Module 2: Activity 1

What's an Air Quality Index?

IT'S OUR AIR

SUMMARY

In this activity, students will learn where they can find the daily Air Quality Index (AQI) forecast and how to interpret it. They will also identify seasonal patterns for ozone and particulate matter in their region, and learn some of the reasons behind those patterns.

ESSENTIAL QUESTIONS

- What is an air quality index (AQI)?
- Where can I find air quality forecasts and measured concentrations of pollutants?
- What are some seasonal patterns for ozone and particulate matter in my community?

TIME NEEDED

- 5-10 minutes a day for one week for Part A, prior to doing Parts B and C
- One block period or two traditional periods for reviewing Part A and doing Parts B and C

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.5 Understand the structure of and processes within our atmosphere.
- EEn.2.5.1 Summarize the structure and composition of our atmosphere.
- EEn.2.5.5 Explain how human activities affect air quality.

A product of the NC Air Awareness Program 2015.

MAKING CONNECTIONS

In this activity, students will learn that the Air Quality Index (AQI) is tool to communicate levels of air pollution to the public. The AQI is a color-coded index with numbers. It's easy to assume the numbers on the AQI are measured concentrations. While each number on the AQI does correspond to a particular measured concentration (a different concentration for each pollutant), the AQI numbers by themselves are not measured concentrations.

The AQI can be compared to movie or video-game ratings. A movie can be rated R for different reasons (violence or language or sexual content) just as a day can be "rated" Code Orange for different reasons (ozone or particulate matter or other pollutants). The AQI can also be compared to grades. A school system has a standardized scale where each letter grade corresponds to a range of number grades: A=93-100, for example. Looking at the report card, you can compare the student's work in different classes because all the teachers are using the same scale.

BACKGROUND

In North Carolina, meteorologists at the Division of Air Quality forecast the air quality every day to help inform citizens how good or bad the air quality is expected to be. The forecast is communicated using the color-coded Air Quality Index (AQI). Knowing how much air pollution is in the air helps people take precautionary steps to protect their health, such as limiting outdoor activity during times when air pollution is higher. One of the biggest air quality problems in North Carolina is ground-level ozone, a strong respiratory irritant that can cause serious health problems. Particulate matter, or particle pollution, can also be a problem in North Carolina. For more information on health problems caused by ozone and particulate matter, see Activity 1 in Module 3.

AIR QUALITY INDEX (AQI)

Air pollution can make it hard to breathe and can cause or exacerbate many health problems, from asthma to cardiovascular disease. For each pollutant, the U.S. Environmental Protection Agency (EPA) has established national air quality standards to protect public health. The states are required to address these.

The Air Quality Index (AQI) is a numerical index that quickly communicates information to the public about the presence and amount of air pollution where they live. It is used all across the United States. In North Carolina, meteorologists at the Division of Air Quality forecast the AQI each day by assessing the actual observed measurements of different pollutants along with meteorological conditions. The Division of Air Quality also keeps track of the actual observed measurements of different pollutants each day and reports and archives those measurements.

The numbers and corresponding colors of the AQI indicate relative health risk. The index goes from 0-500. One of the advantages of the AQI is that it uses the same "yardstick" to communicate about different pollutants that are measured in different units. It's a comprehensive index that accounts for multiple air pollutants and creates a simple and straightforward assessment of the air quality conditions for a region regardless of differences in pollutant units or EPA standards for different pollutants.

If a particular pollutant is mentioned following the AQI, it means that pollutant is expected to have the highest AQI. This is useful for people with specific health conditions that make them more susceptible to a particular pollutant. For example, if the AQI forecast is given as "149 ozone," it means forecasters are expecting a level of ozone that corresponds to "unhealthy for sensitive groups," and that other pollutants are expected to be lower than 149.

Air Quality Index and Health Messages

Air Quality Index	Guidelines to protect your health
Good: Code Green 0-50	No health affects expected
Moderate: Code Yellow 51-100	Usually sensitive people consider limiting prolonged or heavy exertion outdoors.
Unhealthy for Sensitive Groups: Code Orange 101-150	Children, active people, older adults, and those with heart or lung disease (like asthma): limited prolonged or heavy exertion outdoors.
Unhealthy: Code Red 151-200	Children, active people, older adults, and those with heart or lung disease (like asthma): avoid prolonged or heavy exertion outdoors.
Very Unhealthy: Code Purple 201-300	Everyone: avoid all outdoor exertion.

Source: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

THE AQI **COLOR CODES**

To help the public interpret the AQI, different colors represent each range on the index. Each range/color corresponds to a particular public health message. The AQI's color code gives general information about air quality – Code Green is good and Code Purple is very unhealthy. For some people, that's enough information. But people who have asthma or other health conditions might need more information when planning their outdoor activities. In that case, they can look at the AQI number to see whether a forecasted Code Yellow day is expected to be "just barely Code Yellow" (AQI 51) or "almost Code Orange" (AQI 100).

WHAT DO AQI **NUMBERS MEAN?**

Note that the numbers on the AQI are not measured concentrations. An AQI number does not have a unit, whereas a measurement does. Measurements of ozone are usually given in parts per million (ppm) or parts per billion (ppb). Particulate matter (also called particle pollution) is measured in micrograms per cubic meter ($\mu g/m^3$).

However, the AQI number does correlate to a specific measured concentration, which is different for each pollutant. For example, an AQI value of 50 equates to an ozone concentration of 59 ppb or to a PM2.5 concentration of 12.0 $\mu g/m^3$.

The table below shows PM2.5 measurements and ozone measurements as they relate to the AQI. PM2.5 means particulate matter that is smaller than 2.5 microns in diameter. For PM2.5, the measurements are averaged over the course of 24 hours. For ozone, the measurements are averaged over the course of 8 hours. (Tip: It's particularly easy to confuse 8-hour ozone measurements in ppb and the corresponding AQI numbers because they are in similar ranges, so when working with data remember to double-check whether you're looking at ozone measurements in ppb or AQI numbers with no units.)

An AQI value over 100 surpasses the EPA daily health standard for that pollutant. For example, 35.5 $\mu g/m^3$ of PM2.5 (averaged over 24 hours) exceeds the EPA daily health standard and is equivalent to 101 on the AQI.

The Clean Air Act requires the EPA to periodically evaluate the health standards for air quality. The standards may then be adjusted to reflect the new understanding of air pollution and health. The colors, numbers and recommended actions on the AQI stay the same although the pollution measurements that correspond to the colors and numbers may change. This allows communication about air quality to the public to remain consistent. When a new, lower standard is issued by the EPA, you may see more Code Yellow, Orange, or Red days than in previous seasons because of the more stringent standard.

PM2.5 and Ozone Measurements and the AQI

Air Quality Index	24-Hour PM 2.5	8-Hour Ozone
Good 0-50 Code Green	0-12 $\mu g/m^3$	0-59 ppb
Moderate 51-100 Code Yellow	12.1-35.4 $\mu g/m^3$	60-75 ppb
Unhealthy for Sensitive Groups: 101-150 Code Orange	35.5-55.4 $\mu g/m^3$	76-95 ppb
Unhealthy 151-200 Code Red	55.5-150.4 $\mu g/m^3$	96-115 ppb
Very Unhealthy 201-300 Code Purple	150.5-250.4 $\mu g/m^3$	116-374 ppb

Source: http://daq.state.nc.us/monitor/aqi/codeChart.shtml

WHERE TO FIND AQI FORECASTS AND REPORTS

AQI forecasts and reports are available from the Division of Air Quality online at www.ncair.org/airaware/forecast. You can view the forecast and reports for both ozone and PM2.5. Choose from the tabs at the top that say, "Previously Observed," "Today's Forecast," and "Tomorrow's Forecast." You can also hear a forecast by calling 1-888-RU4-NCAIR (1-888-784-6224).

Your local newspaper, TV station, or news website may also give AQI forecasts and reports, although the forecasts and reports may include only the pollutant with the highest AQI.

SEASONAL PATTERNS OF OZONE AND PARTICULATE MATTER

Typically, ozone is more of a problem in the summer because sunlight and heat are two important ingredients in the formation of ground-level ozone, in addition to emissions of nitrogen oxides (NO_x) and volatile organic compounds. Ozone is forecast from April 1 to October 31. (See Activity 4 in Module1: "The Criteria Pollutants and a Closer Look at Ozone" for more information on both ozone and particulate matter.)

In North Carolina, particulate matter concentrations also tend to be highest during the summer months, primarily because humidity levels are higher: Water droplets aid in the formation and accumulation of particulate matter. Additionally, air masses tend to stagnate in the summer because upper level winds are weaker, so there are fewer cold fronts coming through. Cold fronts bring pristine air masses from less populated and ultimately less polluted regions, such as Canada. These clean air masses pass through much more frequently in the spring, fall, and winter, sweeping out elevated levels of particulate matter. Although concentrations of particulate matter tend to be highest in the summer, the levels don't fall as much in the other seasons as the levels of ozone do, because the formation of particulate matter is not as dependent on sunlight.

Particulate matter can be a problem locally in the fall or winter when people burn leaves in the yard or burn wood for heating. Also, temperature inversions – where a layer of cold air is trapped under a layer of warm air – are more common in the winter in North Carolina, and the lack of mixing can lead to a build-up of particles near the ground. These short-lived particle events can have noticeable impacts on people with asthma or other respiratory problems.

MATERIALS

- AQI charts for projection (included)
- Daily newspaper and/or internet connection
- Archived records of ozone and particulate matter, available online at http://www.epa.gov/airdata/

WARM UP

Review the AQI with your students, covering the colors, numbers and health messages. AQI charts for projections provided on page 8. Use one or more of the analogies given in "Making Connections" to get across the idea that the AQI number is not a measurement, although each number does correspond to a measurement (a different measurement for each pollutant).

Teacher Tips

This is a great activity to begin while the class is working on a daily weather log. While students are gathering data each day on temperature, relative humidity, dew point, etc. from around campus, have them write down the daily AQI forecasts and AQI reports as described in Part A. They may not know what the numbers mean yet, but they will have a lot of weather data, experience and background knowledge to use when you are ready to answer the questions on the rest of the Air Quality Index activity.

Remember that Part A takes one week (a few minutes each day), so have students get started on that one week before you plan to do this activity in class. For less advanced classes, on the day of the activity, have students do Part B, then review the answers to that as well as the answers to the questions from Part A together before they move on the Part C. More advanced classes could do Part B as homework the night before doing Part C in class.

– Mark Townley

THE ACTIVITY

PART A: Recording AQI Forecast and Actual AQI for One Week

1. Every day for a week, use the chart below to record air quality forecasts from the local newspaper, TV news, news website, or from the Division of Air Quality (DAQ) (www.ncair.org/airaware/forecast). If using the DAQ website, be aware that the forecast for the following day is typically posted about 3 p.m. After the first day, and for each following day, check back and see what the AQI was for the previous day and fill out the "Actual AQI" portion of the table. (Note that ozone is not forecast between November and March.)

Table Comparing Forecast and Actual AQI

Location:				
	Forecast AQI		Actual AQI	
Date	For Ozone	For PM	For Ozone	For PM

2. Answer the following questions:

- Which pollutant was more of a problem during this time period – ozone or particulate matter?
- How accurate were the forecasts?
- Were there any days where the forecast color code was different than the reported color code? If so, what might have contributed to the discrepancy? (Tip: On the website www.ncair.org/airaware/forecast, click on "forecast discussion" on the left to see what Division of Air Quality meteorologists are saying about the forecast.)

PART B: Calculating AQI

Fill in the blanks in this table, using the AirNow AQI calculators at http://www.airnow.gov/index.cfm?action=resources.aqi_conc_calc and http://www.airnow.gov/index.cfm?action=resources.conc_aqi_calc

Pollutant	Measurement with Units	AQI Number	Color Code
Ozone, 8-hour		71	
PM2.5, 24-hour	12 $\mu g/m^3$		
Ozone, 8-hour	101 ppb		
PM2.5, 24-hour		71	
Ozone, 8-hour		49	
PM2.5, 24-hour	51 $\mu g/m^3$		

Answer Key

Pollutant	Measurement with Units	AQI Number	Color Code
Ozone, 8-hour	[66 ppb]	71	[Code Yellow]
PM2.5, 24-hour	12 $\mu g/m^3$	[50]	[Code Green]
Ozone, 8-hour	101 ppb	[164]	[Code Red]
PM2.5, 24-hour	[21.6 $\mu g/m^3$]	71	[Code Yellow]
Ozone, 8-hour	[58 ppb]	49	[Code Green]
PM2.5, 24-hour	51 $\mu g/m^3$	[139]	[Code Orange]

PART C: Looking for AQI Patterns

1. Look at a whole year's worth of ozone and PM2.5 data from a monitor in your town or nearby. To obtain ozone and PM2.5 data, go to http://www.epa.gov/airdata/. Click on "download data" then choose "daily data." Specify the pollutant, year, and monitor location. If you live in a small town, look for your county on the "select a county" bar or choose a nearby city from the "select a city" bar. "Exceptional events" include wildfires or other natural disasters; most years do not have exceptional events.

   PLEASE NOTE:
   - The data will be downloaded as an Excel spreadsheet. Make sure it contains a full year's worth of data; if not, choose an earlier year. (Remember that ozone is monitored from April 1-October 31, while PM is monitored all year.)
   - On the PM2.5 spreadsheets, the data at the top of the spreadsheet is from every third day; don't use this data. Instead, scroll down past the first 125 or so rows to get to the daily data (the Parameter Code in Column I reads 88502 for daily data).

2. Fill in the table below using the AQI chart provided to assign colors to the measured concentrations of ozone and PM2.5.

Table Showing Number of Code Yellow/Orange/Red AQI Days Per Month

Location: _____ **Year:** _____

Month	Number of Days with Code Yellow/Orange/Red AQI for Ozone			Number of Days with Code Yellow/Orange/Red AQI for PM2.5		
	Yellow	Orange	Red	Yellow	Orange	Red
January	N/A	N/A	N/A			
February	N/A	N/A	N/A			
March	N/A	N/A	N/A			
April						
May						
June						
July						
August						
September						
October						
November	N/A	N/A	N/A			
December	N/A	N/A	N/A			

3. Answer the following questions:
- What two months have the highest number of days with ozone AQIs that are Code Yellow or above?
- Explain why this might be so given your knowledge of how ground-level ozone forms.
- Is there a time of year when particle pollution seems to be the worst? If so, what time of year?
- Why do you think that particle pollution was worse at that time of year, or if there was no pattern, why do you think that was?
- Do you think your answers to the questions above would be different if you'd had more than one year's worth of data to look at? Explain.

WRAP UP AND ACTION

Have students imagine that they have asthma that is made worse when the AQI is orange or above. What strategy would they use to monitor air quality forecasting? Would they look at the forecast every day? Only during certain times of the year? What actions would they take in response to different air quality forecasts?

If you are not planning to do the next two activities in this module ("Making a Simple Predictive Model for Ozone" and "Forecasting Air Quality"), show your class the video "What is IN the Air?" It reviews AQI and air quality forecasting. It includes interviews with a doctor who studies the health effects of air pollution and with meteorologists at the Division of Air Quality.

ASSESSMENT

HAVE STUDENTS:

- Explain in writing how the AQI helps protect public health.
- Put together a brochure intended for the general public that explains the Air Quality Index. The brochure should include information about both ozone and particulate matter.
- Share your brochures with other classes, school administration and/or the community to help educate them about air quality.

EXTENSIONS

Sign up for daily emails about the AQI forecast at www.enviroflash.info/ and post the forecasts in the classroom each day. Have students come up with a list of audiences in the school that might need to know this information (such as coaches and physical education teachers), and ways to communicate the AQI to those audiences daily.

Using the year of AQI data, have students produce bar graphs (one for ozone, one for PM2.5) showing the percentages of Code Green/Yellow/Orange/Red days for each month.

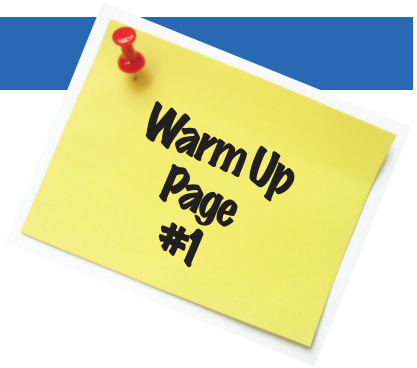
RESOURCES

Explanation of AQI from AirNow, a program of the EPA and other agencies: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

Air quality forecast and discussion from the N.C. Division of Air Quality: www.ncair.org/airaware/forecast.

Current readings of pollutants and archives for many monitoring sites in North Carolina: http://daq.state.nc.us/monitor/

What's an Air Quality Index?



Air Quality Index and Health Messages

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Moderate: Code Yellow 51-100	Usually sensitive people consider limiting prolonged or heavy exertion outdoors.
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Unhealthy: Code Red 151-200	Children, active people, older adults, and those with heart or lung disease (like asthma): avoid prolonged or heavy exertion outdoors.
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Source: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

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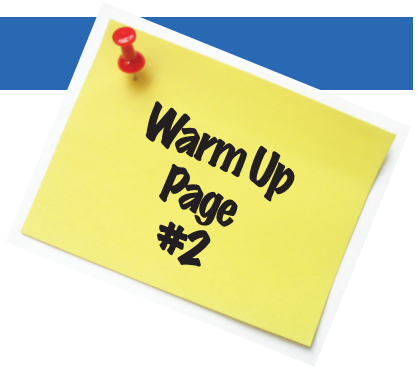

PM2.5 and Ozone Measurements and the AQI

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IT'S OUR AIR

What's an Air Quality Index?

Student Page #1

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Ozone, 8-hour		49	
PM2.5, 24-hour	51 $\mu g/m^3$		

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2. Fill in the table below using the AQI chart provided on Student Page #4 to assign color codes to the measured concentrations of ozone and PM2.5.

Table Showing Number of Code Yellow/Orange/Red AQI Days Per Month

Location: _____ **Year:** _____

Month	Number of Days with Code Yellow/Orange/Red AQI for Ozone			Number of Days with Code Yellow/Orange/Red AQI for PM2.5		
	Yellow	Orange	Red	Yellow	Orange	Red
January	N/A	N/A	N/A			
February	N/A	N/A	N/A			
March	N/A	N/A	N/A			
April						
May						
June						
July						
August						
September						
October						
November	N/A	N/A	N/A			
December	N/A	N/A	N/A			

PART C: Looking for AQI Patterns (continued)

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- What two months have the highest number of days with ozone AQIs that are Code Yellow or above?

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