End of Ozone Season Report

Central Ohio: April 1 through October 31, 2016

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 ozone and particle pollution levels are considered to be unhealthy for sensitive groups of people. From April through October, ground-level ozone concentrations peak when warm temperatures and sunlight, mixed with pollutants, enhance the formation of ozone. This can create unhealthy levels of air pollution, triggering Air Quality Alerts. MORPC works 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 ozone season and how it compares to previous years.

Summary

- Beginning in 2016, the federal ozone standard tightened from 75 ppb to 70 ppb. A wider range of meteorological conditions can lead to Air Quality Alert days under these tighter standards. MORPC's air quality forecasters continue to refine and adjust forecasting procedures to account for these broader conditions.
- Compared to last year, Central Ohio had a higher percentage of days in the Good Air Quality Index (AQI) category. Air quality remained within the Good AQI category on 65% of days, compared with 60% of days in 2015 and 58% of days in 2014.
- Air Quality remained in the Good category for a higher percentage of days in 2016 despite this being the second hottest summer on record. In 2016, average temperatures in Ohio from May through October were warmer than those observed in 2015; this additional heat and sunlight combined with emissions to create the conditions necessary for ozone formation.
- The Air Quality Alert issued on April 18 was the earliest in a season that an ozone alert has been issued for the Columbus region since records began in 2002. On April 18, temperatures reached 81°F, which was 19°F above average for April. Similarly, the Air Quality Alert issued for September 23 marked the first time there has been an ozone exceedance in September in the region since 2013.
- Under the tighter federal standards, there were 10 ozone exceedances in the Central Ohio region in the summer 2016 season compared to 3 in 2015. Under the previous standard of 75 ppb, the region would have had only 3 exceedances this year.
- Despite challenges in forecasting for the new standard, MORPC's next-day forecasts had a percent correct rate of 78% and a probability of detection of 85% for high pollution events.

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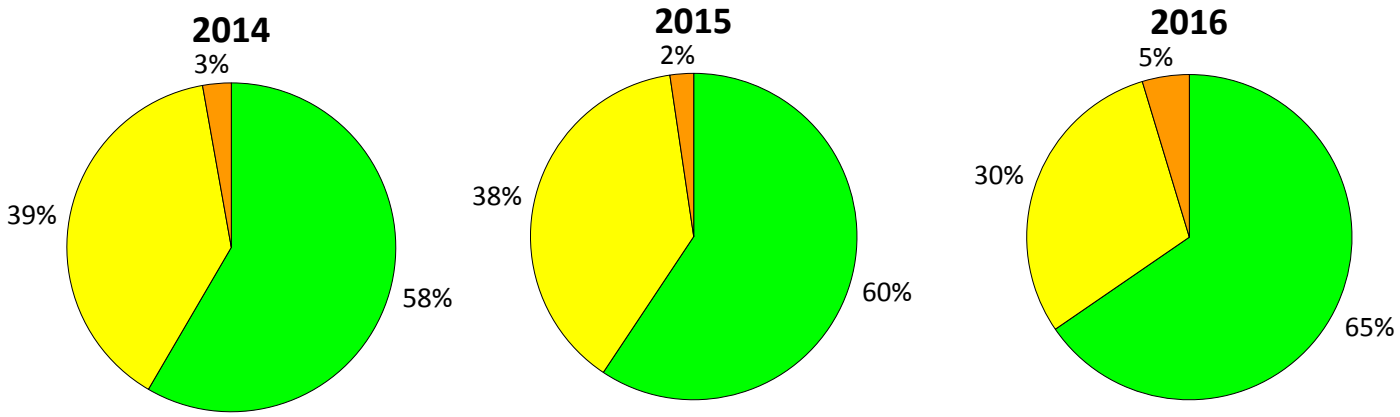
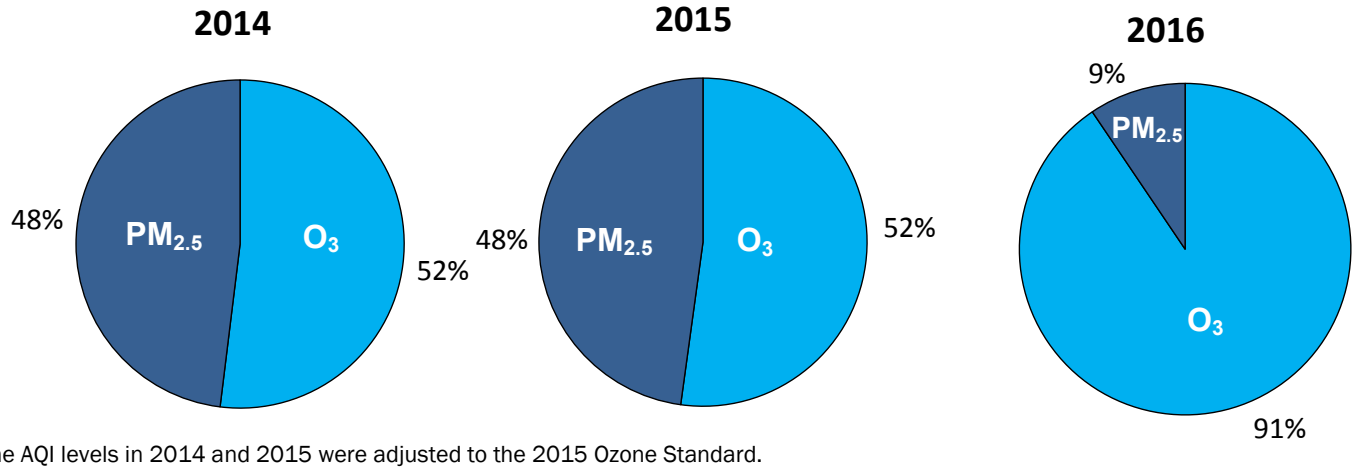
Air quality in the Columbus region during the 2016 summer season was similar to air quality in the 2014 and 2015 summer seasons. Air quality remained within the Good category of the Air Quality Index (AQI) on 65% of days, compared with 60% of days in 2015 and 58% of days in 2014 (see pie charts below). Unhealthy for Sensitive Groups (USG) or greater AQI levels were observed on 5% of days in summer 2016, compared to 2% in 2015 and 3% in 2014. However, ozone was the dominant pollutant on a much greater percentage of summer days in 2016 compared to 2014 and 2015. Of the 74 days in summer 2016 when AQI levels reached the Moderate category or higher, ozone was the dominant pollutant 91% of the time (67 days), while $PM_{2.5}$ was the dominant pollutant only 9% of the time (7 days). In 2014 and 2015, ozone and $PM_{2.5}$ were dominant on roughly the same percentage of days.

Percentage of Days at Each AQI Level During Summer — $PM_{2.5}$ and Ozone*



*Ozone AQI levels in 2014 and 2015 were adjusted to the 2015 Ozone Standard.

Dominant Pollutant on Summer Days with AQI Levels of Moderate or Higher*



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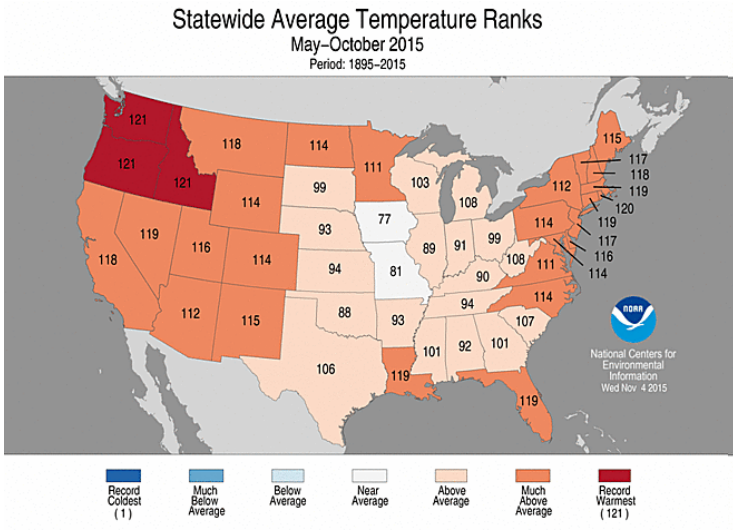
Weather and Air Quality Conditions

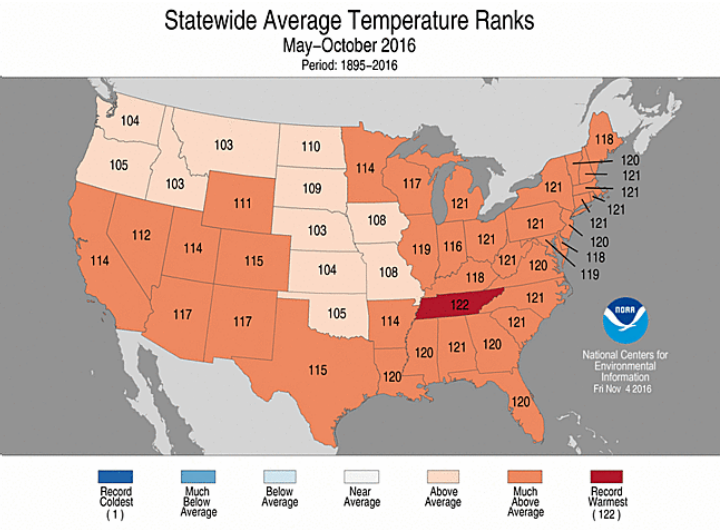
Comparing Air Quality and Weather Conditions in 2015 and 2016

While the overall air quality in summer 2016 was similar to that observed in 2015, ozone was the dominant pollutant on a much greater percentage of days in 2016. Ozone levels are typically highest in central Ohio during warm, dry periods with little precipitation, as sunny skies and high temperatures enhance ground-level ozone formation.

In 2016, average temperatures in Ohio from May through October were warmer than those observed in 2015 and were the second-highest on record. Precipitation was about average for summer 2016, and slightly drier than precipitation observed in 2015. The maps below illustrate ranks for average temperature (top) and precipitation (bottom) from May through October of both 2015 (left) and 2016 (right) compared to climatology statistics from 1895 through the present day. The warmer temperatures and drier conditions in 2016 likely contributed to more Unhealthy for Sensitive Groups ozone days and to ozone being the dominant pollutant on a larger percentage of days than in previous years.



Rankings are out of 121 years.



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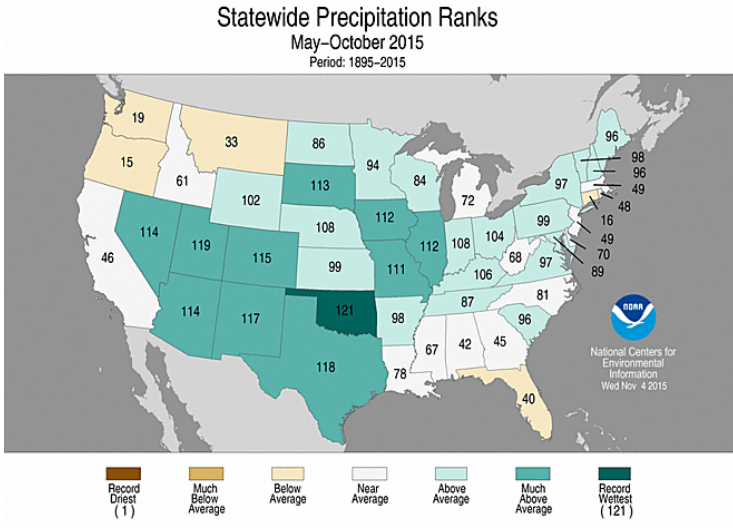

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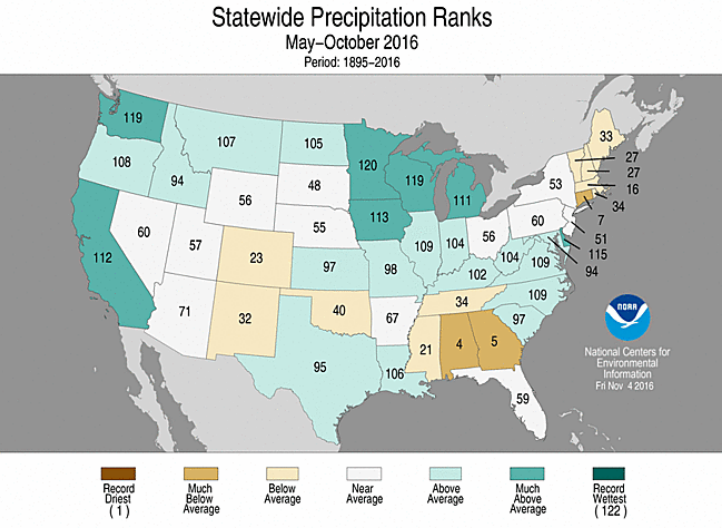
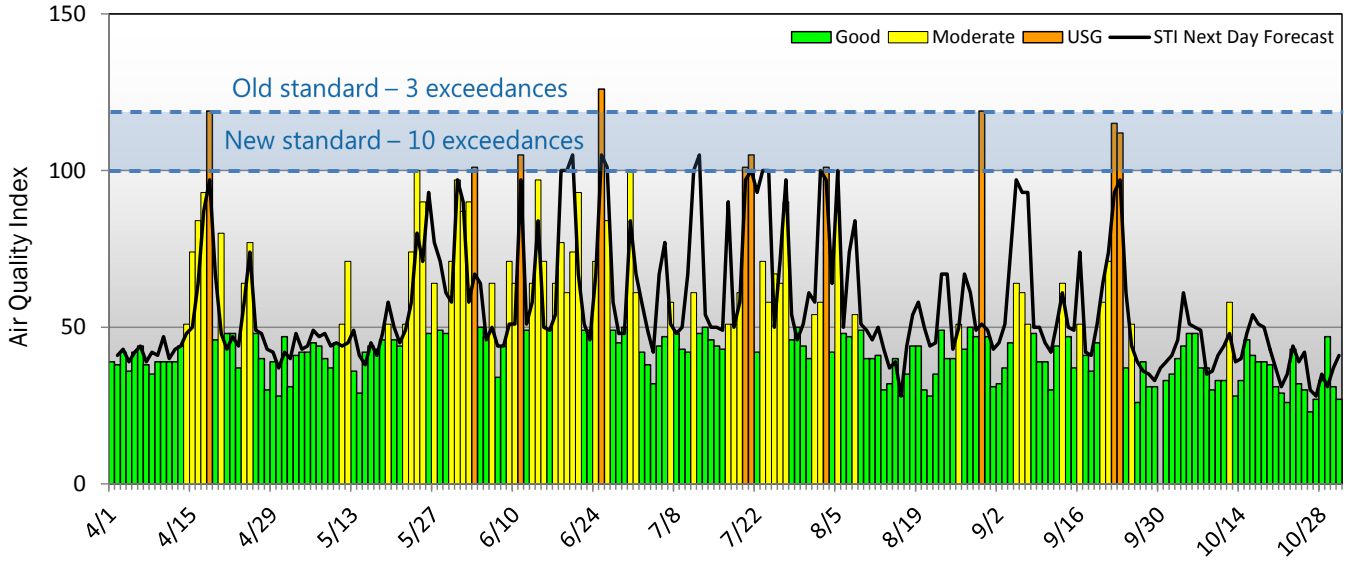


Rankings are out of 122 years.

Highest AQI Days and Seasonal Weather Summary (1/3)

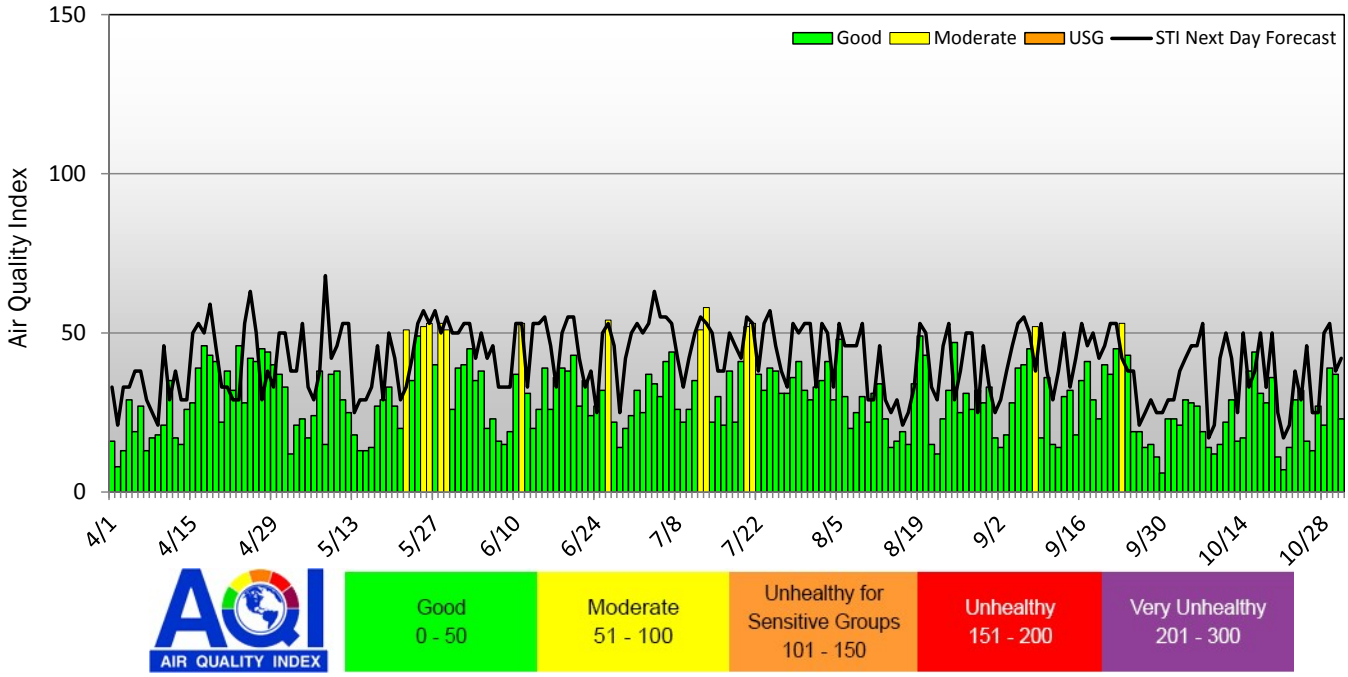
STI meteorologists were generally able to capture the trend of observed air quality levels with their next-day forecasts. The charts below show daily observed AQI levels (colored bars) and next-day forecasts (black line) for ozone and $PM_{2.5}$. The previous and current ozone exceedance standards are indicated by the dotted horizontal blue lines on the ozone chart.

Daily Maximum Ozone AQI Values and Forecasts, Summer 2016*



*No Next-day ozone forecast was issued for April 1. There was insufficient ozone data on September 30 for a valid AQI calculation.

Daily Maximum $PM_{2.5}$ AQI Values and Forecasts, Summer 2016



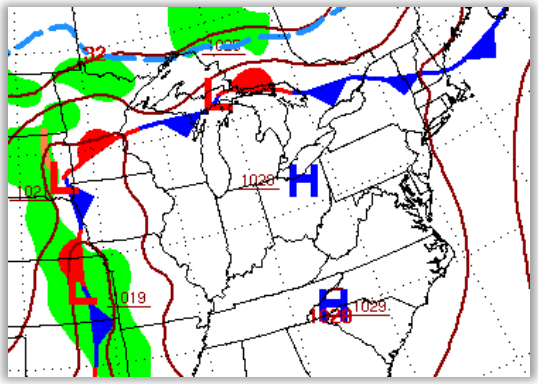
Highest AQI Days and Seasonal Weather Summary (2/3)

Summer 2016 USG AQI Days and Air Quality Alert Days

The table below shows the forecast and observed 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 AQI	Peak Pollutant	Peak Monitor(s)	# of USG Sites
4/18/16	**97**	**105**	**119**	**Ozone**	**New Albany**	**4**
5/25/16	71	101	90	Ozone	Centerburg	0
6/3/16	67	87	101	Ozone	New Albany	1
6/11/16	**97**	**100**	**105**	**Ozone**	**Heath, London, New Albany**	**3**
6/20/16	105	105	74	Ozone	New Albany	0
6/25/16	105	108	126	Ozone	New Albany	2
6/26/16	101	101	84	Ozone	London	0
7/12/16	**105**	**101**	**51**	**$PM_{2.5}$**	**Columbus—Fairgrounds**	**0**
7/20/16	97	87	101	Ozone	Columbus Maple Canyon Dr., Columbus Franklin Park	2
7/21/16	100	115	105	Ozone	New Albany	1
8/3/16	97	90	101	Ozone	New Albany	1
8/30/16	51	61	119	Ozone	Columbus Maple Canyon Dr.	1
9/22/16	93	100	115	Ozone	Columbus Maple Canyon Dr.	2
9/23/16	97	108	112	Ozone	London	1

April 18: The Air Quality Alert issued on this day was the earliest in a season that an ozone alert has been issued for the Columbus region since records began in 2002. Leading up to April 18, surface high pressure over Ohio produced mostly sunny skies and light winds for multiple days, allowing for day-to-day pollutant build-up. On April 18, temperatures reached 81°F, which was 19°F above average for April (source: NWS Wilmington, OH). The warm temperatures enhanced ozone formation, and calm winds limited pollutant dispersion. These conditions resulted in four monitoring sites reporting USG AQI levels, the most from any day this season.



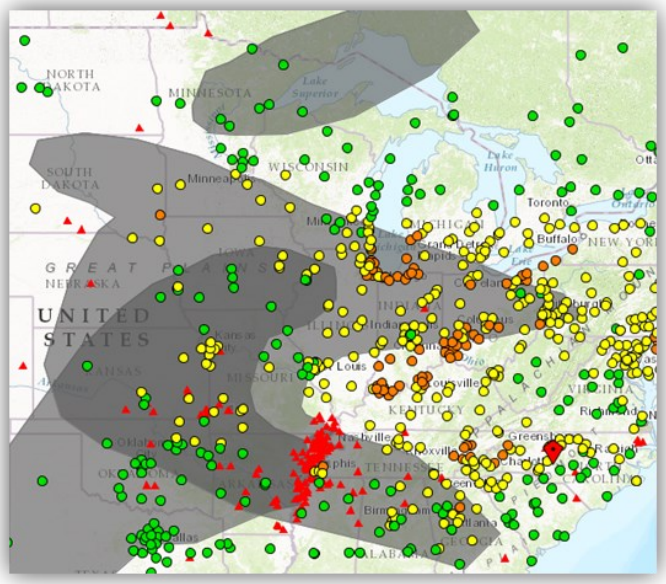
Surface weather map from 7:00 a.m. EST on April 18. Surface high pressure over Ohio led to light winds and stable conditions, enhancing ozone formation. Source: NOAA Weather Prediction Center.

AIR QUALITY INDEX

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

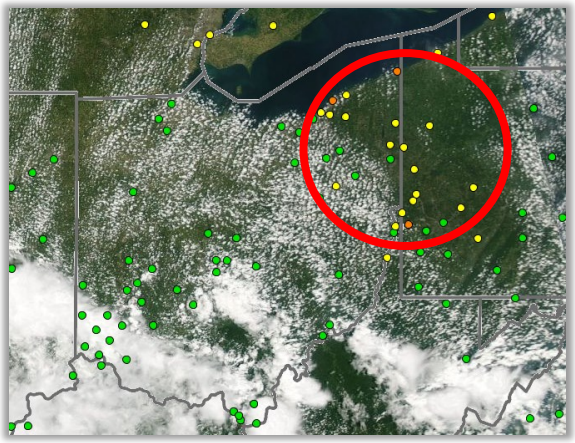
Highest AQI Days and Seasonal Weather Summary (3/3)

June 11: An upper-level ridge of high pressure over the eastern U.S. produced mostly sunny skies and temperatures in the low 90s in the Columbus area, increasing ground-level ozone production. Moderate southwesterly winds brought additional pollutants from the Dayton and Cincinnati area into central Ohio. Furthermore, smoke transported into the region from agricultural fires in the lower Mississippi River basin may have also enhanced ozone formation.



Observed ozone AQI levels (green, yellow, and orange dots), Hazard Mapping System (HMS) smoke (gray), and fire detections (red triangles) on June 11. Source: AirNow-Tech.

July 12: An Air Quality Alert Day was issued on July 12 for central Ohio. On this day, an upper-level ridge of high pressure over the state limited vertical mixing, and temperatures in the upper 80s enhanced ozone formation. However, stronger-than-forecast southerly winds transported cleaner air into the region and kept the lower levels of the atmosphere well mixed. In addition, increasing clouds during the early afternoon limited ozone production during peak ozone hours. As a result, ozone levels remained Good (48 AQI). While clouds limited ozone formation in the Columbus area, monitoring sites in regions without cloud cover in northeastern Ohio and western Pennsylvania (red circle, right) observed Moderate and USG ozone levels.



MODIS Aqua Satellite imagery over Ohio showing observed daily ozone AQI categories on July 12. Source: AirNow-Tech.

AIR QUALITY INDEX

Good	Moderate	Unhealthy for Sensitive Groups	Unhealthy	Very Unhealthy
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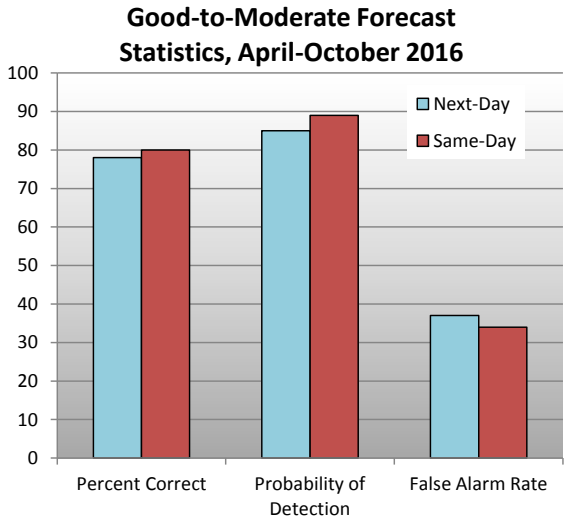
Forecast Performance

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 chart on the right and described below. All forecast statistics discussed in this summary are described at the bottom of this page.

Of the 214 next-day forecasts issued, 166 were correct at the Good-to-Moderate threshold, resulting in a Percent Correct (PC) of 78%. Of the 75 days with observed AQI levels of at least Moderate, 64 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 37%. The PC, POD, and FAR for the same-day forecasts this year were better than the next-day forecasts; the same-day forecasts had a PC of 80%, a POD of 89%, and a FAR of 34%.

USG AQI levels were observed on ten days in central Ohio during summer 2016. The next-day or same-day forecasts called for USG AQI levels on four of these ten days. Air Quality Alerts (next-day or same-day forecasts above 100 AQI) were issued for eight days during summer 2016; of those days, USG ozone AQI levels were observed on four days, Moderate ozone AQI levels were observed on three days, and Good ozone AQI levels were observed on one day.

The introduction of the new ozone standard has impacted the way forecasts are made for USG ozone days. Under the old ozone standard, there was a fairly narrow set of meteorological conditions that had to be met for ozone to reach alert levels, including sunny skies, hot temperatures, and light winds. Under the new standard, this range of conditions has expanded, and alert days may be observed even when there are partly cloudy skies, slightly cooler temperatures, or moderate westerly winds.

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

Pollutant (concentration)	Same-Day Forecast		Next-Day Forecast	
	Bias	MAE	Bias	MAE
8-hr Ozone (ppb)	+2.8	5.4	+3.6	6.4
24-hr $PM_{2.5}$ ($\mu g/m^3$)	+1.8	2.1	+2.6	3.2

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.