Air Quality Monitoring

End of Season Report

Central Ohio: November 2016 through October 2017

The Mid-Ohio Regional Planning Commission (MORPC) is part of a network of agencies across the country that issues daily air quality forecasts and notifies the public when air pollution levels are considered to be unhealthy for sensitive groups of people. MORPC monitors for two main air pollutants that are a threat to public health in Central Ohio: ground-level ozone pollution and particle pollution ($PM_{2.5}$). Ozone pollution is more common in the summer and is monitored from March through October. Particle pollution can occur year round. High concentrations of ground-level ozone or particle pollution in the air can affect us all, especially sensitive groups of people. Sensitive groups include children, adults who are active outdoors, people with heart or lung disease (such as asthma) and older adults.

MORPC contracts with Sonoma Technology, Inc. (STI) to deliver year-round daily air quality forecasts and Air Quality Alerts. This report provides an analysis of the 2016-2017 season for both ozone and particle pollution.

Summary

- Overall, the majority of days were in the Good Air Quality Index (AQI) category in central Ohio. For ozone, 78% of summer days were in the Good AQI category. For $PM_{2.5}$, 93% of all days were in the Good AQI category.
- Two Unhealthy for Sensitive Groups (USG) AQI days were observed during the year, once on June 3rd and once on September 26th. The dominant pollutant was ozone on both days. There were no Unhealthy for Sensitive Groups AQI days for particle pollution. September 26th is the latest USG AQI day in the year for ozone on record.
- A similar trend of improving air quality can be seen across the wider region, including in Cleveland, Cincinnati and Indianapolis.
- Temperature and precipitation were both above average in Ohio over the past year, despite some month-to-month variation. In general, wetter months in the winter and cooler, wetter months in the summer lead to cleaner air quality conditions.
- The season's two highest $PM_{2.5}$ AQI days were both caused by smoke transport from wildfires outside of Ohio. On September 5, 2017, smoke was transported into the region from numerous large wildfires in California and the Pacific Northwest. On November 8, smoke was transported into the region from fires in the Great Smoky Mountains.

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Overview

Central Ohio: November 2016 through October 2017

Ozone Pollution

The Mid-Ohio Regional Planning Commission monitors and sends out forecasts and alerts for ground level ozone pollution levels from March through October. Ground-level ozone pollution is created when emissions from sources such as cars, industry and lawn equipment react chemically in the presence of sunshine. Concentrations of ground-level ozone peak when temperatures are warm, it's sunny and winds are light. Ozone is the main ingredient of smog.

Particle Pollution

The Mid-Ohio Regional Planning Commission monitors and sends out forecasts and alerts for particle pollution levels year round. Fine particle pollution ($PM_{2.5}$) is made of microscopically small solid or liquid particles. Some sources of these fine particles are diesel trucks, buses, power plants, and wood burning fireplaces. Concentrations of $PM_{2.5}$ often peak during overnight hours when cool air is trapped near the ground and pollution levels build in that layer of air. Particle pollution can also be transported into central Ohio over large distances, such as from distant wildfires, if weather conditions are right.

Air Quality Index (AQI)

The Mid-Ohio Regional Planning Commission issues daily forecasts and Air Quality Alerts to keep the public informed of local air pollution levels. MORPC uses the Air Quality Index to report pollution levels. The higher the AQI level the greater the health concern. When air pollution is expected to reach 101 AQI or above, MORPC will issue an Air Quality Alert for Central Ohio.

Air Quality Index	Health Advisory
Good 0-50	None.
Moderate 51-100	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups 101-150	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
Unhealthy 151-200	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
Very Unhealthy 201-300	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.

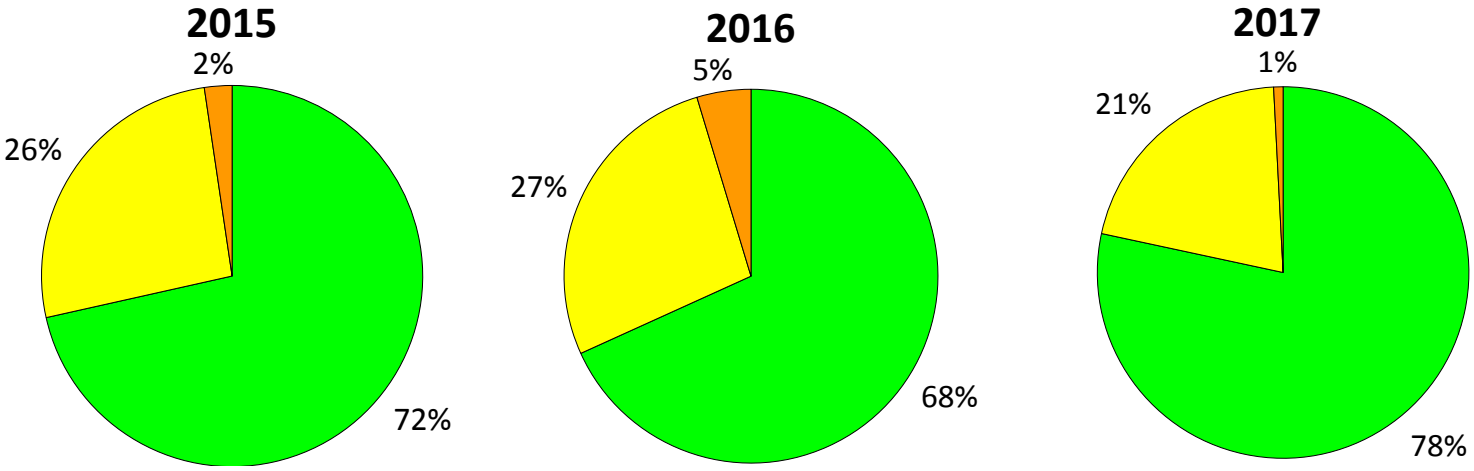
Overview

Central Ohio: November 2016 through October 2017

Air quality in the Columbus region has been steadily improving over the past three years. This past summer, ozone concentrations remained within the Good category of the Air Quality Index (AQI) on 75% of days, compared with 68% of days in 2016 and 72% of days in 2015 (see pie charts below). USG or greater AQI levels were observed on 1% of days in summer 2017, compared to 5% in 2016 and 2% in 2015.

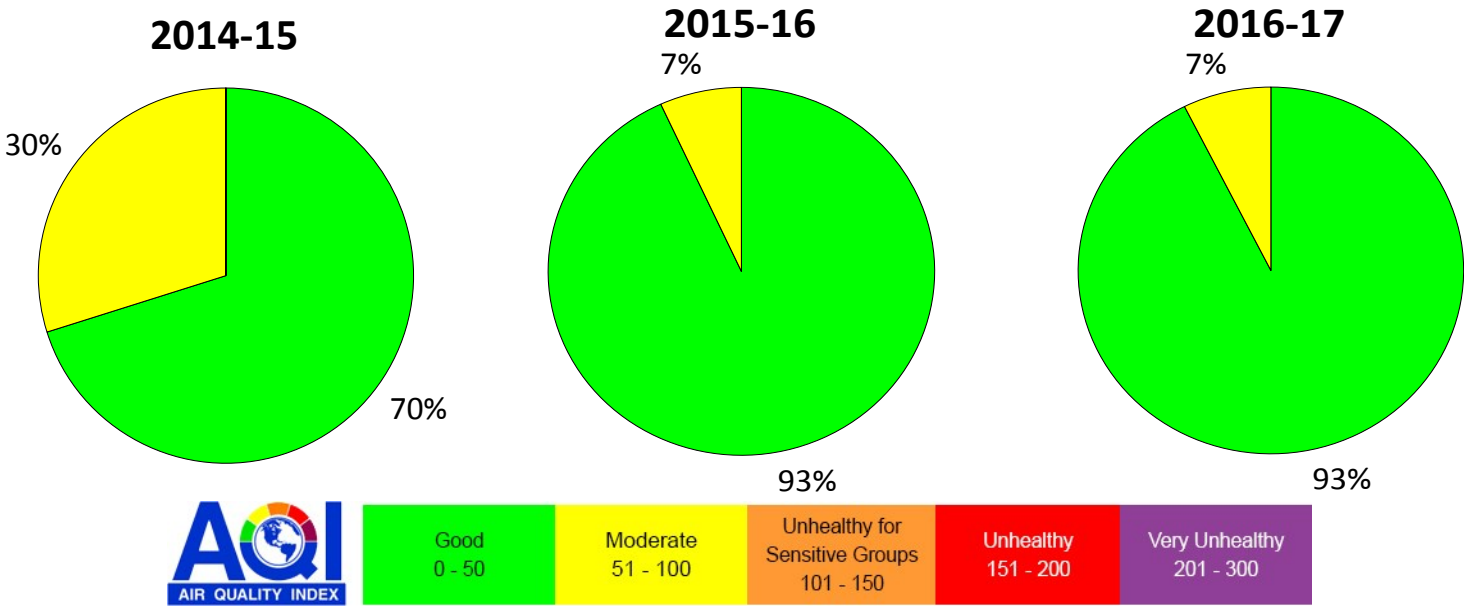
This past year, $PM_{2.5}$ concentrations were about the same as in 2015-16 and better than in 2014-15. Concentrations remained in the Good category on 93% of days and Moderate on 7% of days. No USG $PM_{2.5}$ days were observed during the past three years. At the bottom of this page is a reference guide for the AQI categories.

Ground-Level Ozone — Percentage of Days at Each AQI Level *



*The 2015 and 2016 ozone seasons were from April through October. The 2017 ozone season was from March through October.

$PM_{2.5}$ — Percentage of Days at Each AQI Level (Nov. 1 through Oct. 31)



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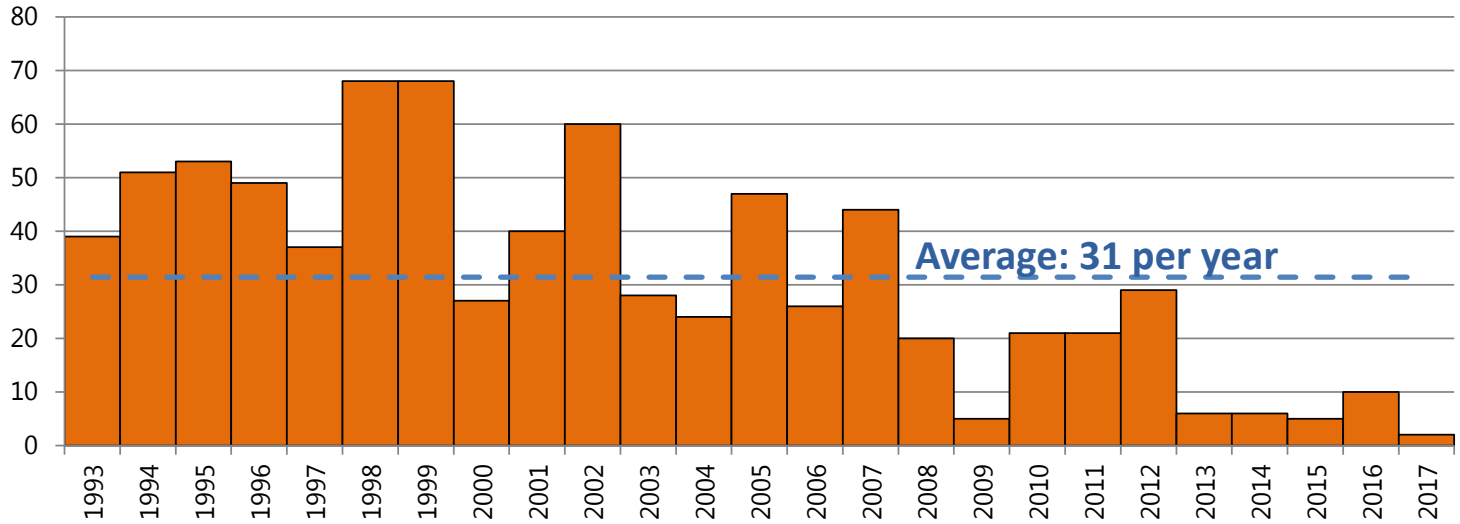
Regional Comparisons

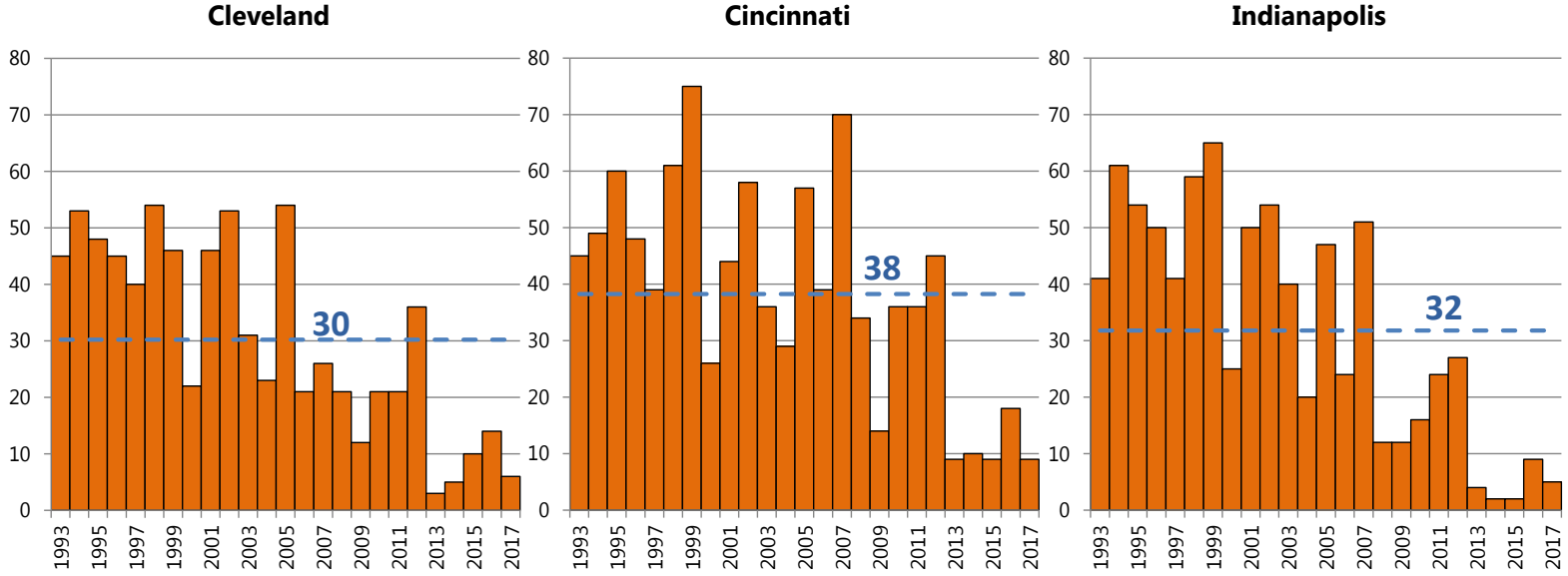
Central Ohio: November 2016 through October 2017

Over the past 25 years, the number of high ozone days (>70 ppb) has generally declined, driven mostly by emissions reductions. However, there is some variation from year to year driven by the weather conditions. The charts below indicate the yearly count of high ozone days since 1993 (orange bars) and the average number of high ozone days over the past 25 years (dashed blue line).

Number of days in Columbus with high ozone levels (>70 ppb)



Regional number of days with high ozone levels (>70 ppb)



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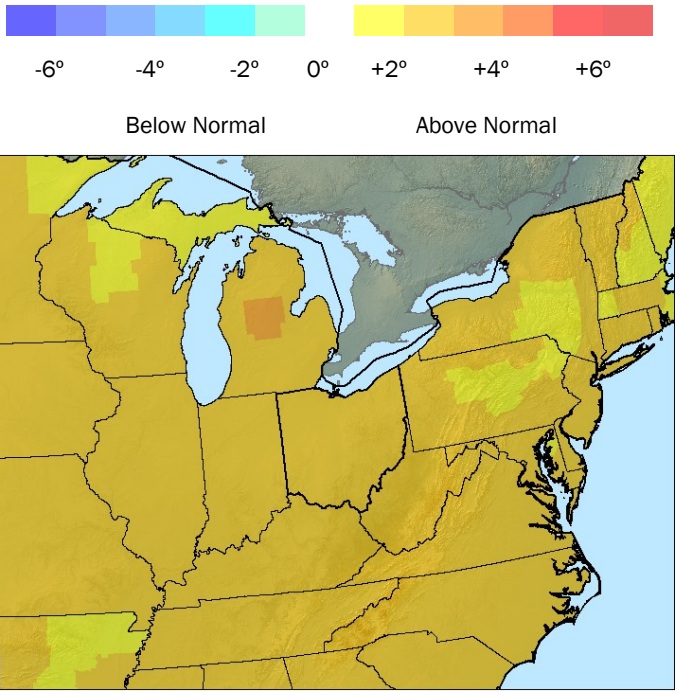
Weather and Air Quality Conditions

Air Quality and Weather Conditions in 2016-17

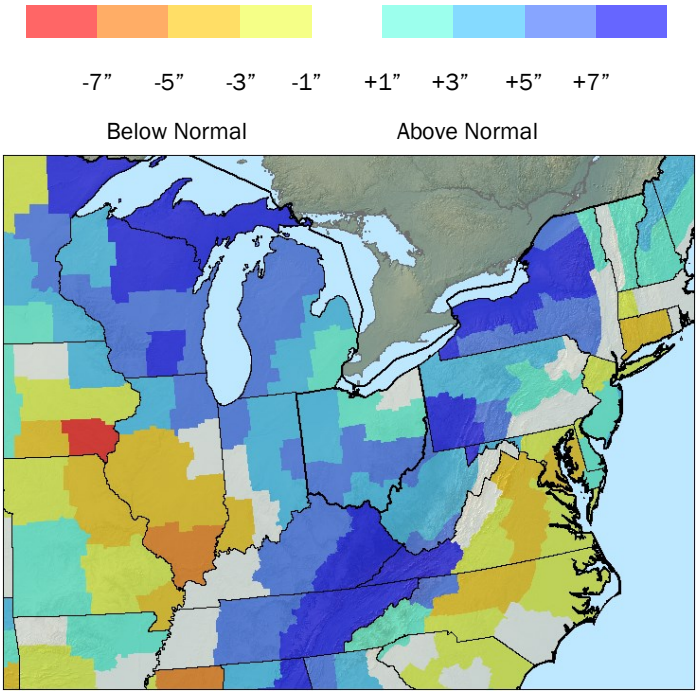
Weather patterns have a large impact on air quality in central Ohio. Ozone levels are typically highest in central Ohio during warm, dry periods with little precipitation and light winds, as sunny skies and high temperatures enhance ground-level ozone formation. In the wintertime, similar stable conditions can lead to strong temperature inversions overnight. In an inversion, a layer of cool air near the ground is overlain by a layer of warmer air. An inversion acts as a cap on the upward movement of air from the layers below and traps particulate matter near the surface leading to higher particle pollution levels. Precipitation decreases the levels of both ozone and particle pollution.

This past year, both temperature and precipitation were slightly above average. During the winter months, temperatures were much warmer than average. The above-average temperatures limited the strength of overnight temperature inversions, reducing the number of Moderate or higher $PM_{2.5}$ days. During the ozone season, daily maximum temperatures were about average, while precipitation was near or slightly above average. These conditions, combined with lower emissions over the last 10 years in central Ohio, resulted in just two USG ozone days (greater than 70 parts per billion ozone), the fewest in that time period.

Temperature Anomalies (°F)
November 2016-October 2017
Versus 1981-2010 Average



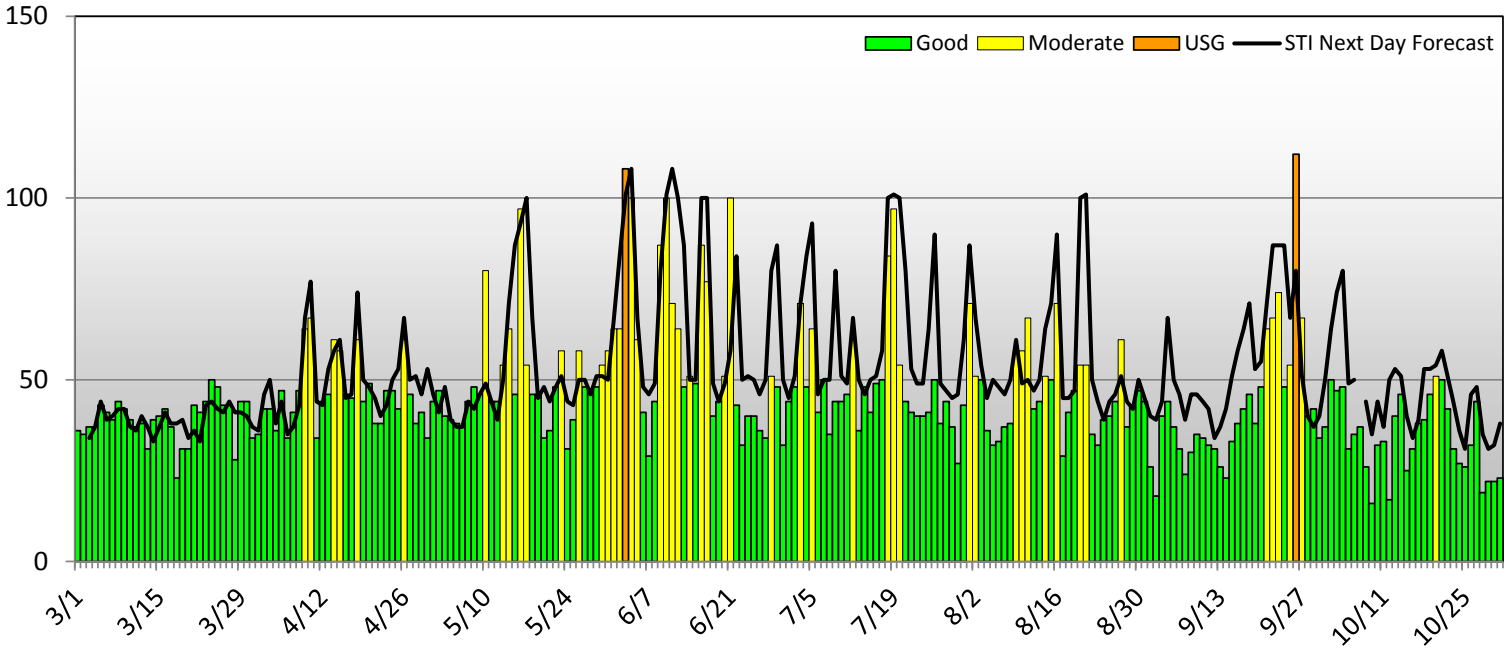
Precipitation Anomalies (inches)
November 2016-October 2017
Versus 1981-2010 Average



Ozone Summary and Highest AQI Days

STI meteorologists were generally able to capture the trend of observed air quality levels with their next-day forecasts. The charts below show daily observed AQI levels (colored bars) and next-day forecasts (black line) for ozone.

Daily Maximum Observed Ozone Levels Compared to Forecasts (March 1 -October 31, 2017)



USG Ozone AQI Days and Alert Days

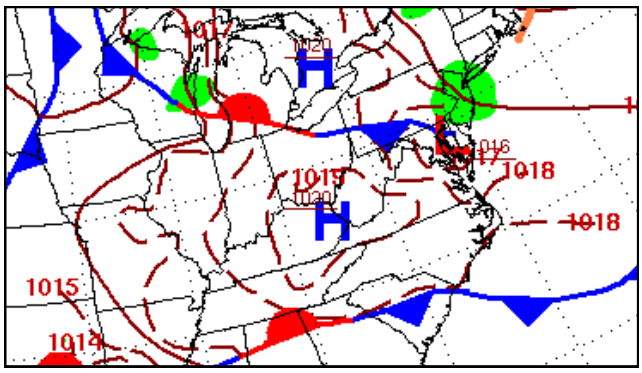
The table below shows the forecast and observed ozone AQI levels on days with forecast or observed AQI levels above 100. Brief descriptions of weather conditions on selected noteworthy high-AQI days (shown in bold in the table below) are provided on this and the following page.

Date	Next-Day Forecast	Same-Day Forecast	Observed Ozone AQI	Peak Monitor(s)	# of USG Sites
6/3/17	**101**	**101**	**108**	**New Albany**	**3**
6/4/17	108	108	100	London/New Albany	0
6/10/17	101	119	100	Centerburg/New Albany	0
6/11/17	108	101	71	Centerburg	0
7/19/17	101	101	97	New Albany	0
8/21/17	**101**	**101**	**54**	**New Albany**	**0**
9/26/17	80	80	112	New Albany	1

Ozone Summary and Highest AQI Days

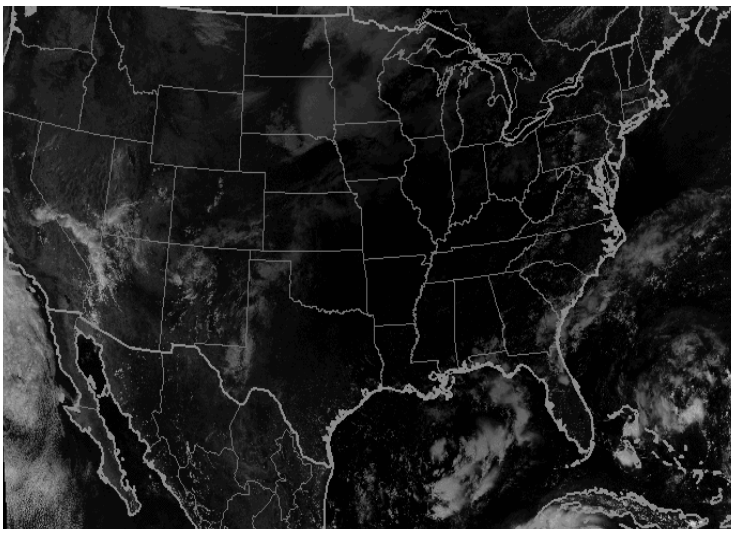
USG Ozone AQI Days and Alert Days

June 3: The Air Quality Alert issued on this day verified with an observed ozone AQI of 108. High temperatures reached 86°F in Columbus, which tied the record for June 3 and increased ozone production. Surface high pressure over Ohio yielded calm to light and variable winds, inhibiting pollutant dispersion. Furthermore, pollutant buildup also played an important part by providing ozone precursors. There were four days of rising Moderate ozone levels leading up to June 3.

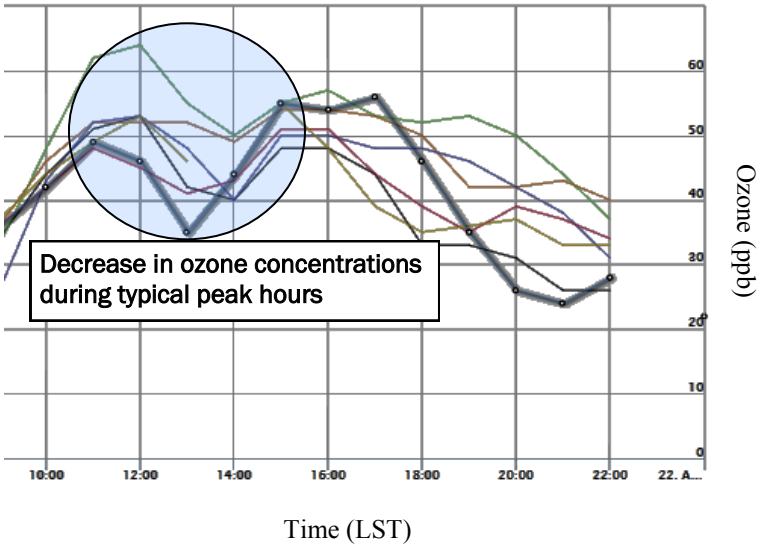


Surface weather map from 7:00 a.m. EST on June 3. Surface high pressure over Ohio led to light winds and stable conditions, enhancing ozone formation. Source: NOAA Weather Prediction Center.

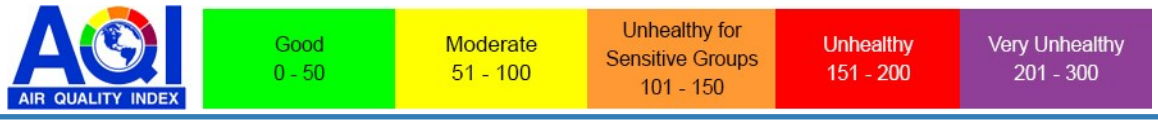
August 21: An Air Quality Alert day was called on August 21 in anticipation of an upper-level ridge of high pressure over the eastern U.S. The ridge limited atmospheric mixing and produced temperatures near 90°F in the Columbus area, increasing ground-level ozone production. However, the solar eclipse that passed from west to east on that day reduced incoming solar radiation in Columbus for multiple hours. This reduction in sunlight, combined with scattered clouds, decreased ozone production during the typical peak ozone hours and resulted in low-Moderate AQI levels.



GOES-16 visible satellite imagery from 2:21 p.m. EDT on August 21. The moon's shadow is cast across the eastern half of the U.S. during the solar eclipse. Source: NOAA GOES-16 Satellite



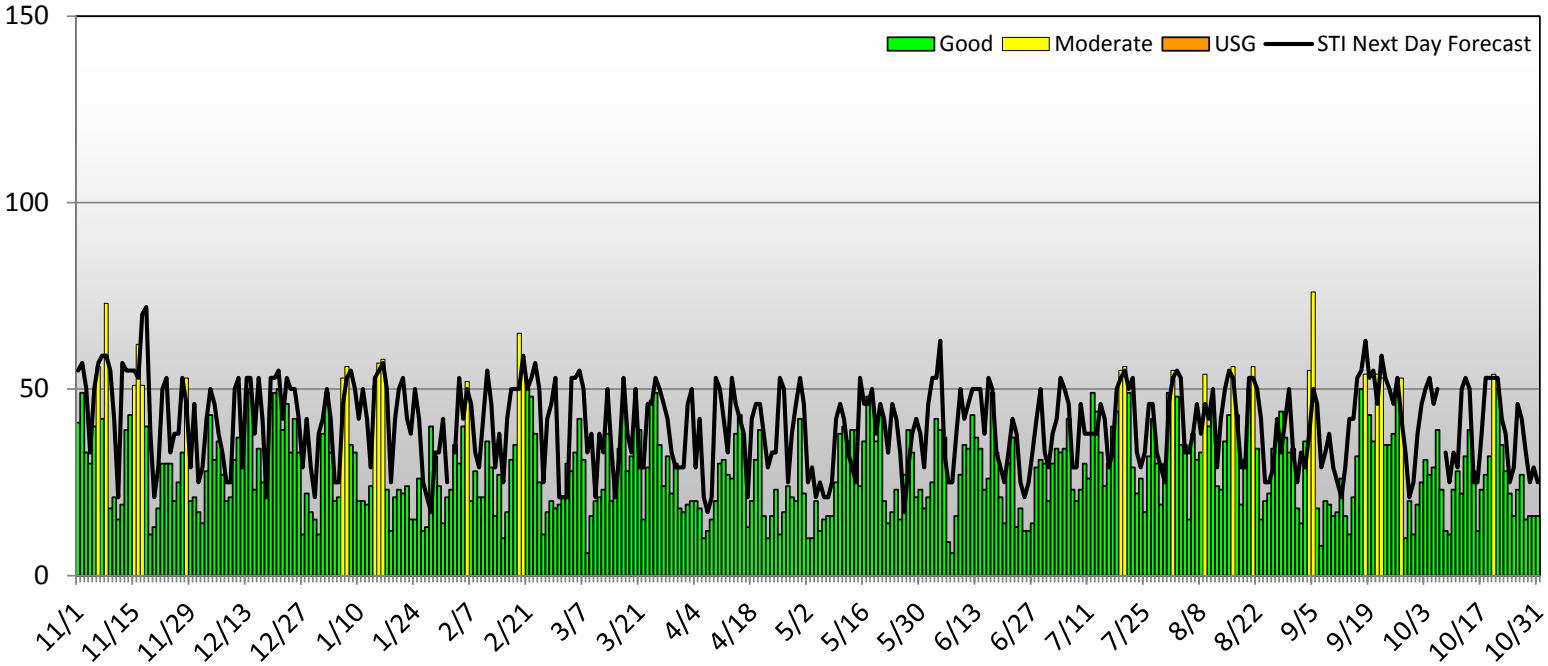
Observed ozone concentrations from Columbus area ozone monitoring sites on August 21, 10:00-23:00 LST. A decrease in ozone concentrations was observed during the solar eclipse between 13-14:00 LST. Source: AirNow



$PM_{2.5}$ Summary and Highest AQI Days

STI meteorologists were generally able to capture the trend of observed air quality levels with their next-day forecasts. The chart below shows daily observed AQI levels (colored bars) and next-day forecasts (black line) for $PM_{2.5}$.

Daily Maximum Observed $PM_{2.5}$ Levels Compared to Forecasts (Nov. 1, 2016—Oct. 31, 2017)



Highest $PM_{2.5}$ AQI Days

The table below shows the forecast and observed AQI levels on days with highest observed $PM_{2.5}$ levels from the past year. Brief descriptions of weather conditions on selected noteworthy high-AQI days (shown in bold in the table below) are provided on the following page.

Date	Next-Day Forecast	Same-Day Forecast	Observed AQI	Peak Monitor(s)
9/5/17	**50**	**70**	**76**	**New Albany**
11/8/16	**59**	**78**	**73**	**Columbus– Fairgrounds**
2/19/17	50	57	65	New Albany
1/16/17	57	61	58	New Albany
1/15/17	55	55	57	New Albany

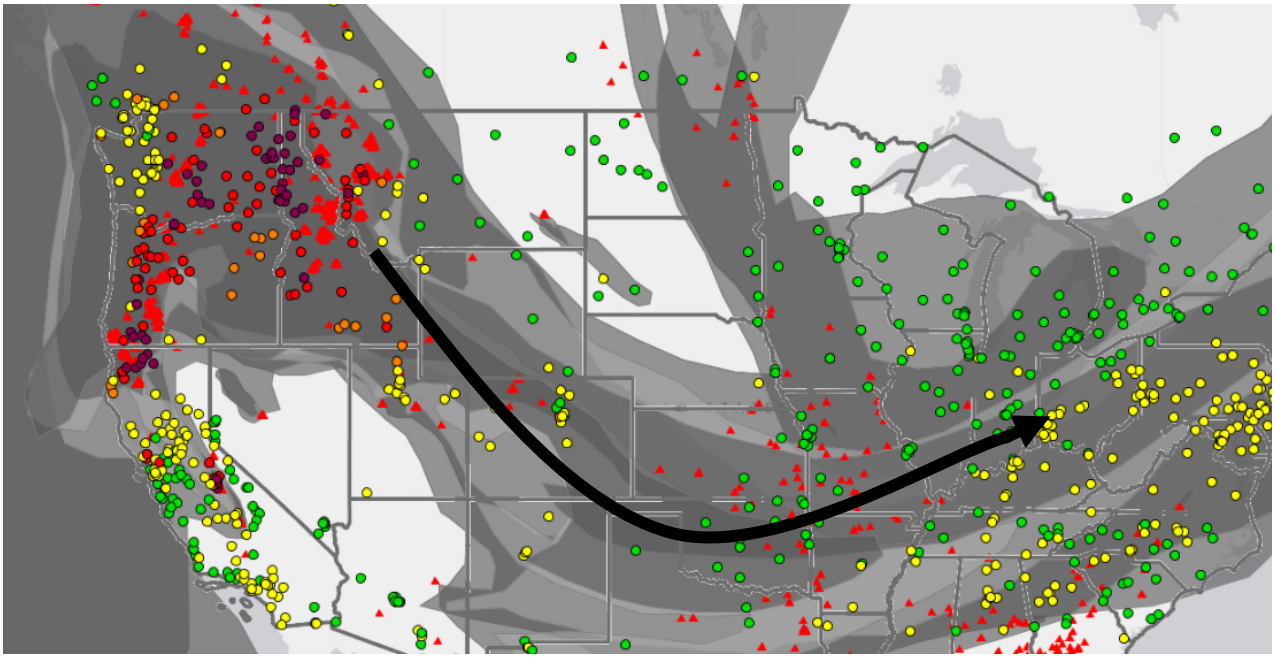
AIR QUALITY INDEX

Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy
0 - 50	51 - 100	101 - 150	151 - 200	201 - 300

$PM_{2.5}$ Summary and Highest AQI Days

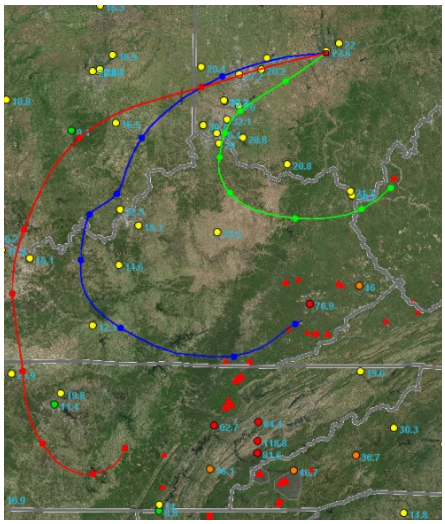
Select Moderate $PM_{2.5}$ AQI Days

September 5, 2017: The highest $PM_{2.5}$ levels this past year were observed on this day. Smoke from numerous large wildfires raging in the Pacific Northwest was transported across the country and toward the East Coast. The smoke increased particle levels in central Ohio and resulted in AQI levels of 76 for $PM_{2.5}$.



Observed Daily $PM_{2.5}$ AQI levels (dots), Hazard Mapping System (HMS) smoke (gray), and fire detections (red triangles) on September 5, 2017. Source: AirNow-Tech.

November 8, 2016: The second highest $PM_{2.5}$ concentrations from the past year were also smoke-enhanced. Wildfires in the Great Smoky Mountains produced smoke, which was gradually transported into Ohio over the course of a few days. Although a cold front moving through late in the day shifted winds to northwesterly and transported clean air into the region, $PM_{2.5}$ concentrations on November 8 averaged 22.6 ug/m^3, or 73 AQI.



Right: 24 hour $PM_{2.5}$ concentrations on November 8 and HYSPLIT 48 hour back trajectory at 100 m (green), 500 m (blue), and 1,000 m (red) ending at 12:00 p.m. EST on November 8. Source: AirNow-Tech.

Forecast Performance

AQI Threshold Forecast Statistics

STI provides same-day, next-day, and extended AQI daily forecasts for central Ohio. A statistical summary of same-day and next-day forecasting performance at the Good-to-Moderate AQI threshold (51 AQI) is shown in the charts on the right and described below. These statistics assess the accuracy of the forecasts in determining if air quality pollution levels would be in the Good AQI range or in the Moderate or higher ranges. All forecast statistics discussed in this summary are described at the bottom of this page.

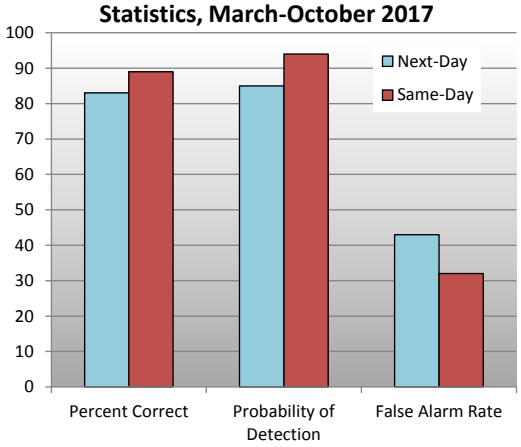
Of the 242 next-day ozone forecasts issued, 200 were correct at the Good-to-Moderate threshold, resulting in a Percent Correct (PC) of 83%. Of the 53 days with observed AQI levels of at least Moderate, 45 were correctly predicted in the next-day forecast, resulting in a Probability of Detection (POD) of 85%. The False Alarm Rate (FAR) for the next-day forecasts was 43%. This performance is similar to 2016 with an improvement of 5% in the Percent Correct rate.

USG ozone AQI levels were observed on two days in central Ohio during summer 2017. The next-day or same-day forecasts called for USG AQI levels on one of these two days. Air Quality Alerts (next-day or same-day forecasts above 100 AQI) were issued on six days during summer 2017; of those days, USG ozone AQI levels were observed on one day. Moderate ozone AQI levels were observed on the other five days, and three of these had AQI levels between 97 and 100.

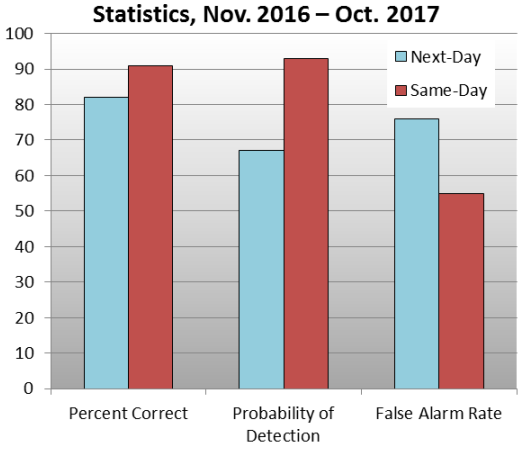
Of the 363 next–day $PM_{2.5}$ forecasts issued, 298 were correct at the Good-to-Moderate threshold, resulting in a PC of 82%. Of the 27 days with observed AQI levels of Moderate, 18 were correctly predicted in the next-day forecast, resulting in a POD of 67%. The FAR for the next-day forecasts was 76%.

The table below shows the Bias and Mean Absolute Error (MAE) for the Columbus region.

Good-to-Moderate Ozone Forecast Statistics, March-October 2017



Good-to-Moderate $PM_{2.5}$ Forecast Statistics, Nov. 2016 – Oct. 2017



Pollutant (Concentration)	Time Range	Same-Day Forecast		Next-Day Forecast	
		Bias	MAE	Bias	MAE
8-hr Ozone (ppb)	March 1 – Oct. 31, 2017	+3.7	5.4	+5.1	7.0
24-hr $PM_{2.5}$ (µg/m³)	Nov. 1, 2016 – Oct. 31, 2017	+1.4	1.8	+2.3	3.0

Statistical Measures

Percent Correct (PC): The percentage of forecasts that matched observations.

Probability of Detection (POD): The ability to correctly predict high-pollution events at or above a certain threshold.

False Alarm Rate (FAR): The percentage of cases for which a forecast of high pollution (at or above the threshold) was incorrect.

Bias: The average difference between forecast and observed concentrations. A positive bias indicates that the forecast concentrations tended to be higher than observed concentrations. A negative bias indicates that the forecast concentrations tended to be lower than observed.

Mean Absolute Error (MAE): Indicates the average absolute difference between forecast and observed concentrations. An MAE near zero suggests that forecasts tend to be fairly accurate.

Although Sonoma Technology, Inc., prepares air quality forecasts using the highest professional standards, forecasting is an inexact science. Therefore, Sonoma Technology, Inc., cannot assume any liability or responsibility for any consequences that might arise due to the accuracy or inaccuracy of forecasts delivered under this contract, or for any decisions or actions taken based on the forecasts provided.

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