnati, Ohio. Trajectories were produced in July 2017 using model version June 26, 2017. All trajectories utilize NARR data for all meteorological input.

Forward trajectories from May 19, 2016 to May 23, 2016 are shown in Figure 71. The left side of the figure shows trajectories at three starting heights 1000 meters (m) AGL (red), 1500 m (blue), and 2000 m (green). The right side of the figure shows ensemble trajectories using meteorological variations at a starting height of 2000 m. These forward trajectories showed transport from the fire and smoke locations towards Ohio which is consistent with the path of the HMS analysis presented in Figure 9.

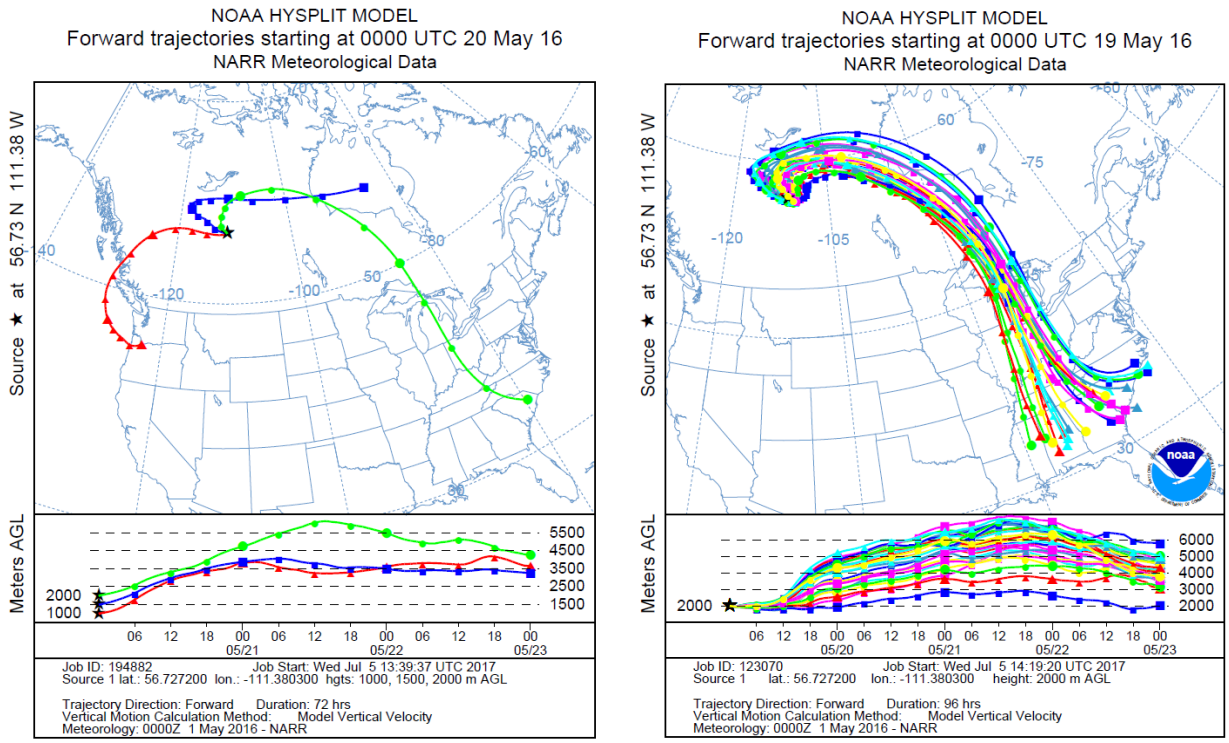

Figure 71. HYSPLIT Forward Trajectories from Fort McMurray May 19-23, 2016

Figures 72 to 78 show backward trajectories from the Cleveland area from May 23, 2016 to May 25, 2016, and in the Cincinnati area on May 24, 2016 and May 25, 2016. The left side of each figure shows back-trajectories at three starting heights 100 m AGL

[24] Available at http://ready.arl.noaa.gov/HYSPLIT_traj.php

(red), 500 m (blue), and 2000 m (green). The right side of each figure shows ensemble trajectories using meteorological variations at a starting height of 100 m.

The backward trajectories in the Cleveland area show transported emissions from the smoke plume in the north in the days leading up to the exceedances. The vertical distribution of the trajectories (shown in the bottom panel of the figures) shows the trajectories subsiding downwards, reaching near surface on May 23, 2016 (Figures 72 and 73). By 1800 EDT (2200 UTC) on May 25, the source of emissions had turned to the south (Figure 75).

The backward trajectories in the Cincinnati area also shows transported emissions from the smoke plume in the north in the days leading up to the exceedance on May 24, 2016, with the vertical distribution showing the trajectories subsiding downwards, reaching near surface on May 23, 2016 (Figure 76). By 1000 EDT (1400 UTC) on May 25, the source of emissions had turned to the south (Figure 78).

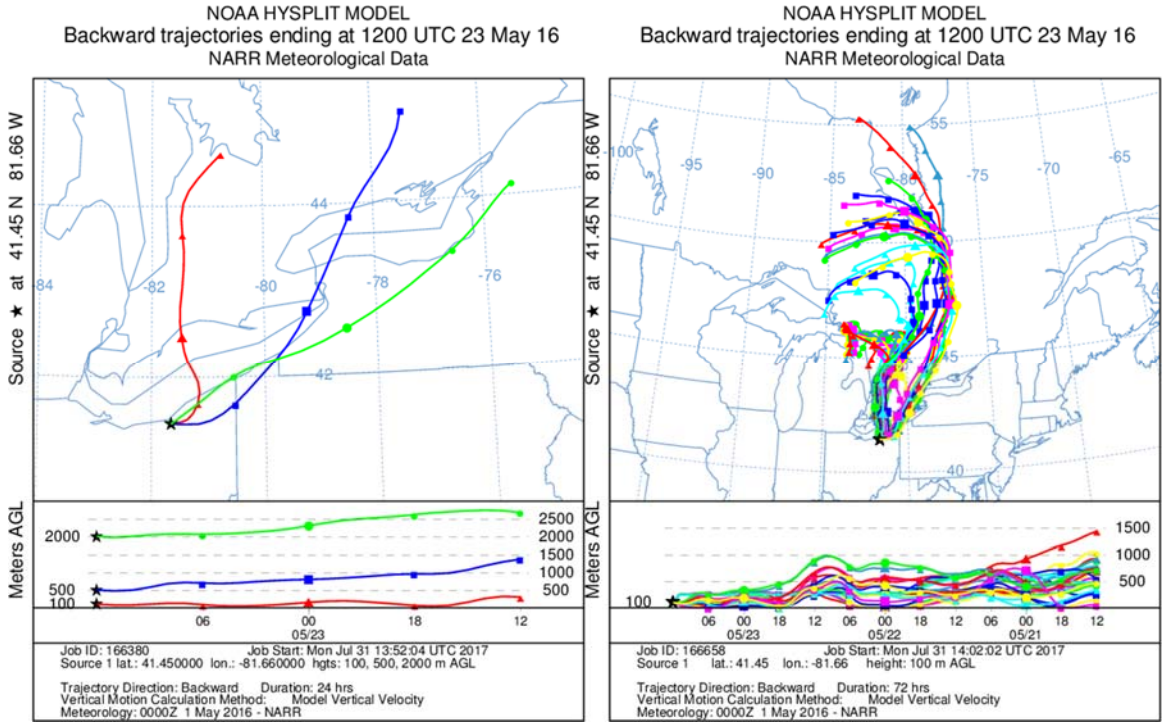

Figure 72. HYSPLIT Backward Trajectories, Cleveland area May 23, 2016 0800 EDT

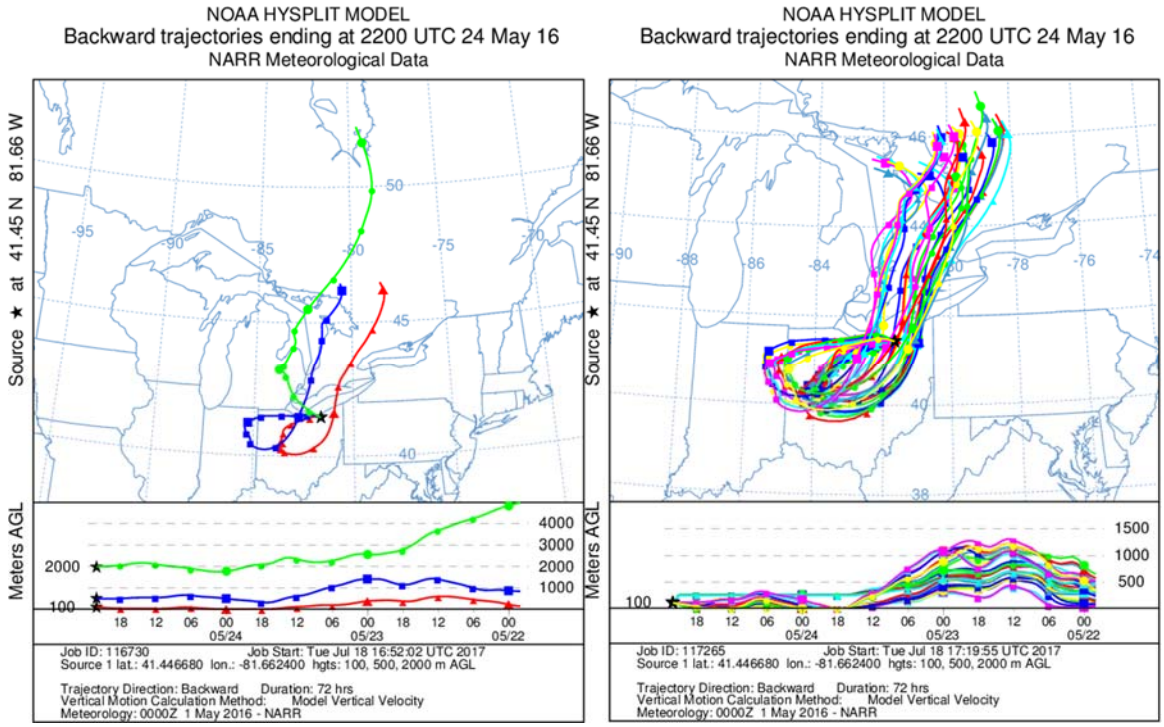

Figure 73. HYSPLIT Backward Trajectories, Cleveland area May 24, 2016 1800 EDT

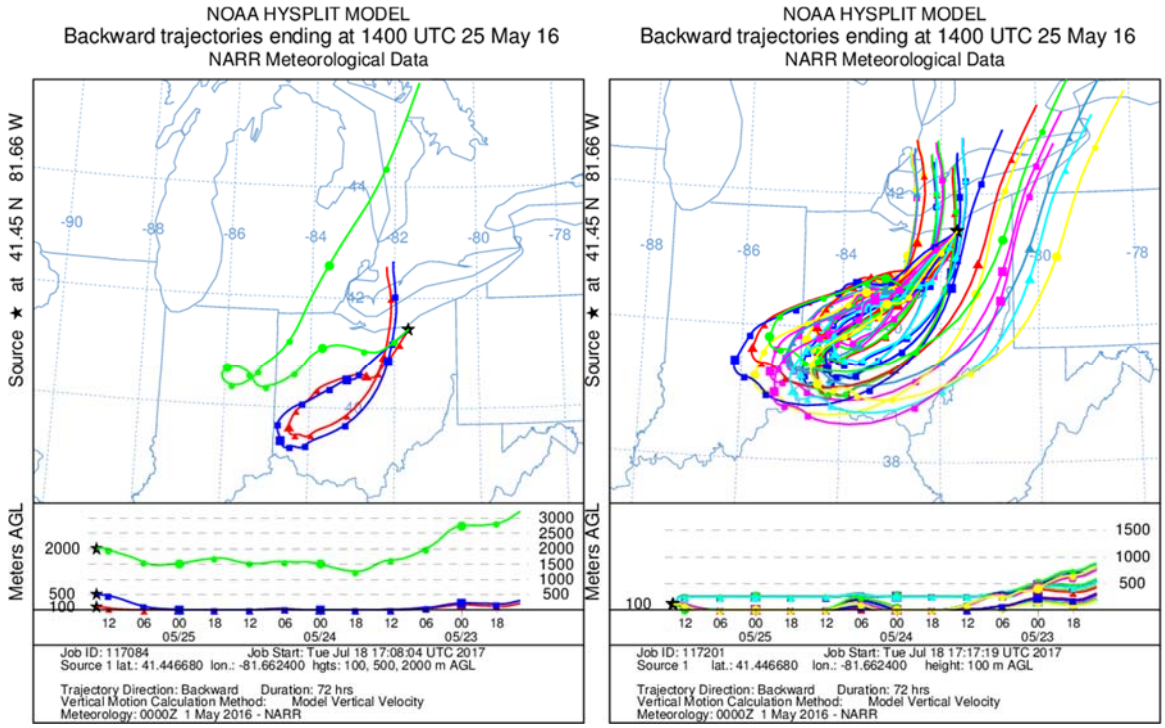

Figure 74. HYSPLIT Backward Trajectories, Cleveland area May 25, 2016 1000 EDT

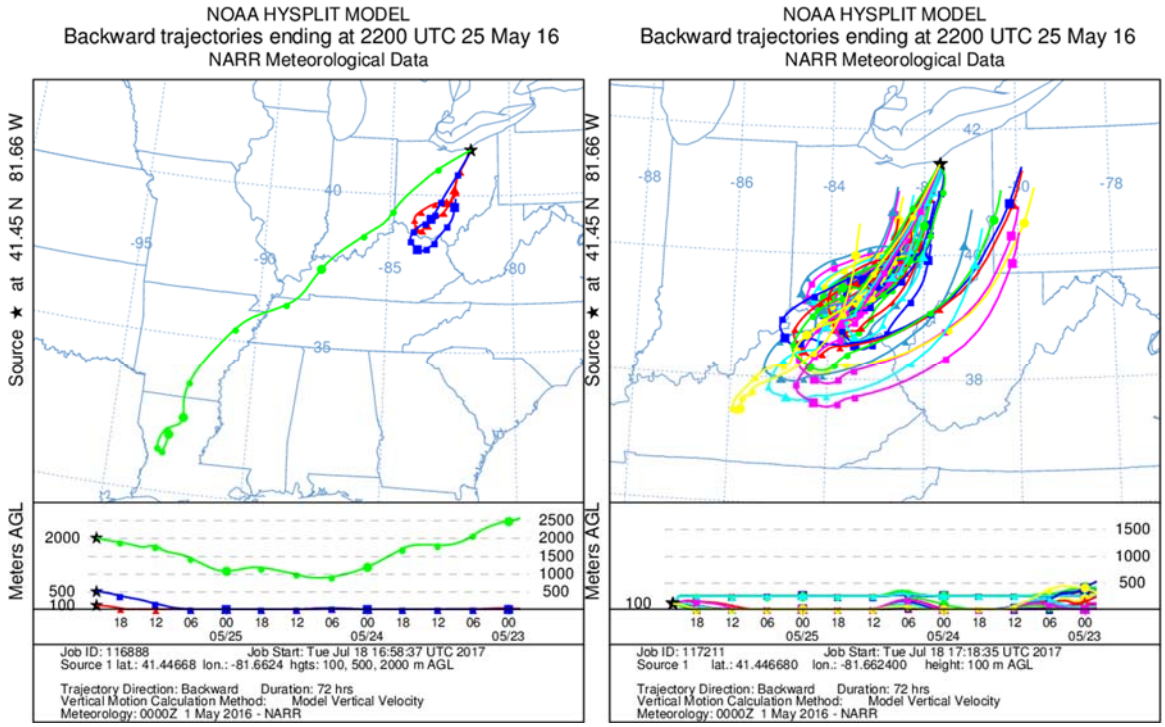

Figure 75. HYSPLIT Backward Trajectories, Cleveland area May 25, 2016 1800 EDT

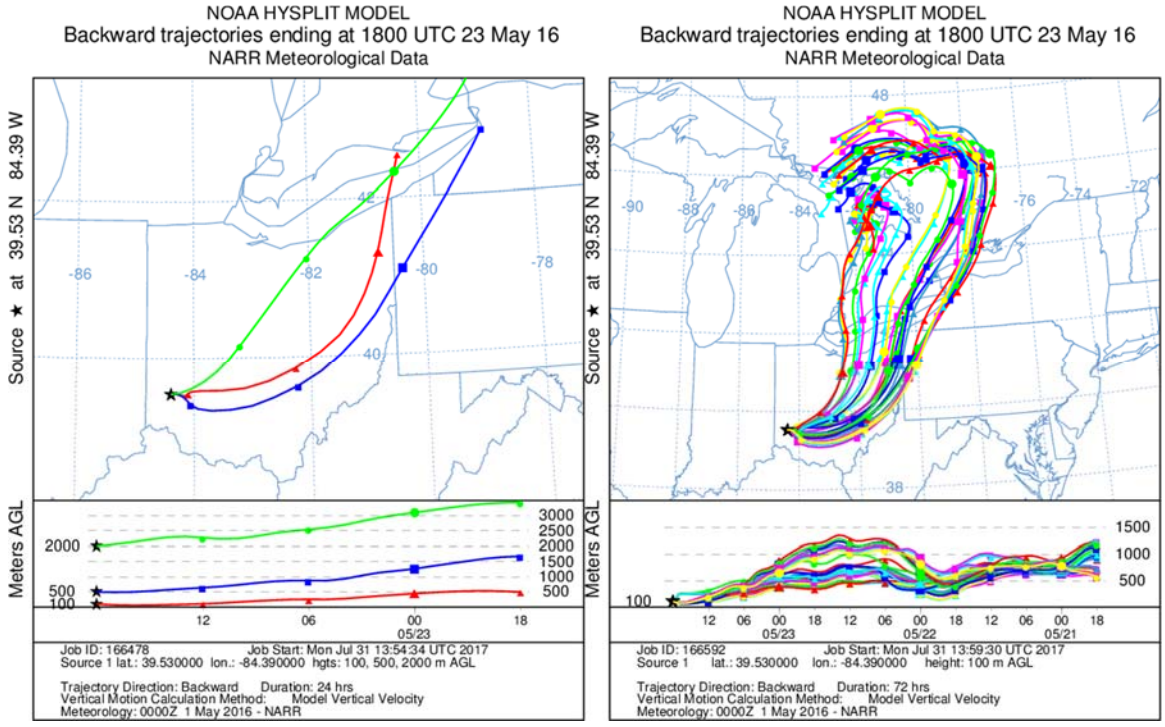

Figure 76. HYSPLIT Backward Trajectories, Cincinnati area May 23, 2016 1400 EDT

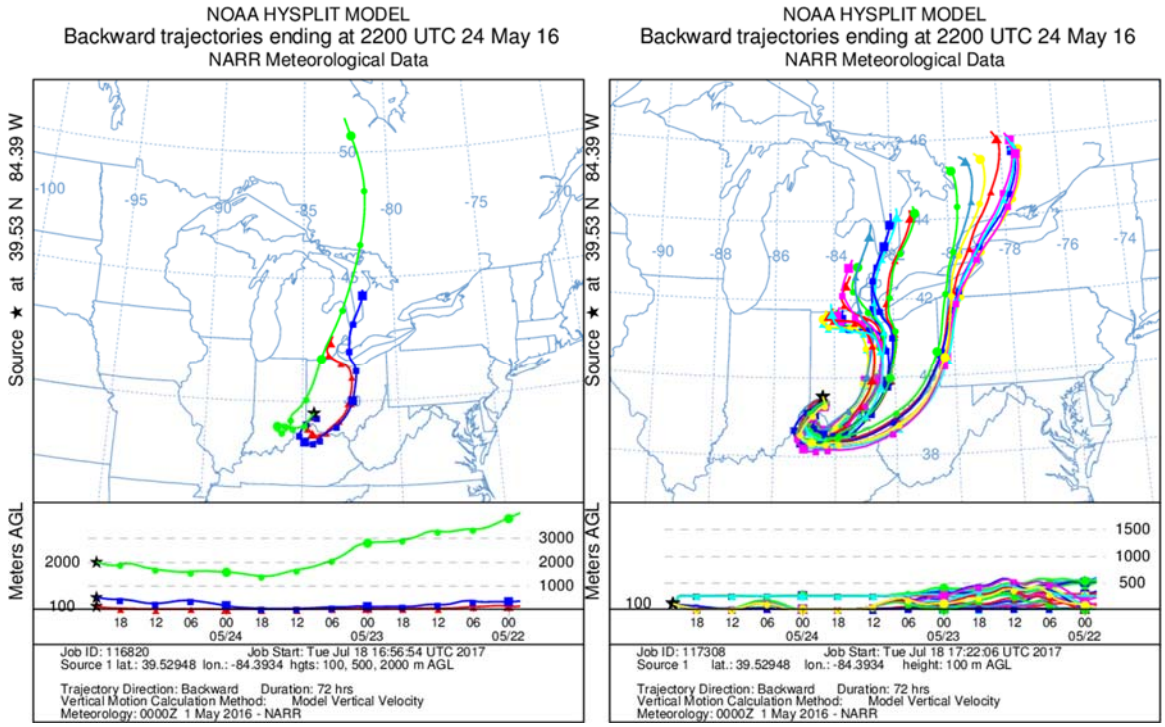

Figure 77. HYSPLIT Backward Trajectories, Cincinnati area May 24, 2016 1800 EDT

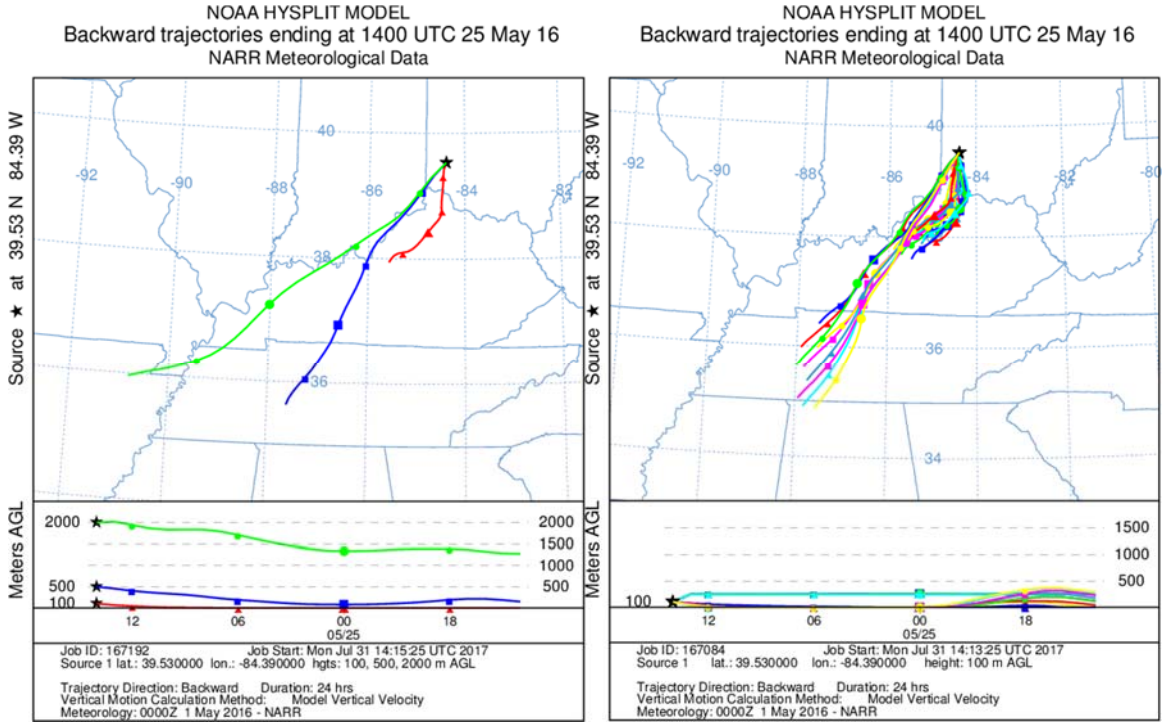

Figure 78. HYSPLIT Backward Trajectories, Cincinnati area May 25, 2016 1000 EDT

Aerosol Optical Depth

Figures 79 to 84 show the Visible Infrared Imaging Radiometer Suite (VIIRS) satellite image overlaid with the 3km aerosol optical depth (AOD)[25] for May 21 to 26, 2016. Aerosols are particles in the air which scatter and absorb sunlight. AOD indicates the level of aerosols in the atmosphere. Sources of aerosols include pollution from factories, smoke from fires, dust from dust storms, sea salt, and volcanic ash and smog.

These images provide further evidence the smoke plume and associated ozone precursors and $PM_{2.5}$ precursors were present in the Ohio and upper Midwest region in the days leading up to the exceedances, and during the exceedances on May 24 and 25, 2016.

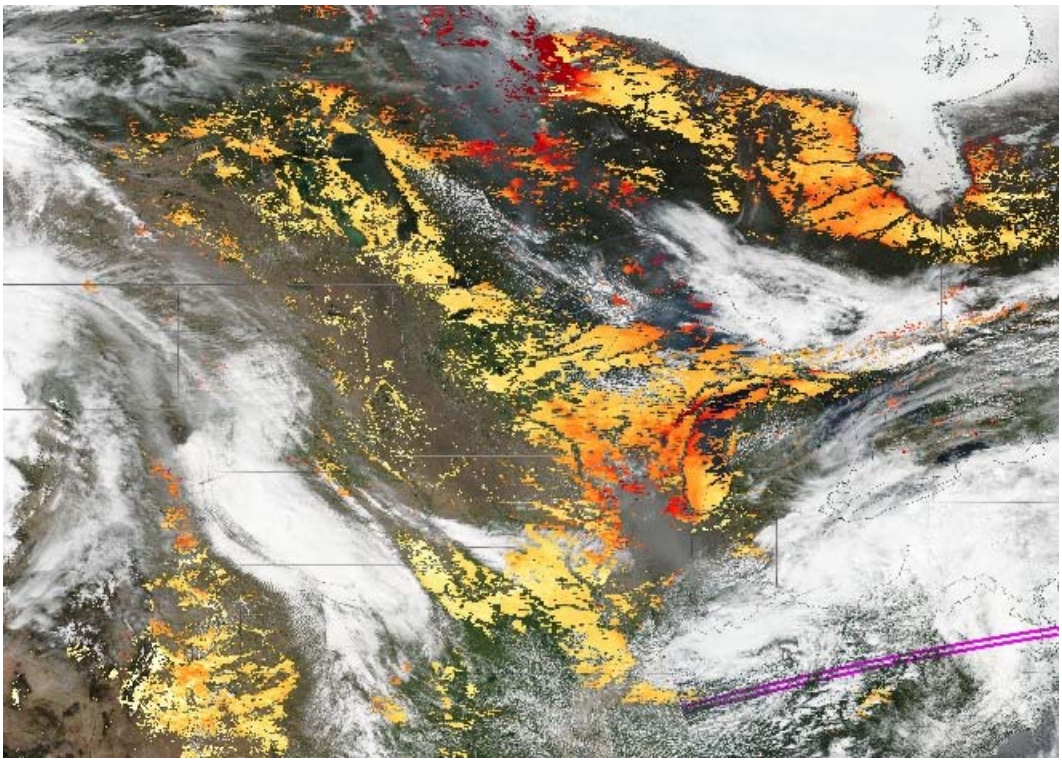

Figure 79. VIIRS Satellite Image with Aerosol Optical Depth for May 21, 2016

[25] obtained from https://worldview.earthdata.nasa.gov/

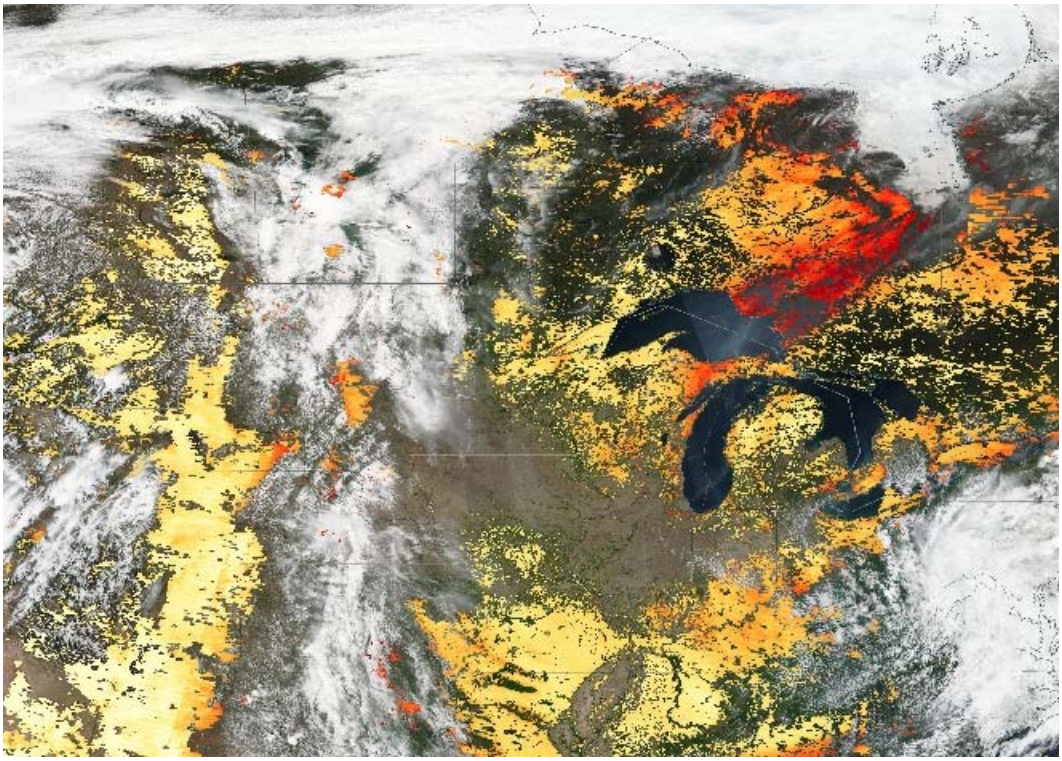

Figure 80. VIIRS Satellite Image with Aerosol Optical Depth for May 22, 2016

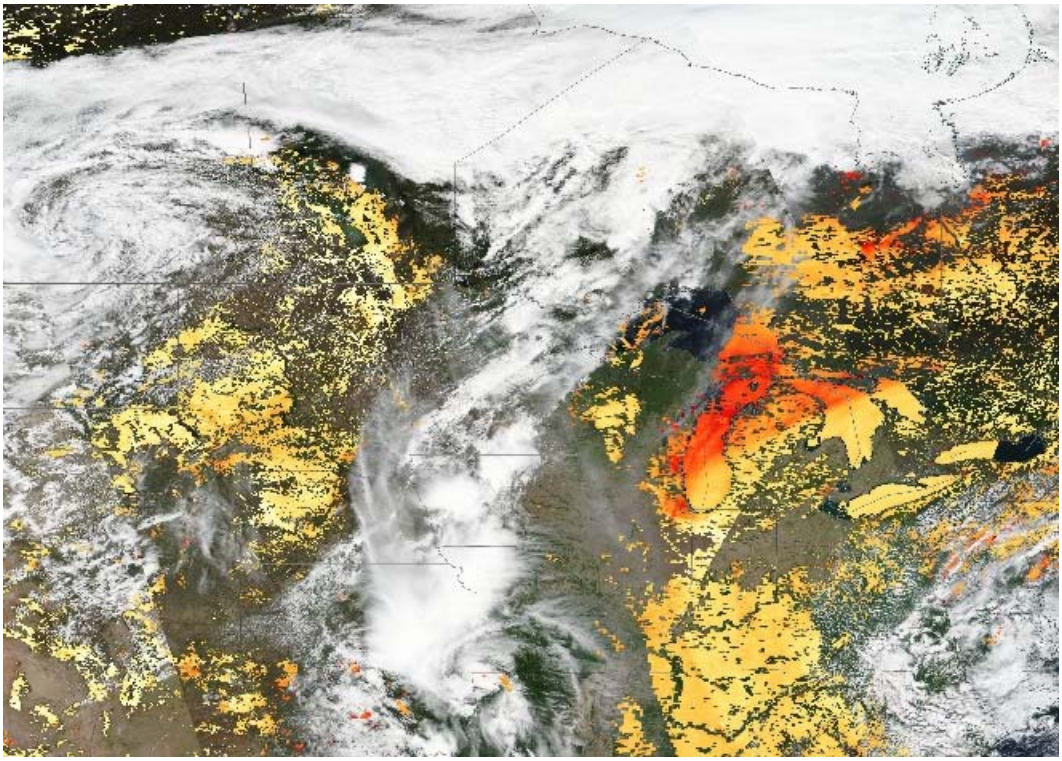

Figure 81. VIIRS Satellite Image with Aerosol Optical Depth for May 23, 2016

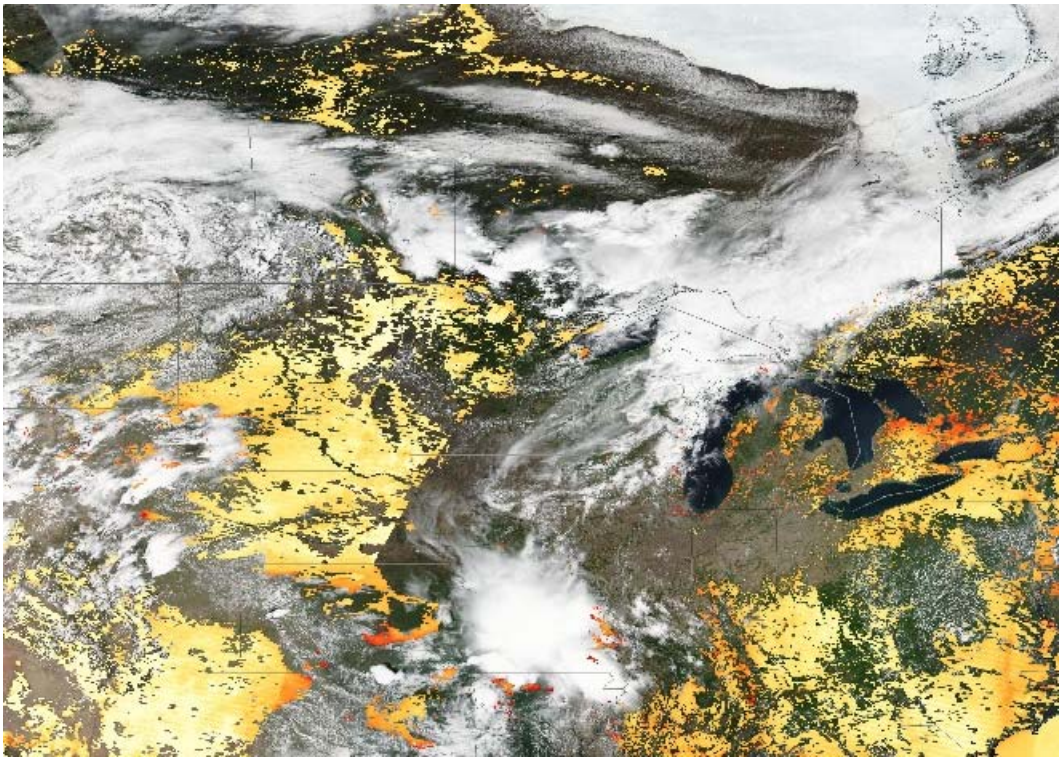

Figure 82. VIIRS Satellite Image with Aerosol Optical Depth for May 24, 2016

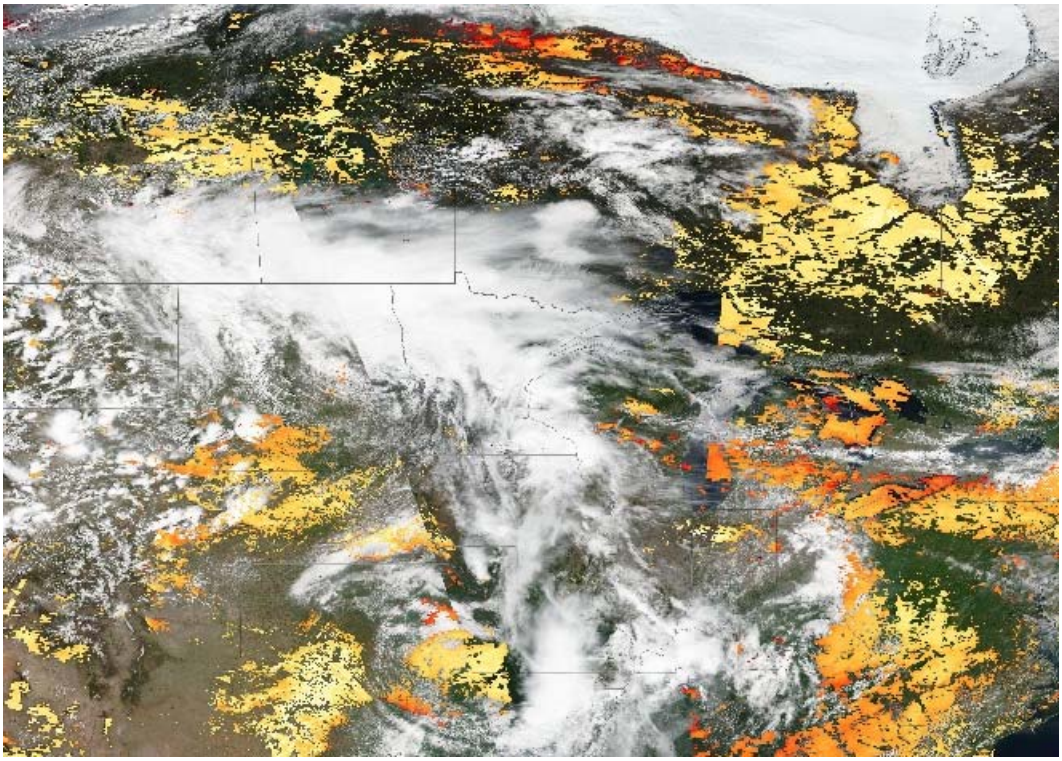

Figure 83. VIIRS Satellite Image with Aerosol Optical Depth for May 25, 2016

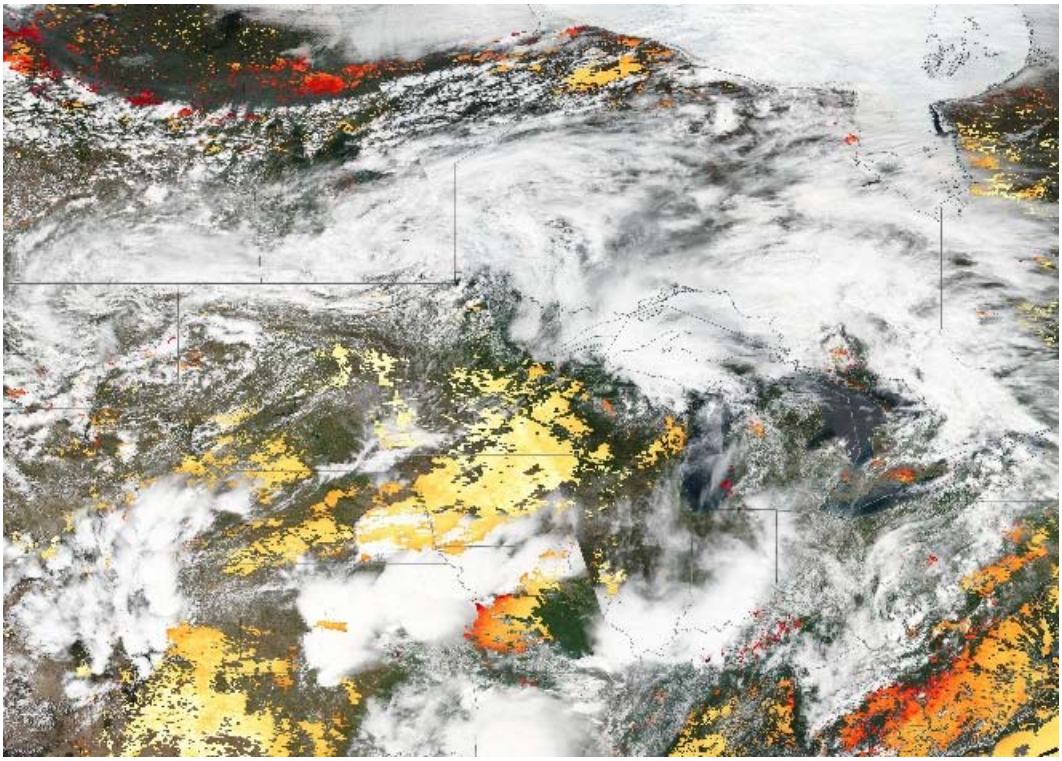

Figure 84. VIIRS Satellite Image with Aerosol Optical Depth for May 26, 2016

Evidence that the Fire Emissions Affected the Monitor

The following description of pollutants which can act as tracers of wildfire emissions is adapted from the Exceptional Event demonstration submitted by the CT DEEP (Appendix B) and Maryland's Exceptional Event demonstration for Canadian Wildfires during July 2016[26].

Ohio EPA's monitoring network observes both total $PM_{2.5}$ mass and speciated compounds such as ionic potassium (K+) and organic carbon (OC), as well as other pollutants such as carbon monoxide (CO) and black carbon (BC) which can act as tracers of wildfire emissions.

Ohio EPA examined hourly ozone, $PM_{2.5}$ and CO at two National Core multi-pollutant monitoring station (NCore) sites for additional weight of evidence: the GT Craig monitor (39-035-0060) in the Cleveland area and the Taft NCore monitor (39-061-0040) in the Cincinnati area. Both monitors are located in urban areas and monitor for multiple parameters. Neither monitor is included in the request for data exclusion; although both were affected by the event, the impact was determined not to have regulatory significance. However, an analysis of the hourly ozone, $PM_{2.5}$ and CO in the days

[26] http://www.mde.state.md.us/programs/Air/AirQualityMonitoring/Documents/MDE_JUL_21_22_2016_EE_demo.pdf

around the event is illustrative of the impact to the monitors in the Cleveland and Cincinnati areas included in the request for data exclusion.

As shown in Figure 85, the GT Craig NCore monitor (39-035-0060) in the Cleveland area experienced an increase in CO, followed by $PM_{2.5}$, in the day prior to the spike in ozone concentrations. The increase in CO along with $PM_{2.5}$ is indicative of the arrival of the smoke plume and associated ozone precursors.

Likewise, Figure 86 shows the Taft NCore monitor (39-061-0040) in the Cincinnati area experienced an increase in CO prior to the spike in ozone concentrations indicative of the smoke plume. This monitor did not experience a significant increase in $PM_{2.5}$; however, $PM_{2.5}$ is not included in the request for data exclusion in the Cincinnati area.

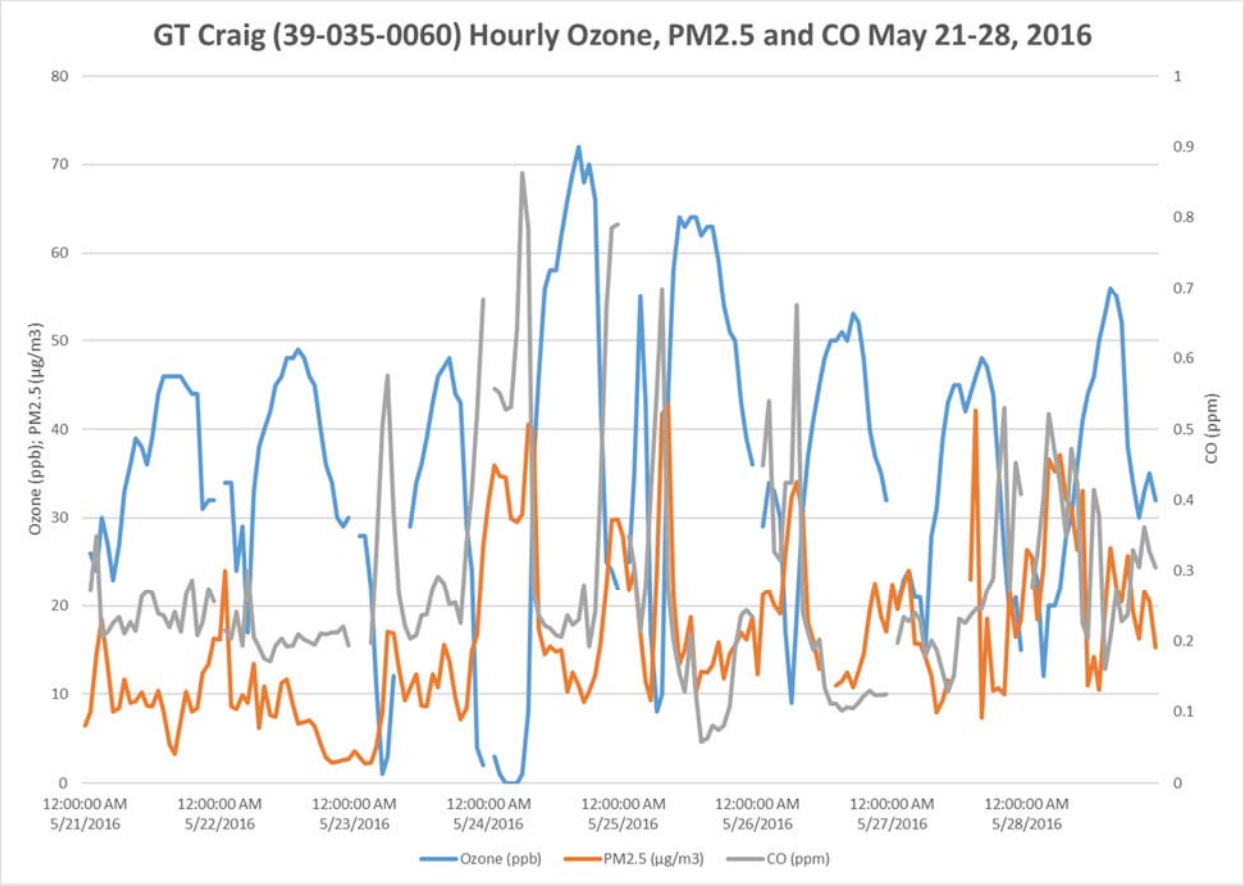

Figure 85. Hourly Ozone, $PM_{2.5}$ and CO at GT Craig (39-035-0060), May 21-28, 2016

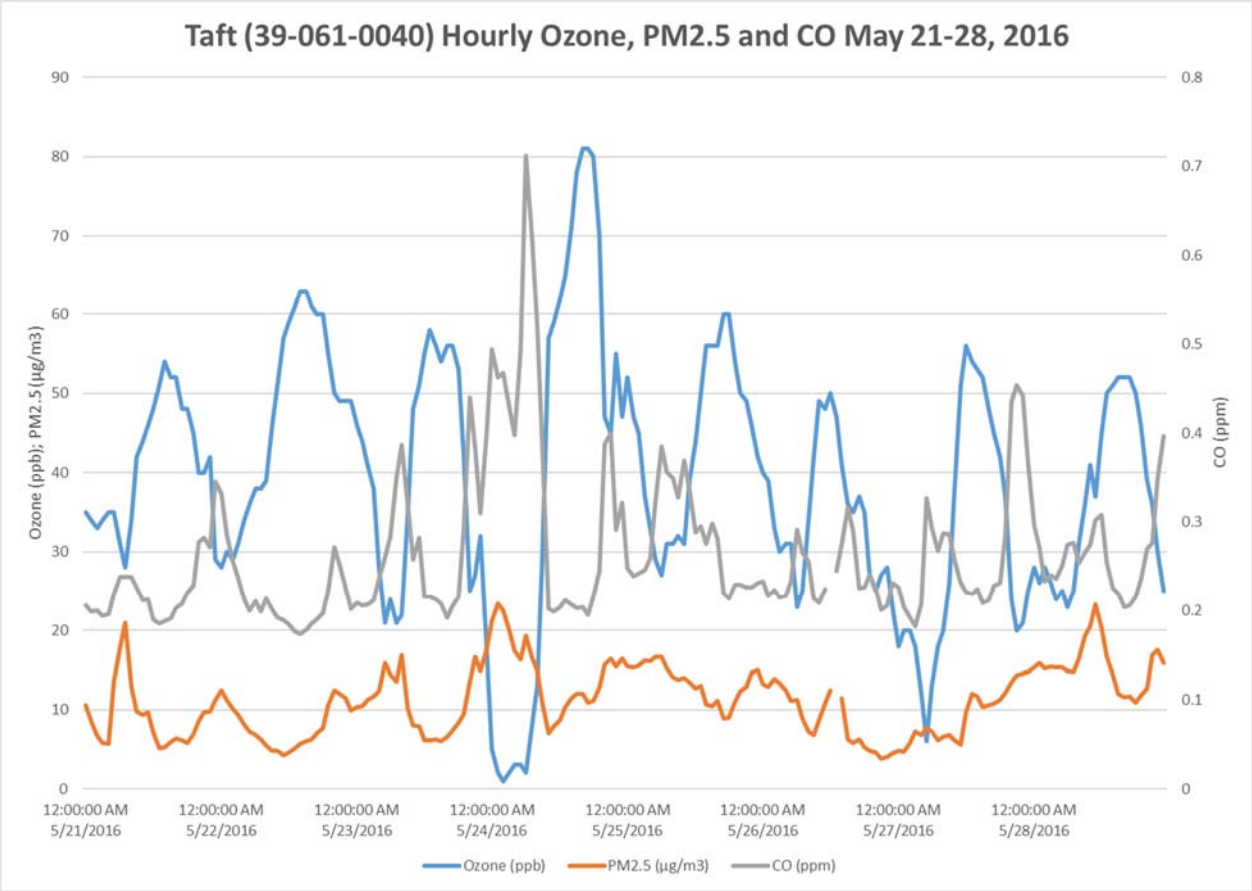

Figure 86. Hourly Ozone, $PM_{2.5}$ and CO at Taft (39-061-0040), May 21-28, 2016

Ohio has one monitor that measures hourly BC via an Aethalometer at the Cincinnati Near Road (Cinci_NR, 39-061-0048) site in Hamilton county. While BC can also be sourced from mobile emissions, globally one-third of BC is sourced from biomass burning, such as forest fires[27, 28]. As shown in Figure 87, this monitor experienced an increase in BC on May 23 and 24, indicative of the arrival of the smoke plume and associated ozone precursors.

[27] Lamarque, J-F., T. C. Bond, V. Eyring, C. Granier, A. Heil, Z. Klimont, and D. Lee, Historical (1850–2000) gridded anthropogenic and biomass burning emissions of reactive gases and aerosols: Methodology and application. Atmos.Chem. Phys. 10(15): 7017–39, 2010.
[28] US EPA, Black carbon, 2010. http://www3.epa.gov/blackcarbon/index.html

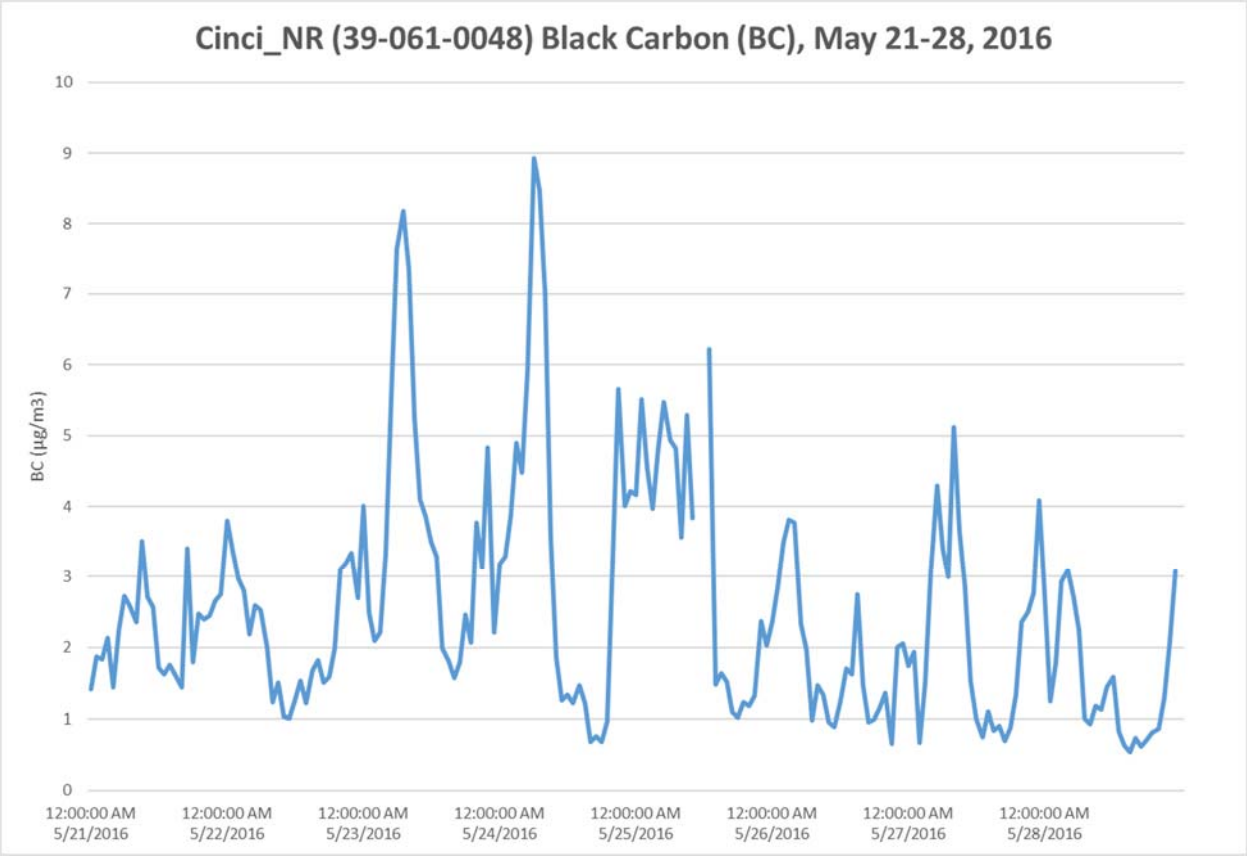

Figure 87. Hourly Black Carbon at Cinci NR (39-061-0048), May 21-28, 2016

Ohio also has several monitors in the Chemical Speciation Network (CSN). CSN sites in the Cleveland area include the GT Craig NCore monitor (39-035-0060) and the St. Theo monitor (39-035-0038) in Cuyahoga county, and Barr School (39-093-3002) monitor in Lorain County. A CSN site in the Cincinnati area is located at the Taft NCore monitor (39-061-0040) in Hamilton County.

Organic carbon (OC) and potassium (K) are most closely associated with wildfire emissions. Ionic potassium (K+) acts as a useful tracer of wildfire smoke because there are few anthropogenic sources, and concentrations above background levels are a signature of wildfire emissions.[29]

Figures 88 to 91 show that K and/or K+, along with OC, increased around the time of the elevated ozone on May 24, 2016, providing further support for the presence of a wildfire smoke plume over the area during that time.

Several sites show multiple peaks which could be contributed to the meandering and extended nature of the smoke plume. These additional peaks may not correlate to an

[29] Lee, T., A.P. Sullivan, L. Mack, J.L. Jimenez, S.M. Kreidenweis, T.B. Onasch, and D.R. Worsnop, Chemical smoke marker emissions during flaming and smoldering phases of laboratory open burning of wildland fuels. Aerosol Science and technology 44(9): i–v, 2010.

increase in ozone or $PM_{2.5}$ where the meteorological conditions for formation did not occur.

Additional speciation analysis at sites in the Upper Midwest is available in the Exceptional Event demonstration submitted by the CT DEEP (Appendix B), providing further evidence of the regional smoke plume.

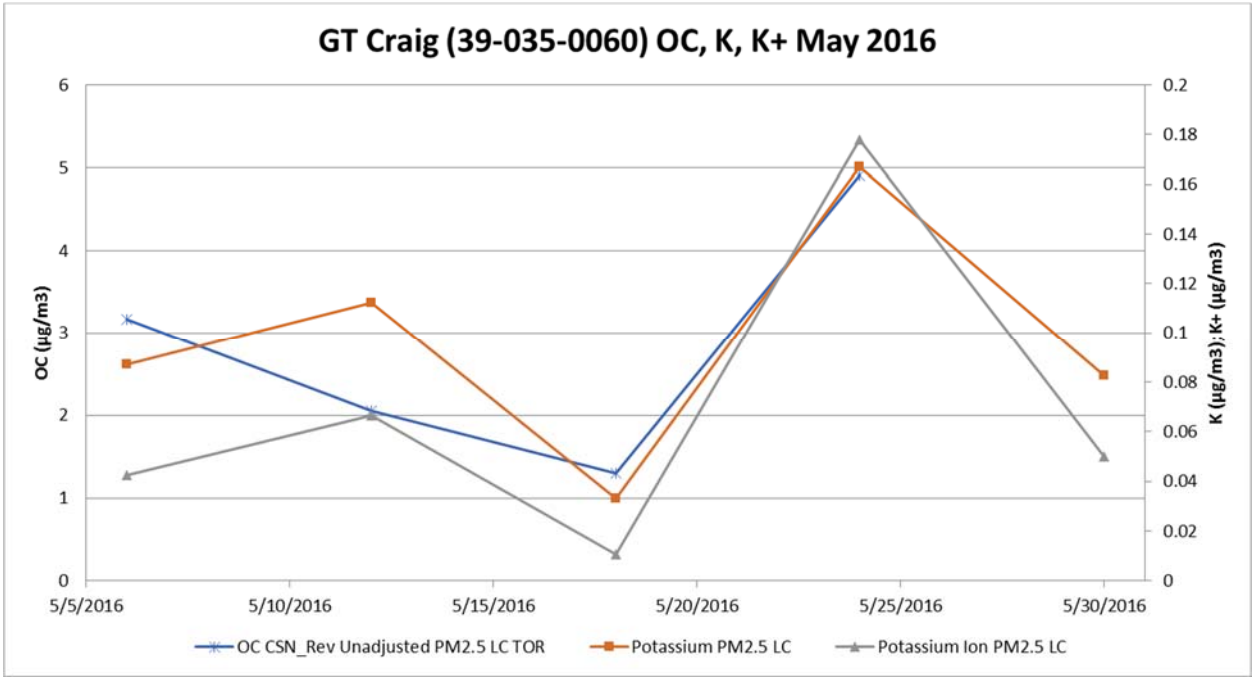

Figure 88. GT Craig (39-035-0060) CSN Data, May 2016

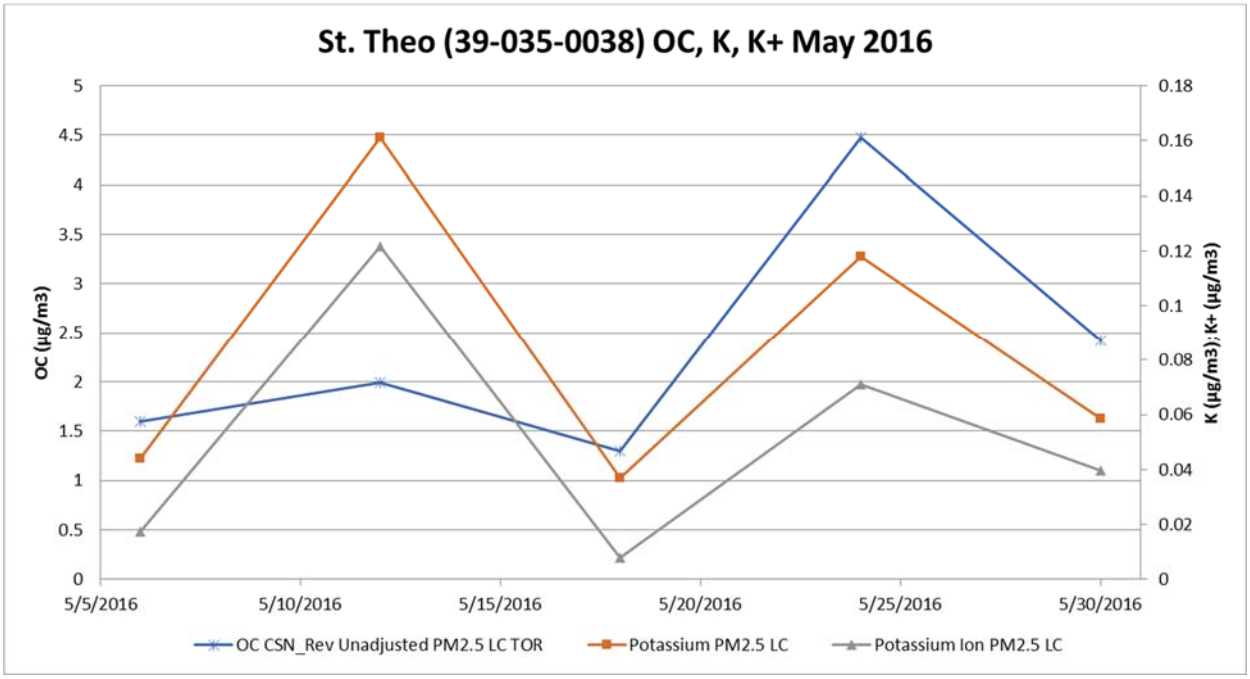

Figure 89. St. Theo (39-035-0038) CSN Data, May 2016

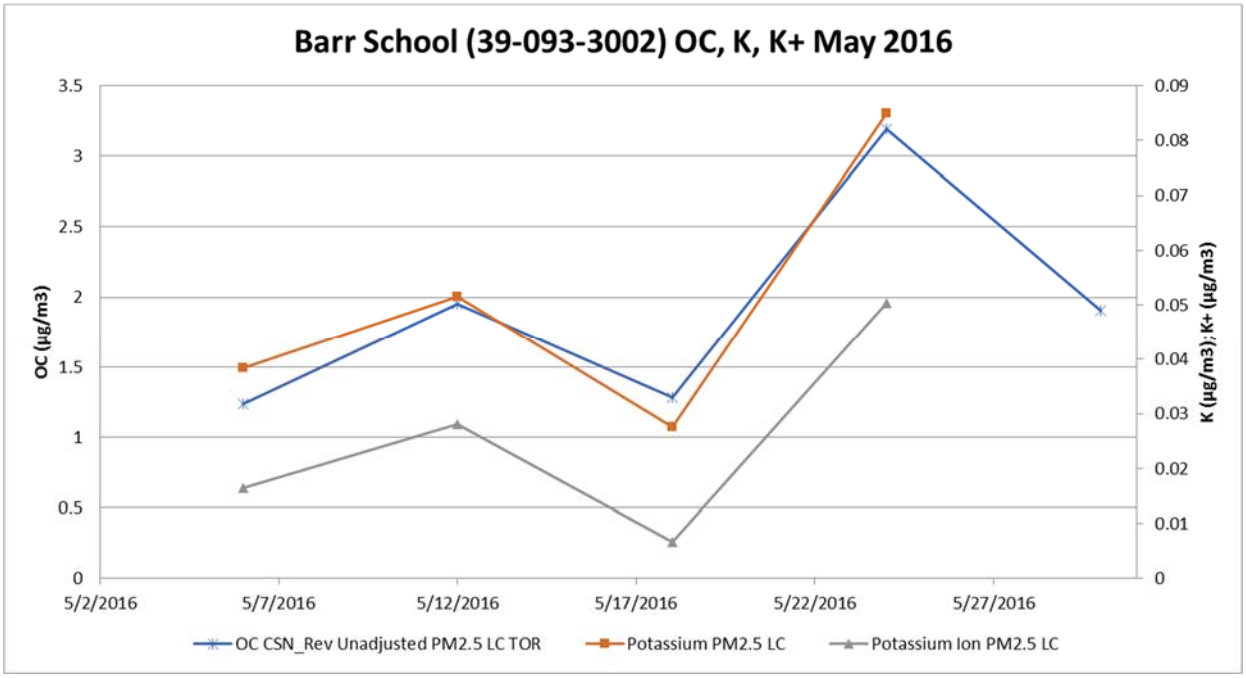

Figure 90. Barr School (39-093-3002) CSN Data, May 2016

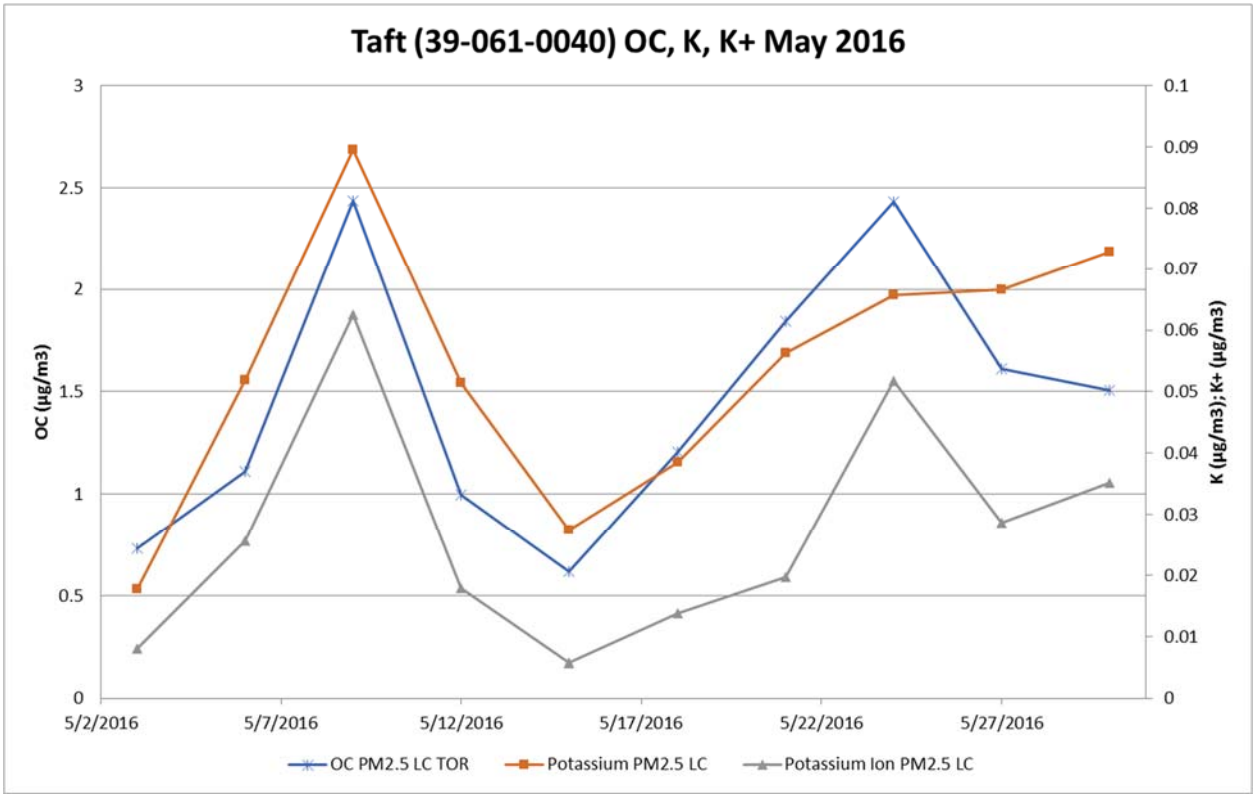

Figure 91. Taft (39-061-0040) CSN Data, May 2016

Additional Evidence that the Fire Emissions Caused the Ozone and $PM_{2.5}$ Exceedances

Electric Generating Unit (EGU) NOx Emissions

EGU emissions were examined to determine if they caused the exceedance. As shown previously in Figure 6, EGU NOx emissions were lower during the smoke event than any other year since at least 2012. Figure 92 shows the actual total daily NOx emissions from EGUs in Ohio, Illinois, Indiana, Kentucky, and Michigan for the 2016 ozone season. Plotted on the right hand axis, as orange bars, are the number of monitors included in this request for data exclusion that exceeded the 70 ppb NAAQS each day. Clearly, the May 24 and 25 ozone event had the most monitored daily exceedances of the summer, except June 11 which was unusually hot with a high temperature of 94°F. Peak NOx emissions from these facilities did not occur until later in the season, yet there were far fewer ozone exceedances. Therefore, the exceedances of May 24 and 25, 2016 cannot be attributed to EGU operation.

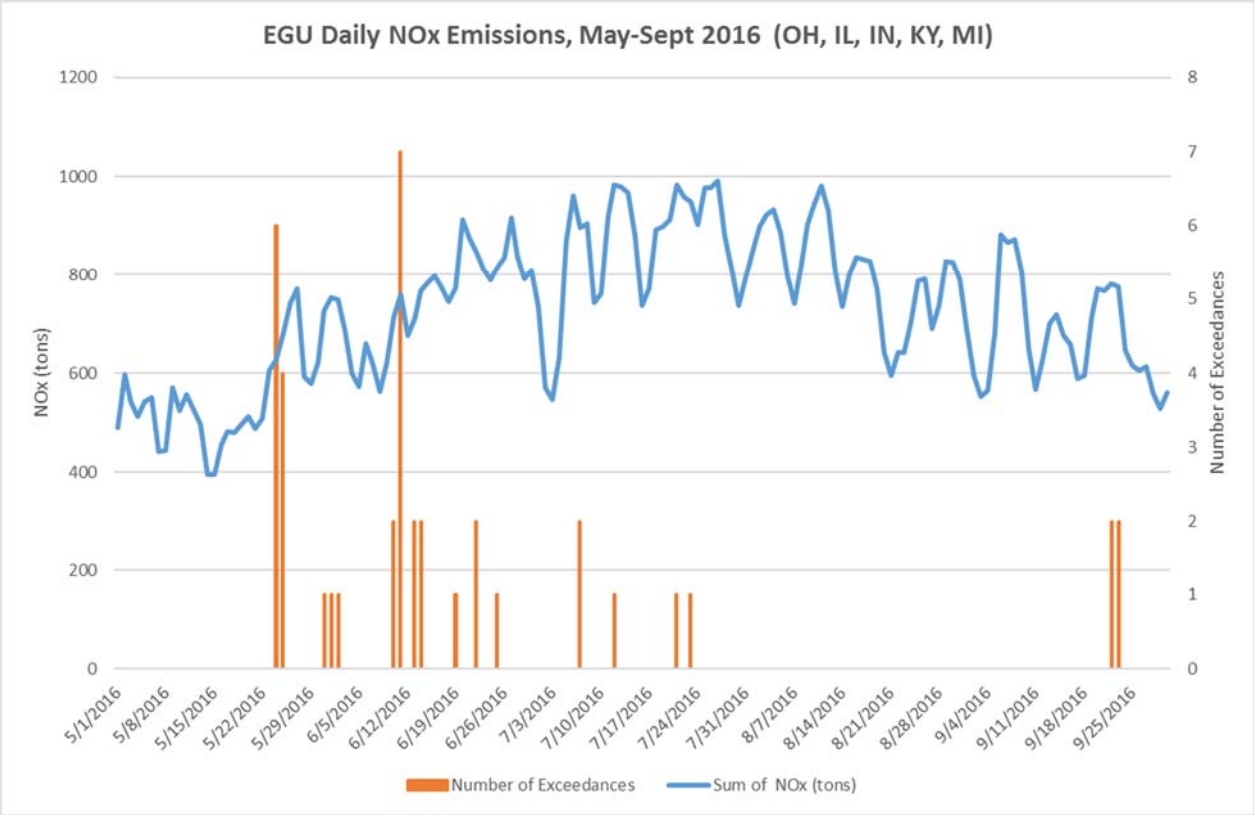

Figure 92. EGU Daily NOx Emissions, May-Sept 2016 (OH, IL, IN, KY, MI)

Similar Day Analysis

A similar day analysis attempts to identify days which are similar in pattern and characteristics (temperatures, winds, transport regime) but without the burden of smoke on ozone production. In a comparison of such days, affected monitors should show substantially less ozone when not impacted by smoke.

May 24, 2016 was used as the target day. It was a clear, sunny day, turning scattered/partly cloudy, with a high temperature of 82 degrees Fahrenheit, calm to light surface winds from the southwest and upper air from the northwest. To isolate similar days within the past five years, days reaching at least 80°F at KCLE airport were identified. From that list, days with surface winds less than 6 m/s from the southwest (>180° and <270°) narrowed the group further. From those potential days, 72-hour HYSPLIT back-trajectories were reviewed along with surface pressure, 850 mb upper air and 700 upper air pressure maps, and upper air soundings from KBUF for the Cleveland area and KILN for the Cincinnati area. Those days subjectively similar to the pattern on May 24, 2016 over the Ohio region determined the final group of days used for similar day comparisons.

There were no days that closely matched the meteorological patterns on May 24, 2016. Four days were determined to have loose similarity and were used for comparison. Figures 93 to 97 show 72-hour Hysplit back-trajectories along with Daily Ozone AQI

maps[30] for May 24, 2016 along with comparison days June 27, 2012, July 25, 2012, June 15, 2014 and July 25, 2015. All comparison trajectories generally show transport from the north. On all days except June 27, 2012, the trajectories also loop around the Cincinnati and Cleveland metropolitan areas picking up those emissions, consistent with the pattern on May 24, 2016. Tables 6 and 7 provide the maximum daily 8-hour ozone and $PM_{2.5}$ values on the comparison days at the monitors requested for data exclusion.

Based on the similar day analysis, no other day since 2012 which had similar meteorological characteristics produced similar levels of ozone. While there were exceedances of 70 ppb on June 27, 2012, the ozone levels were 3 to 11 ppb lower than on May 24, 2016. In addition, June 27, 2012 was warmer (86°F), and there have been significant emissions reductions since 2012.

July 25, 2012 was also warmer (89°F in Cleveland) with higher emissions, yet had lower ozone and $PM_{2.5}$ levels in the Cleveland area. In the Cincinnati area, July 25, 2012 is not meteorologically similar to May 24, 2016, as the back-trajectories show transported emissions from the west rather than the north, and the high temperature was 100°F. Therefore, the June 25, 2012 ozone values in the Cincinnati area should not be included in the analysis.

June 15, 2014 and July 25, 2015 are better comparisons, with a high temperature of 83°F and 87°F respectively, and more comparable emissions (yet still higher than those in 2016). Compared to May 24, 2016, ozone was 7 to 28 ppb lower on June 15, 2014 and 8 to 28 ppb lower on July 25, 2015. $PM_{2.5}$ was also significantly lower around these days than on May 24, 2016.

This evidence suggests the May 24, 2016 exceedance event was influenced by factors not explained by a similarity analysis, lending support to the conclusion that the influence of wildfire smoke created the ozone and $PM_{2.5}$ exceedances on May 24 and 25, 2016.

[30] Note, due to the change in the ozone standard, the AQI color scale on the 2016 map is based on orange being greater than 70 ppb. Earlier years use 75 ppb for orange.

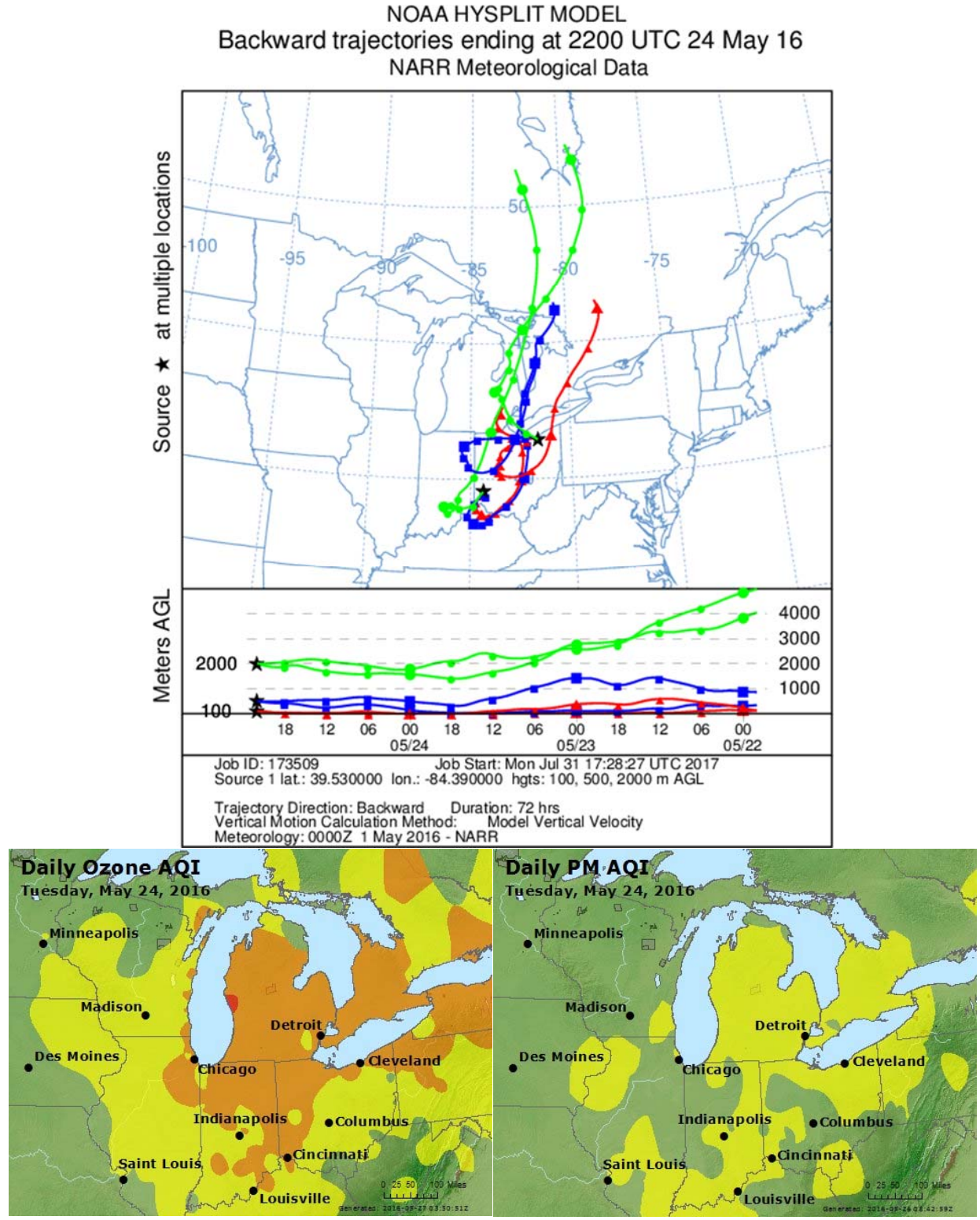

Figure 93. HYSPLIT back-trajectory (top), Daily Ozone AQI (bottom left) and Daily $PM_{2.5}$ AQI (bottom right) for May 24, 2016

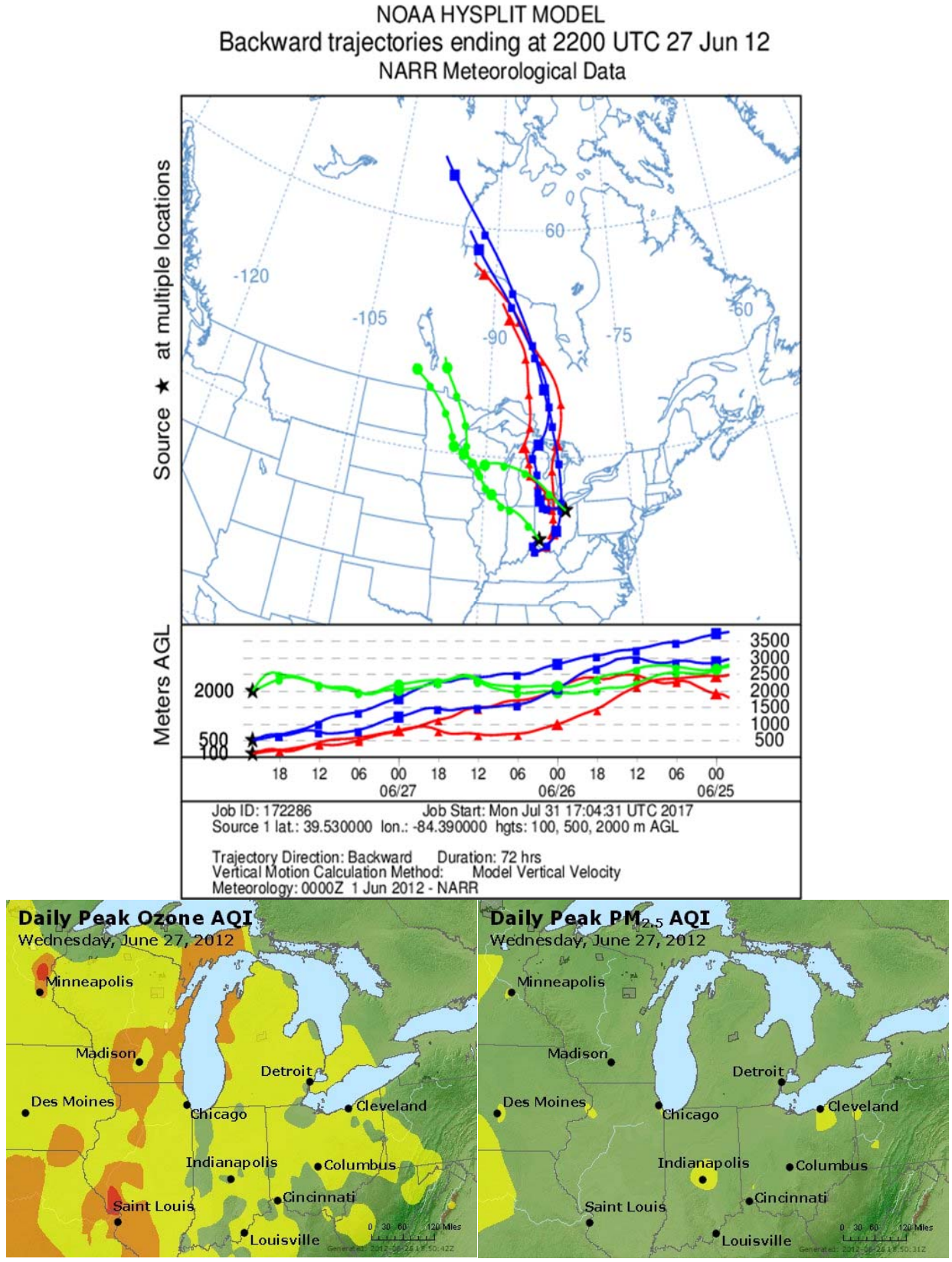

Figure 94. HYSPLIT back-trajectory (top), Daily Ozone AQI (bottom left) and Daily $PM_{2.5}$ AQI (bottom right) for June 27, 2012

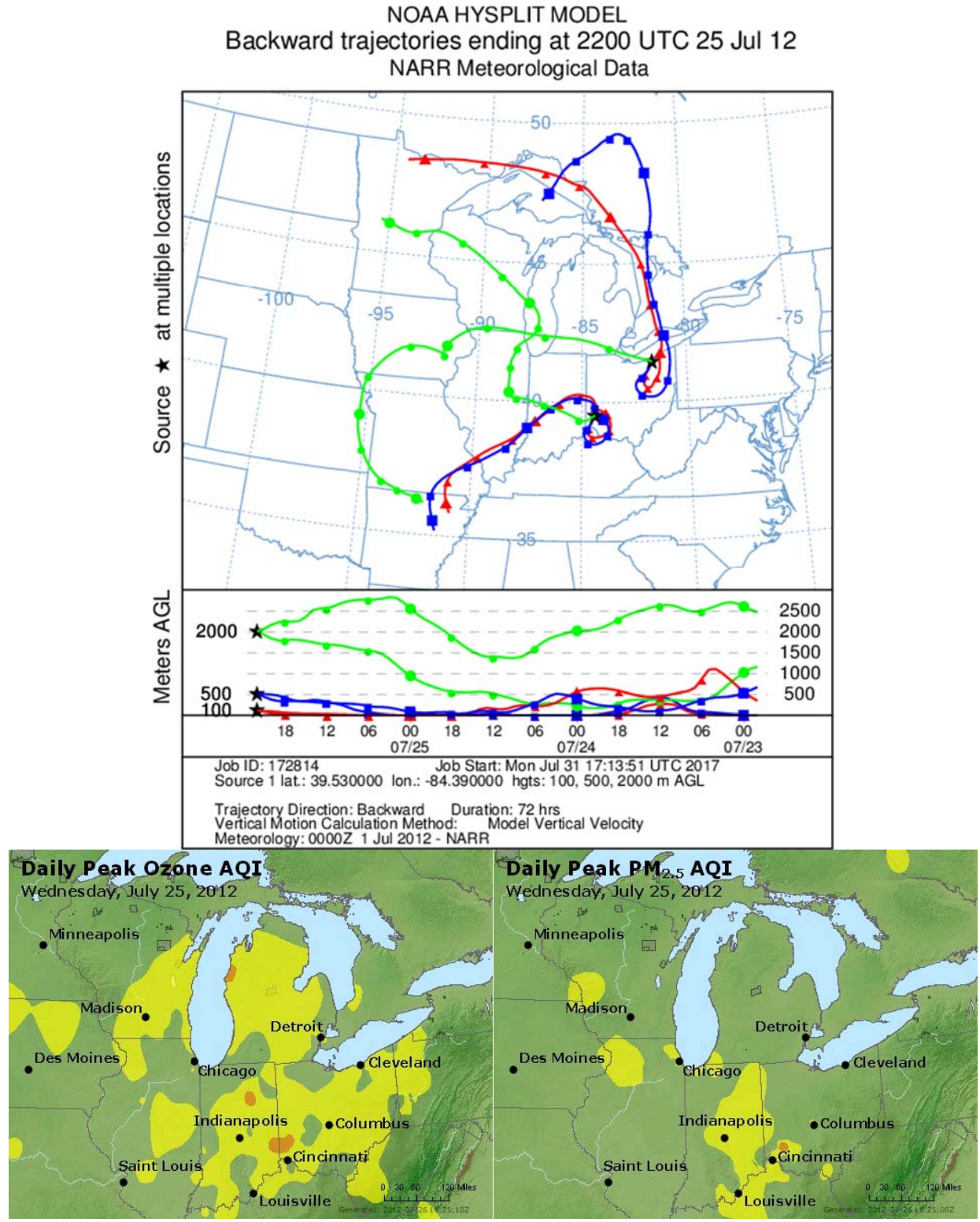

Figure 95. HYSPLIT back-trajectory (top), Daily Ozone AQI (bottom left) and Daily $PM_{2.5}$ AQI (bottom right) for July 25, 2012

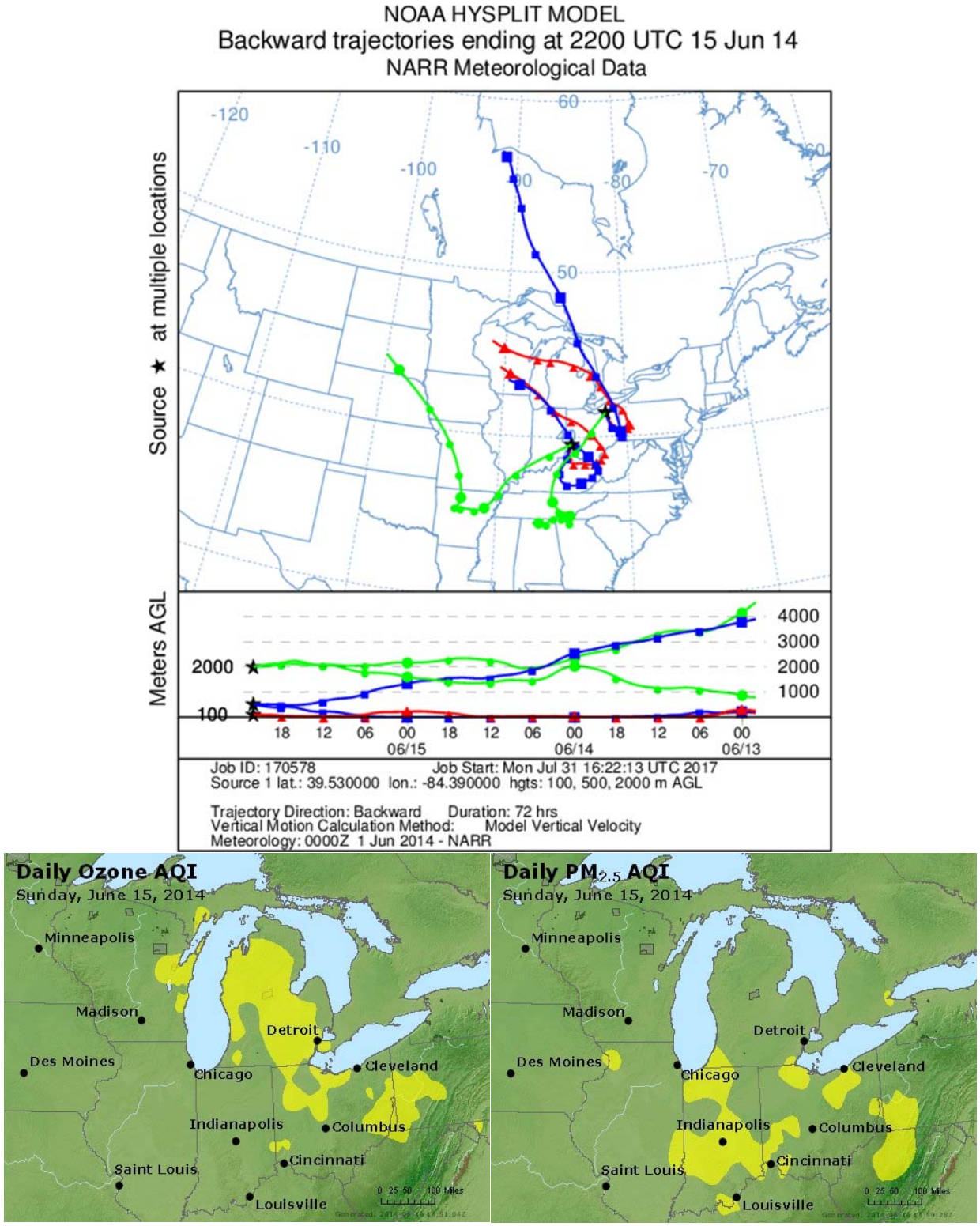

Figure 96. HYSPLIT back-trajectory (top), Daily Ozone AQI (bottom left) and Daily $PM_{2.5}$ AQI (bottom right) for June 15, 2014

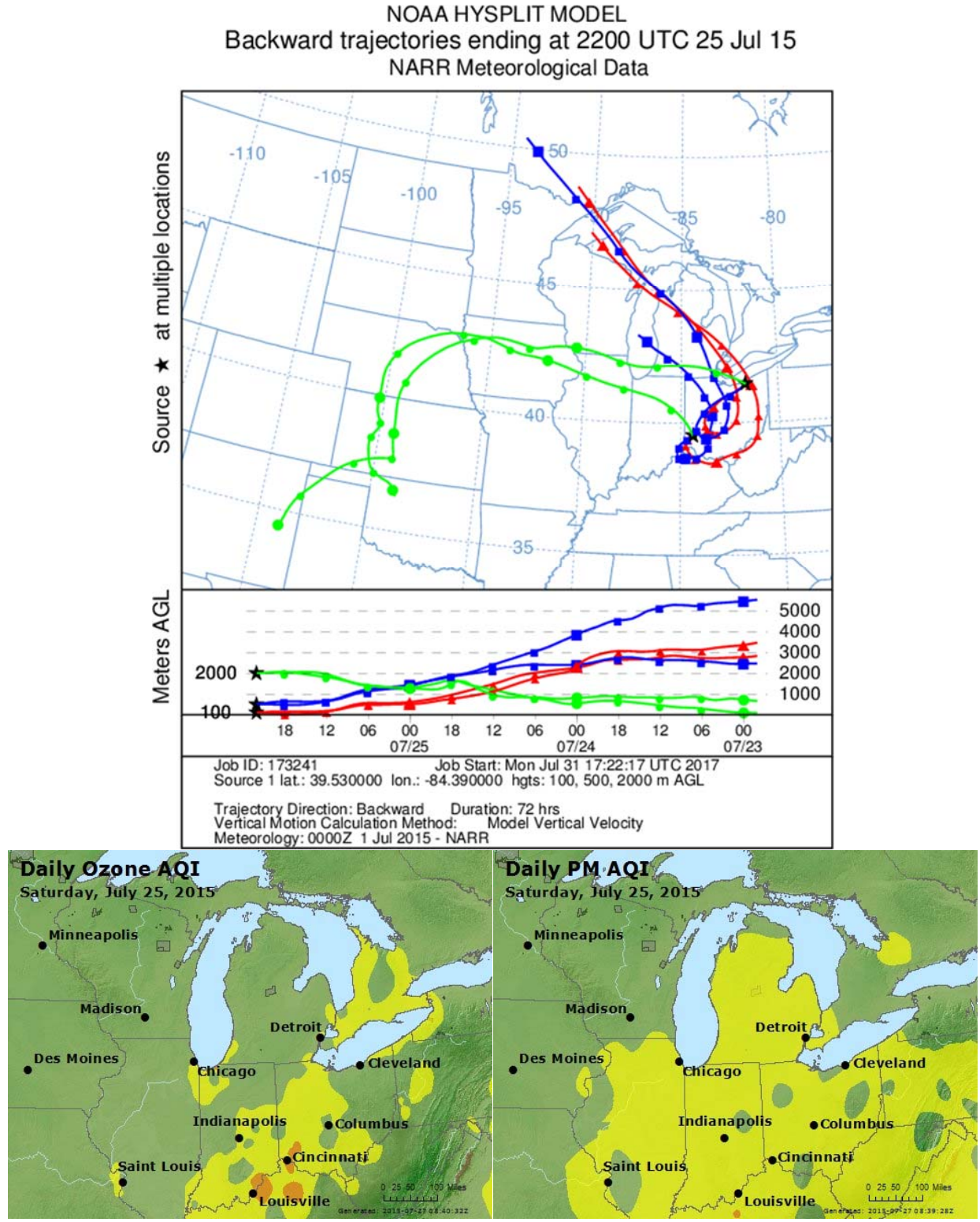

Figure 97. HYSPLIT back-trajectory (top), Daily Ozone AQI (bottom left) and Daily $PM_{2.5}$ AQI (bottom right) for July 25, 2015

Table 6. Similar Day Analysis: Comparison of Maximum Daily 8-hour Ozone Values

Area	Monitor ID	Site Name	County	Maximum Daily 8-hour Ozone (ppb)				
				5/24/16	6/27/12	7/25/12	6/15/14	7/25/15
Cleveland	39-035-0034	District	Cuyahoga	74	71	61	55	57
	39-035-5002	Mayfield	Cuyahoga	73	64	65	58	57
	39-055-0004	Notre Dame	Geauga	82	71	63	58	58
	39-085-0003	Eastlake	Lake	77	74	70	49	65
	39-093-0018	Elyria	Lorain	70	63	61	63	53
Cincinnati	39-017-0018	Midd	Butler	78	71	82*	60	70
	39-017-9991	Oxford	Butler	74	68	82*	60	36; 46[31]

*Not meteorologically similar to May 24, 2016

Table 7. Similar Day Analysis: Comparison of $PM_{2.5}$ Values

Area	Monitor ID	Site Name	County	$PM_{2.5}$ ($\mu g/m^3$)				
				5/24/16	6/27/12	7/25/12	6/15/14	7/25/15
Cleveland	39-035-0065	Harvard Yards	Cuyahoga	21.7	7.9; 24.2[32]	16.9; 16.2[33]	8.4; 17.3[34]	13.6; 13.7[35]

NOAA CMAQ Ozone Model Predictions

The following comparison of NOAA CMAQ Model predictions with actual ozone concentrations is adapted from the Exceptional Event demonstration submitted by the CT DEEP (Appendix B), with additional figures provided by the Maryland Department of the Environment.

The NOAA CMAQ model v.4.6 ('the model') has used wildfire particulate emissions since the summer of 2014, however, gaseous wildfire emissions, which would have included ozone precursors, have not been input into the ozone forecast which would likely lead to under-prediction of wildfire induced ozone events. Although this model has issues about land/water interfaces and using the most up-to-date emissions inventory, it is generally a reliable tool for the air quality forecaster.

It is widely recognized that the model over-estimates ozone concentrations in the U.S. during the mid-summer, however, in the May 24 and 25, 2016 case, the model is greatly under-predicting the observed ozone levels.

[31] Not measured on date; adjacent measurements on 7/22/15 (36) and 7/27/15 (46) provided
[32] Not measured on date; adjacent measurements on 6/26/12 (7.9) and 6/29/12 (24.2) provided
[33] Not measured on date; adjacent measurements on 7/23/12 (16.9) and 7/26/12 (16.2) provided
[34] Not measured on date; adjacent measurements on 6/13/14 (8.4) and 6/16/14 (17.3) provided
[35] Not measured on date; adjacent measurements on 7/23/15 (13.6) and 7/26/15 (13.7) provided

Maryland Department of the Environment air quality staff analyzed gridded model output for May 2016 over the eastern U.S. domain and have plotted the model bias from the observed daily maximum 8-hour ozone average. Since the model does not assimilate the gaseous smoke emissions into the ozone calculations, the model shows a strong negative bias over the region of the smoke plume. Figures 98 and 99 show the model to observation differences for May 24 and 25, 2016, with areas in Ohio showing up to negative 27 ppb model bias. The strength of this bias on such a large area indicates the magnitude of the impact that the plume likely had on the region.

Figure 100 shows the model to observation differences from May 18 to 28, 2016 specifically for the monitors requested for data exclusion. Table 8 shows the model to observation differences on May 24 and 25, 2016, specifically for the monitors requested for data exclusion. The model under-predicted ozone between 18 and 27 ppb on May 24, 2016 and between 8 and 20 ppb on May 25, 2016.

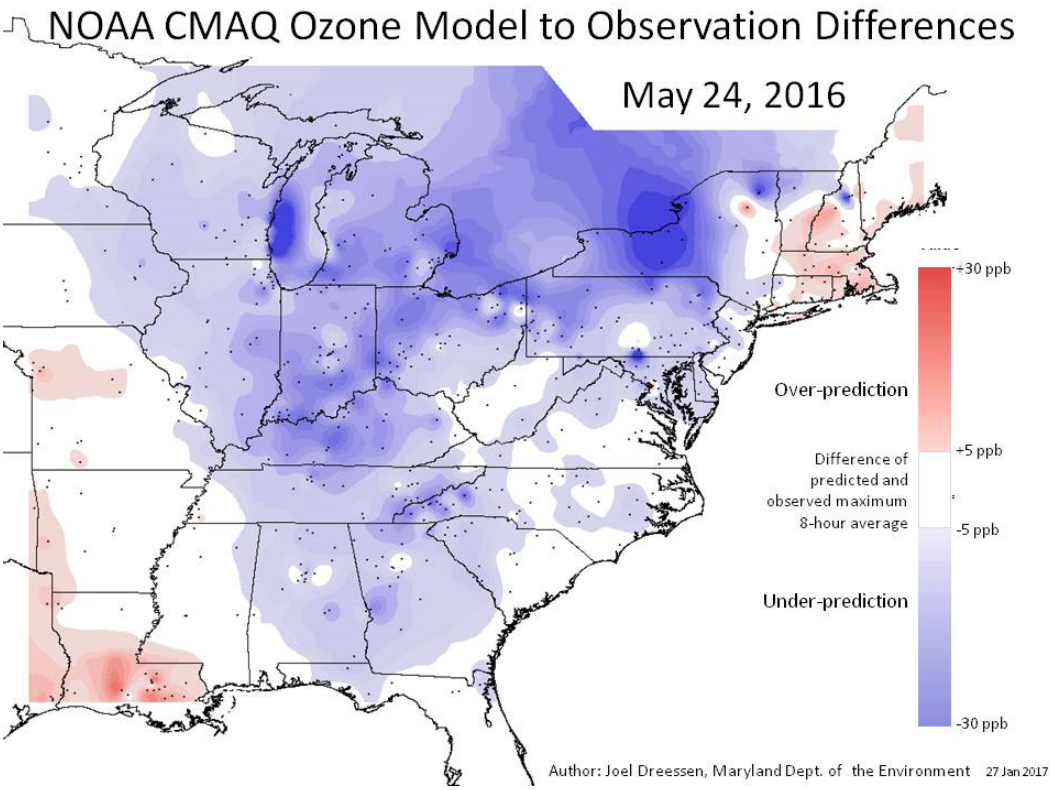

Figure 98. NOAA CMAQ Ozone Model to Observation Differences, May 24, 2016

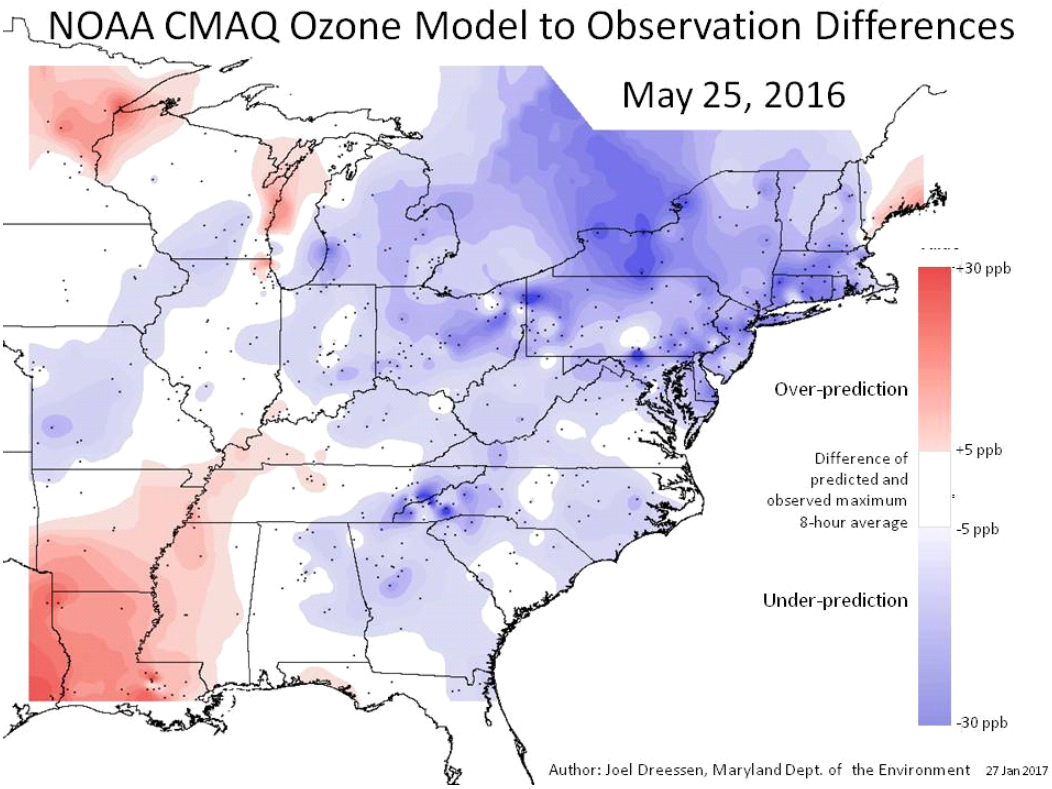

Figure 99. NOAA CMAQ Ozone Model to Observation Differences, May 25, 2016

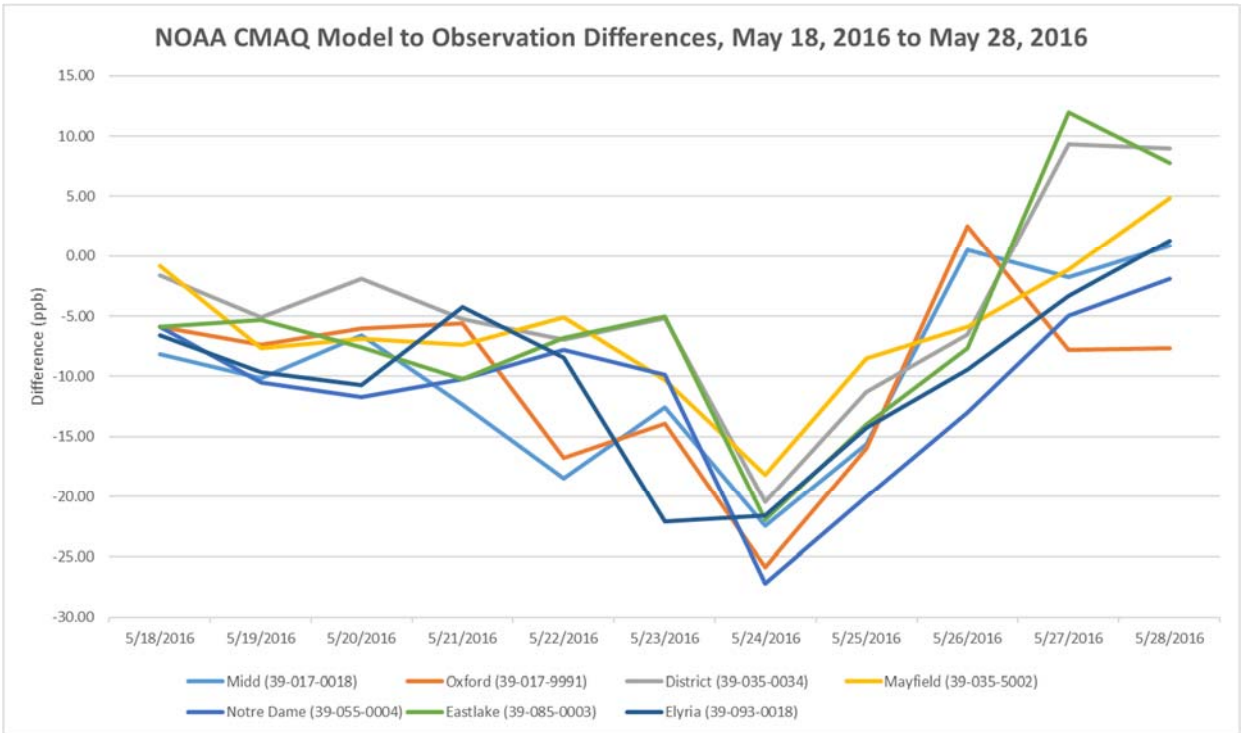

Figure 100. NOAA CMAQ Ozone Model to Observation Differences, May 18 to 28, 2016

Table 8. NOAA CMAQ Ozone Model to Observation Differences, May 24 and 25, 2016

Area	Monitor ID	Site Name	County	CMAQ Model to Observation Difference (ppb)	
				5/24/2016	5/25/2016
Cleveland	39-035-0034	District	Cuyahoga	-20.46	-11.26
	39-035-5002	Mayfield	Cuyahoga	-18.20	-8.50
	39-055-0004	Notre Dame	Geauga	-27.23	-20.05
	39-085-0003	Eastlake	Lake	-21.96	-13.99
	39-093-0018	Elyria	Lorain	-21.60	-14.24
Cincinnati	39-017-0018	Midd	Butler	-22.46	-15.63
	39-017-9991	Oxford	Butler	-25.84	-15.95

Conclusion - Clear Causal Relationship

On May 24 and 25, 2016, the Fort McMurray wildfire generated ozone, $PM_{2.5}$ and their precursors resulting in elevated concentrations at five ozone monitors and one $PM_{2.5}$ monitor in the Cleveland area, and at two ozone monitors in the Cincinnati area. The monitored ozone and $PM_{2.5}$ concentrations were unusually high given recent trends. Among the 11 instances for which ozone data exclusion is requested (7 monitors on 1 or 2 days, as specified in Table 1), all were among the four highest ozone concentrations in 2016, all were above the 97th percentile among data from 2012 to 2016, and 5 of the 11 instances were above the 99th percentile. The May 24, 2016 $PM_{2.5}$ data requested for exclusion is the third highest value in 2016 at a percentile of 98.3.

The meteorological conditions that existed during the event were likely not sufficient to have caused the ozone or $PM_{2.5}$ exceedances without the added burden of the additional wildfire-related precursor emissions. As the smoke plume aged and mixed with anthropogenic NOx, ozone and $PM_{2.5}$ concentrations accumulated to levels likely not possible without the smoke.

The comparisons and analyses provided above support Ohio EPA's assertion 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 specified in Table 1, and thus satisfies the clear causal relationship criterion.

D. Not Reasonably Controllable or Preventable

The May 2016 Fort McMurray wildfire was both not reasonably controllable and not reasonably preventable.

The Exceptional Events Rule presumes that wildfire events on wildland are not reasonably controllable or preventable [40 CFR §50.14(b)(4)]. 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."

Although authorities have been unable to officially determine the cause of the Fort McMurray wildfire, it is suspected to be the result of human activity as there was no evidence of lightning[36]. As such, the Fort McMurray fire qualifies as a wildfire as it was an unplanned ignition likely caused by human activity.

The fire was likely started in the wilderness area known as the Horse River Trail System. Despite intense management activities to suppress the fire, the wildfire impacted 589,000 hectares of land (1,500,000 acres) and 1,958 structures were lost or damaged[37]. As such, the Fort McMurray fire predominantly occurred on wildland.

Based on the documentation provided in this section, the Fort McMurray wildfire was caused by an unplanned ignition likely due to human activities on wildland. Ohio EPA is not aware of any evidence clearly demonstrating that prevention or control efforts beyond those actually made would have been reasonable. Therefore, emissions from this wildfire were not reasonably controllable or preventable.

E. A Natural Event

The May 2016 Fort McMurray wildfire was a natural event. The definition of "wildfire" at 40 CFR §50.1(n) states, "A wildfire that predominantly occurs on wildland is a natural event." Based on the documentation provided in Section D of this submittal, the event qualifies as a wildfire because an unplanned ignition likely due to human activities caused the unplanned wildfire event. The EPA generally considers the emissions of precursors from wildfires on wildland to meet the regulatory definition of a natural event at 40 CFR 50.1(k), defined as one 'in which human activity plays little or no direct causal role.' This wildfire event occurred on wildland as documented in Section D of this submittal, and accordingly, Ohio EPA has shown that the event is a natural event and may be considered for treatment as an exceptional event.

F. Procedural Requirements

Public Notification of the Event

The Exceptional Events Rule [40 CFR 50.14(c)(1)(i)] requires air agencies to "notify the public promptly whenever an event occurs or is reasonably anticipated to occur which may result in the exceedance of an applicable air quality standard." Ohio EPA posts

[36] CTV News, *Lack of lightning suggests a human caused Fort McMurray fire: professor*, May 4, 2016
[37] KMPG, *May 2016 Wood Buffalo Wildfire Post-Incident Assessment Report*, May 2017.

daily air quality forecasts available at: http://epa.ohio.gov/dapc/airohio/forecast.aspx and http://airnow.gov/.

Initial Notification of Potential Exceptional Event

The Exceptional Events Rule [40 CFR 50.14(c)(2)(i)] requires air agencies to notify U.S. EPA of its intent to request exclusion data due to an exceptional event by creating an initial event description and flagging the associated data in the AQS database. Ohio EPA submitted initial notification and event description on May 31, 2017 by email. Due to an issue with AQS, flagging the associated data was initially delayed, but the data has now been flagged.

Deadlines

The Exceptional Events Rule [40 CFR 50.14 Table 2] establishes an initial notification and demonstration submittal deadline for Exceptional Events demonstrations for data that will or may influence the initial designation of areas for any new or revised national ambient air quality standard. For 2016 data which may influence 2014-2016 design values and therefore impact designations under the 2015 ozone standard, the submittal deadline was May 31, 2017. Ohio EPA met this deadline with its submittal of a demonstration on May 31, 2017. Ohio EPA hereby submits a revised demonstration containing additional supportive analysis and weight of evidence.

Public Participation

The Exceptional Events Rule [40 CFR 50.14(c)(3(v)] requires air agencies to document that they followed the public comment process and that the comment period was open for a minimum of 30 days. Further, air agencies must submit any received public comments to U.S. EPA and address in their submission those comments disputing or contradicting the factual evidence in the demonstration.

Ohio published solicitation for public comment concerning the May 2016 Canadian Wildfire Ozone and $PM_{2.5}$ Exceptional Event Demonstration in the widely distributed county publications on August 24, 2017. The public comment period closed on September 27, 2017. Appendix C includes a copy of the public notice. This public comment period ran concurrent with U.S. EPA's review of the demonstration. No public comments were received during the comment period.

Mitigation Plan

The Exceptional Events Rule [40 CFR 51.930(b)] requires states having areas with historically documented or known seasonal events to develop and submit a mitigation plan. Ohio is not required to develop and submit a mitigation plan.

Summary

Ohio EPA's Exceptional Event demonstration shows that the May 2016 Fort McMurray wildfire adversely affected ozone and $PM_{2.5}$ data in a regulatory significant way, such that ozone and $PM_{2.5}$ data from May 24 and 25, 2016 for the monitors identified in Table 1 should be excluded from regulatory determinations.