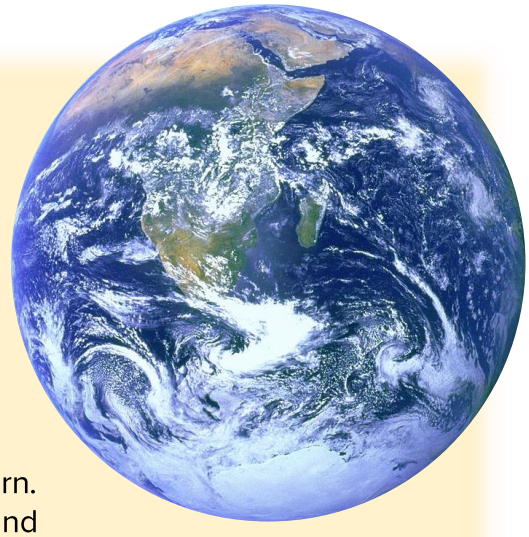
MODULE 2

What's the Air Forecast?

Human Impacts, Weather, and the Story of a Code Red Day

Module Overview



This photograph of Earth, commonly known as "The Blue Marble," was taken by the crew of the Apollo 17 spacecraft. When humans first began taking pictures of Earth from space in the 1960s, air and water pollution had already become huge problems in the United States. Photographs like this one, as well as books like Silent Spring by Rachel Carson, inspired people to take action to save the planet. In 1970 the first Earth Day was held and the Clean Air Act was signed. The modern environmental movement was born. Since then, humans have done a lot to both damage and protect the Earth and its air. In this module, students will investigate a "bad air day" to understand the sources and types of man-made air pollution, focusing on ozone, a common contributor to bad air days in the region. They will also learn about weather, and the complex ways in which weather and air pollution interact. In doing so, they will use the same sophisticated computer models that meteorologists use to predict both the weather and air pollution. Students will also take a historical look at how air quality has changed over time, using both the Air Quality Index (AQI) and EPA data as guides. As a culminating activity, students will use what they have learned to create an air quality report to inform the public about whether their air is safe to breathe.

Anchor phenomenon: A hazy day that occurred in Washington D.C. in July, 2018.

Pacing

- 9 activities + summative assessment project
- Approximately 11-13 45-60 minute class periods + assessment project

Module Contents

When to Teach This Module

Finding the right place within a science scope and sequence to investigate air pollution with students can be tricky. Below you will find some information about the module that can help you decide where this it might fit into your own plans for student leaning:

- **Connection to Weather:** This module includes a significant connection to weather concepts, but it *does not* go into detail about those concepts. As such, the module would be a great addition to a weather module – either during or after – to incorporate human impacts on Earth's atmosphere. Activity 8 is designed to be a refresher on weather topics and vocabulary, so even if students have studied weather in a previous year, they should be able to engage with the topics of this module.

- **Connection to Natural Resource Usage:** Air pollution is very much a story about human population and the consequences of how we use natural resources. While the module itself does not go into detail about kinds of natural resources, it would fit well as a part of a larger investigation of fossil fuels, and how our usage of those fuels affects the environment. The module is a great way to incorporate human impacts on the environment into a unit on these resources.

Standards Overview

Middle School NGSS standards alignment

Performance Expectations

Focus PE:

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Background PE:

MS-ESS3-3. Apply scientific principles to design a method for monitoring ~~and minimizing~~ a human impact on the environment.* [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

Science & Engineering Practices

Focus SEP: Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- ~~Develop or~~ **modify a model—based on evidence – to match what happens if a variable or component of a system is changed.**
- **Use** ~~and/or develop~~ **a model of simple systems with uncertain and less predictable factors**.
- ~~Develop and/or~~ **use a model to predict and/or describe phenomena**.

Background SEP: Obtaining, evaluating, and communicating information
Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods.

- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

Disciplinary Core Ideas

Focus DCI: ESS 3.C: Human Impacts on Earth Systems
Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

Background DCI: ESS 2.D: Weather and Climate
Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. ~~These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns~~.

Crosscutting Concepts

Focus CCC: Patterns – Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems.
- Graphs, charts, and images can be used to identify patterns in data.

Background CCC: Systems and System Models – A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems.

NGSS 5th Grade Standards alignment

Performance Expectations:

Focus PE:

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Science & Engineering Practices

Focus SEP: Developing and Using Models

Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop and/or use models to describe and/or predict phenomena.

Background SEP: Obtaining, evaluating, and communicating information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.

- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.
- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.
- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.
- Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts

Disciplinary Core Ideas

Focus DCI: ESS3.C: Human Impacts on Earth Systems

Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

ESS 2.A: Earth Materials and Systems

Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.

Focus CCC: Patterns – Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.
- Patterns of change can be used to make predictions.
- Patterns can be used as evidence to support an explanation.

Background CCC: Systems and System Models – A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

- A system can be described in terms of its components and their interactions.

Virginia Standards of Learning (SOLs) alignment

Science & Engineering Practices	
5.1 (e)	Developing and using models. The student will… • develop models using an analogy, example, or abstract representation to describe a scientific principle or design solution • identify limitations of models
6.1 (e)	Developing and using models. The student will… • use, develop, and revise models to predict and explain phenomena • evaluate limitations of models
Content Standards	
6th Grade 6.9	6.9 The student will investigate and understand that humans impact the environment and individuals can influence public policy decisions related to energy and the environment. Key ideas include c) major health and safety issues are associated with air and water quality
6th Grade 6.7	6.7 The student will investigate and understand that air has properties and that Earth's atmosphere has structure and is dynamic. Key ideas include a) air is a mixture of gaseous elements and compounds; b) the atmosphere has physical characteristics; e) atmospheric measures are used to predict weather conditions; and f) weather maps give basic information about fronts, systems, and weather measurements.
Earth Science ES.11	ES.11 The student will investigate and understand that the atmosphere is a complex, dynamic system and is subject to long-and short-term variations. Key ideas include b) biologic and geologic interactions over long and short time spans change the atmospheric composition; c) natural events and human actions may stress atmospheric regulation mechanisms; and d) human actions, including economic and policy decisions, affect the atmosphere.
Earth Science ES.12	ES.12 The student will investigate and understand that Earth's weather and climate are the result of the interaction of the sun's energy with the atmosphere, oceans, and the land. Key ideas include b) weather patterns can be predicted based on changes in current conditions; d) models based on current conditions are used to predict weather phenomena

Common Core State Standards alignment

Literacy Standards	
RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.
Math Standards	
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
7.RP.A.3	Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.

5E Module Flow

Activity 1 (Engage): What's That in the Sky?
Timing: 30-45 minutes
Purpose: Introducing the anchor phenomenon
- ✓ Students will make observations and hypotheses, and ask questions to better understand the anchor phenomenon

Activity 2 (Explain): What is Weather?
Timing: 1-2 class periods
Purpose: Building background knowledge of weather terminology to determine if the phenomenon could be natural
- ✓ Students will understand the primary characteristics used to describe weather
- ✓ Students will use weather data to determine if the phenomenon is natural or man-made

Activity 3 (Explore): Pollution, Power Plants, and People
Timing: 60 minutes
Purpose: Determining whether the phenomenon may be man-made by looking at how humans impact the environment.
- ✓ Students will use maps to identify connections among air quality, population, and electricity production

Activity 4 (Explain): The Criteria Air Pollutants
Timing: 45-60 minutes
Purpose: Building understanding of different kinds of air pollution and their sources, including the 6 criteria pollutants, in order to identify the pollutant causing the phenomenon
- ✓ Students will define air pollution
- ✓ Students will know there are different kinds of air pollution, and some are more important for us to consider
- ✓ Students will identify the pollutant that caused the Code Red Day in DC

Activity 5 (Explain): O_3, Oh My! Getting to Know Ozone
Timing: 30 minutes
Purpose: Understanding ozone and its role in air quality
- ✓ Students will understand what ozone is from both a general and chemical perspective
- ✓ Students will understand the different between beneficial (stratospheric) and harmful (tropospheric) ozone

Activity 6 (Explore): Air Quality in the DC/Baltimore Region
Timing: 2 class periods
Purpose: Understanding the Air Quality Index (AQI) and using it to explore air pollution and air quality issues at the local level

- ✓ Students will learn to interpret the Air Quality Index (AQI)
- ✓ Students will research current and historical AQI data from the DC/ Baltimore area
- ✓ Students will identify the major air pollutants in the DC/Baltimore area and analyze data to show how they have changed over time

Activity 7 (Explore): Air Pollution Trends and the Clean Air Act
Timing: 1-2 class periods
Purpose: Understanding how humans can have a positive impact on air quality by investigating how air quality has changed since the Clean Air Act

- ✓ Students will interpret graphs to determine how air quality in the US has changed over time
- ✓ Students will use the Clean Air Act to discuss whether humans have a positive or negative impact on the planet

Activity 8 (Elaborate): Smog City: How Weather Affects Air Quality
Timing: 45 minutes
Purpose: Determining how air quality and weather interact, along with how humans affect air quality

- ✓ Students will understand how different weather conditions affect AQI
- ✓ Students will understand how emissions from various sources and population affect AQI

Activity 9 (Elaborate): Making an Air Quality Prediction
Timing: 45-60 minutes
Purpose: Appplying knowledge about air quality and weather to a real world situation

- ✓ Students will be able to make an AQI prediction using data from a variety of information sources including weather conditions

Activity 10 (Evaluate): Creating an Air Quality Report
Timing: variable, minimum two class periods
Purpose: Showing student understanding of module objectives

- ✓ Students will create an air quality report based on an AQI forecast and weather conditions

Module Materials

Activity 1 (Engage): What's That in the Sky?

- ❒ Handouts: I See, I Think I Wonder, Investigation Tracker
- ❒ Materials needed: Computer & projector
- ❒ Optional materials: Air Quality Champion Interview

Activity 2 (Explain): What is Weather?

- ❒ Handouts: Visual vocabulary sheets
- ❒ Materials needed: Computer & projector, Resources for students to research weather terms (student computers with internet access, textbooks, library books, etc.)
- ❒ Optional materials: Chart paper & markers, I Have, Who Has game cards

Activity 3 (Explore): Pollution, Power Plants, and People

- ❒ Handouts: Human Activities and the Earth
- ❒ Materials needed: Computer & projector
- ❒ Optional materials: Student computers, chart paper

Activity 4 (Explain): The Criteria Air Pollutants

- ❒ Handouts: The Criteria Air Pollutants (foldable or regular), Reading: *The Region's Air Quality Reached Unhealthy Code Red Levels on Monday*
- ❒ Materials needed: Computer & projector, air pollution information stations, sources of air pollution signs
- ❒ Optional materials: scissors

Activity 5 (Explain): O_3, Oh My! Getting to Know Ozone

- ❒ Materials provided: Ozone: Good Up High, Bad Nearby (graphic organizer)
- ❒ Materials needed: Computer & projector, speakers
- ❒ Optional materials: Student computers

Activity 6 (Explore): Air Quality in the DC/Baltimore Region

- ❒ Handouts: Air Quality Index reading, Historical AQI Data Investigation, AQI Through the Years
- ❒ Materials needed: Computer & projector, "The Air Quality Today in <blank> is" posters
- ❒ Optional materials: Student computers (highly recommended), graph paper

Activity 7 (Explore): Air Pollution Trends and the Clean Air Act

- ❒ Handouts: Air Pollution Summary
- ❒ Materials needed: Computer & projector, speakers, Pollutant Trends Graphs
- ❒ Optional materials: Student computers (highly recommended), How Much Pollution is Too Much (handout)

Activity 8 (Elaborate): Smog City: How Weather Affects Air Quality

- ❒ Handouts: Save Smog City From Ozone
- ❒ Materials needed: Computer & projector
- ❒ Optional materials: Student computers (highly recommended)

Activity 9 (Elaborate): Making an Air Quality Prediction

- ❒ Handouts: AQI prediction guide
- ❒ Materials needed: Computer & projector
- ❒ Optional materials: Student computers (highly recommended)

Activity 10 (Evaluate): Creating an Air Quality Report

- ❒ Handouts: Project guidelines, Grading rubric
- ❒ Materials needed: n/a
- ❒ Optional materials: Student computers (highly recommended), video recording devices

Ozone

Ozone is a gas found in different parts of the atmosphere. Ozone in the upper atmosphere, or stratosphere, helps protect the Earth from the sun's harmful rays. In the lowest level of the atmosphere, the troposphere, exposure to ozone also can be harmful to both human health and some plants. For this reason, ozone is often described as being "good up high and bad nearby" (U.S. EPA, 2003a). Most ground-level ozone forms in the air from chemical reactions involving nitrogen oxides (NOx), volatile organic compounds (VOCs), and sunlight. Ozone levels are typically highest during the afternoon hours of the summer months, when the influence of direct sunlight is the greatest. These highest levels occur during what is known as the "ozone season," which includes at least the spring and summer months but whose time frame varies by state (U.S. EPA, 2003b).

Variations in weather conditions play an important role in determining ozone levels. Daily temperatures, relative humidity, and wind speed can affect ozone levels. In general, warm dry weather is more conducive to ozone formation than cool wet weather. Wind can affect both the location and concentration of ozone pollution. NOx and VOC emissions can travel hundreds of miles on air currents, forming ozone far from the original emissions sources. Ozone also can travel long distances, affecting areas far downwind. High winds tend to disperse pollutants and can dilute ozone concentrations. However, stagnant conditions or light winds allow pollution levels to build up and become more concentrated.

Inhalation exposure to ozone can cause many harmful health effects. Examples include respiratory effects, such as difficulty breathing, coughing, and airway inflammation. For people with lung diseases such as asthma, emphysema, and chronic obstructive pulmonary disease (COPD), these effects can lead to emergency room visits and hospital admissions. Ozone exposure also is likely to cause premature death from lung or heart diseases. In addition, evidence indicates that long-term ozone exposure may lead to the development of asthma and permanent lung damage (U.S. EPA, 2013).

People most at risk from breathing air containing ozone include people with asthma, children, older adults, and people who are active outdoors, especially outdoor workers. In addition, people with certain genetic characteristics, and people with reduced intake of certain nutrients, such as vitamins C and E, are at greater risk from ozone exposure. Research also indicates people with certain health conditions, such as obesity or diabetes, may be at increased risk of ozone-related health effects. Elevated concentrations of ozone can also affect some vegetation and ecosystems (U.S. EPA, 2013).

Trends in Ozone Levels in the US

Between the 1978-1980 and 2014-2016 averaging periods, ambient ozone concentrations decreased significantly. The 8-hour ozone levels in 2014-2016 were the second lowest on record. However, despite reductions in ambient concentrations of ozone over the past quarter century, ozone concentrations above the health-based air quality standards remain one of the most persistent air pollution problems in many parts of the U.S.

Adapted from: *Ozone Concentrations*, Report on the Environment, US EPA,
https://cfpub.epa.gov/roe/indicator_pdf.cfm?i=8

AQI Basics

What is the U.S. Air Quality Index (AQI)?

The U.S. AQI is EPA's index for reporting air quality.

How does the AQI work?

Think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 or below represents good air quality, while an AQI value over 300 represents hazardous air quality.

For each pollutant an AQI value of 100 generally corresponds to a concentration equal to the level of the short-term national ambient air quality standard (NAAQS) for protection of public health. AQI values at or below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is unhealthy: at first for certain sensitive groups of people, then for everyone as AQI values get higher.

The AQI is divided into six categories. Each category corresponds to a different level of health concern. Each category also has a specific color. The color makes it easy for people to quickly determine whether air quality is reaching unhealthy levels in their communities.

AQI Basics for Ozone and Particle Pollution

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Five Major Pollutants

EPA establishes an AQI for five major air pollutants regulated by the Clean Air Act. Each of these pollutants has a national air quality standard set by EPA to protect public health:

- ground-level ozone
- particle pollution (also known as particulate matter, including PM2.5 and PM10)
- carbon monoxide
- sulfur dioxide
- nitrogen dioxide

Adapted from *AQI Basics*, Air Now. https://www.airnow.gov/aqi/aqi-basics/

Quantities and the Earth's Atmosphere

The vast majority of Earth's atmosphere is made up of just two gases: nitrogen or N_2 (78%) and oxygen or O_2 (21%). Trace gases such as argon (1%), water vapor (1%), carbon dioxide (0.04%), and others are also present in very small amounts. Pollutants may be harmful at even smaller amounts. To describe these very small amounts of gases, scientists use the measures parts per million (ppm) and parts per billion (ppb). One percent is equal to one part per hundred or 10,000 parts per million. Similarly, one part per million equals 0.0001%.

$$1\% = \frac{1}{100} \times \frac{10{,}000}{10{,}000} = \frac{10{,}000}{1{,}000{,}000}$$ 1% = 10,000 ppm

$$\frac{1}{1{,}000{,}000} \times \frac{0.0001}{0.0001} = \frac{0.0001}{100} = 0.0001\%$$ 1 ppm = 0.0001%

Expressed using ppm, the major components of Earth's atmosphere are:

- Nitrogen: 780,800 ppm (78.08%)
- Oxygen: 209,500 ppm (20.95%)
- Argon: 9,340 ppm (0.93%)
- Water vapor: ~10,000 ppm (~1%)
- Carbon dioxide: 410 ppm (0.041%)

Additional sources of background information for teachers:

The Clean Air Act:

- Plain English Guide to the Clean Air Act: https://www.epa.gov/sites/production/files/2015-08/documents/peg.pdf

Acronyms

- NAAQS: National Ambient Air Quality Standards – the is the "safe" level of each pollutant.

Activity 1 (Engage): What's That in the Sky?

Activity summary: Students are introduced to the anchor phenomenon for the unit by looking at a picture of a city at two different times: half of the picture shows the city hazy with smog, and the other half is clear. Students consider what could be causing this unusual phenomenon.

Standards Connection

DCI: ESS 3.C – Human Impacts on Earth's Systems

Warmup: What is it like outside today? Use descriptive language to provide as many details as possible.

- Use this warmup as a way to get students thinking about how they would describe current weather conditions. They will almost certainly not describe the air quality, but they may say things like "it is clear" or "it is cloudy." Tell students to keep these words in mind for later in the activity.

1. **Frame the activity:** Tell students that they are starting a new investigation today. For this investigation, they are going to take on the role of meteorologists (weather scientists) to study a strange thing that happened in the city (or a nearby city) a few summers ago. It will be up to them to use their scientific skills to figure out what happened. Then they will need to use their weather forecasting skills to figure out if the strange thing is going to happen again, and what to people about it.

Air Quality Champion

Amelia Draper is the StormTeam 4 meteorologist on NBC in Washington, D.C. As the station scientist, she is responsible for informing people about the weather and the air quality. Read more about Amelia and her story at the end of the module.

2. **Introduce the phenomenon:** Hand out the I See, I Think, I Wonder sheets to students. Show students the picture on the next page and tell them that this picture shows a similar situation to the one that happened nearby, but in a different city. Start by having students write down what they **see** in the picture in the top row of their paper. Encourage them to write about the whole picture, and only write things they can see directly.

ACTIVITY DETAILS

Time: 30-45 minutes

Objectives

- ✓ Students will make observations and hypotheses, and ask questions to better understand the anchor phenomenon

Materials

- ✓ Computer & projector
- ✓ Investigation Tracker (teacher guide)

Handouts

- ✓ I See, I Think, I Wonder
- ✓ Investigation Tracker
- ✓ Air Quality Champion interview (optional)

Personal connection (recommended)

- ✓ Sometime during the module, have students read the interview with this module's Air Quality Champion to help them understand the people who keep us safe from air pollution and the kinds of work that they do.

TEACHER NOTES

The phenomenon

- ✓ This image shows the city of Tieling, China, at two different times during a 10-day period in 2019. The left side shows the city shrouded in smog (ground-level ozone), while the right side shows the city on a clear day. Moderate winds and cooler temperatures can keep ozone levels low, so it is not unusual to have very different levels of smog during a relatively short period of time. Smog is still a problem in many US cities, although things have improved. You can find historical photos of Baltimore air pollution here: http://darkroom.baltimoresun.com/2017/04/from-the-vault-air-pollution-baltimore/#1 and a photo of DC here: https://www.washingtonpost.com/lifestyle/kidspost/good-day-to-play-outside-learn-about-air-pollution-to-find-out/2015/08/03/3708e168-30a5-11e5-97ae-30a30cca95d7_story.html If you show any of these photos to students, try to keep the pollution connection secret until later in the module.

Credit: Tomskyhaha / CC BY-SA

Students should recognize the very hazy sky and buildings on the left side of the picture and the blue sky and clear buildings on the right side of the picture. They may also note the clouds on one side and not the other, and the fact that there are buildings that go across the picture. After students have had some time to write, have them turn to a partner to share what they wrote. Encourage them to add things their partner noticed to their sheets.

Next, have students write down what they **think** is going on in this image in the middle row of their paper. When they've had a chance to write some ideas, have them share with a partner again. They may have a variety of ideas, such as:

- the picture was altered (ex. colored)
- the image shows two different places
- the image shows the same place at different times
- the left side shows the city on a foggy day and the right side shows the city on a clear day

Finally, have students write down what they **wonder** about this picture using questions in the bottom row, and again have them share with their partner. Things they may consider:

- Has this photo been altered in any way?
- Why is the sky so foggy/cloudy on the left side?
- Is this all one city?
- Why does the picture look so different on each side?
- Where was this photo taken?

Once students have had a chance to share with their partner, give them a chance to share some of the things they saw, thought, and wondered about the picture with the whole group. Acknowledge students' answers and help them make connections with one another, but do not give away any information about the picture.

3. **What could be causing this?** Ask students what they think could be causing the city to look this way. Hand out the Investigation Tracker sheet to students, and have them brainstorm some ideas with a partner in the first row (Activity 1). If students struggle to come up with ideas, use questions to help them brainstorm. Possible answers:
    - It is smoky because of a fire
    - It is foggy
    - It is snowing
    - There is something else falling from the sky (ex. volcanic ash)
    - The air is polluted

    After they have had time to come up with some ideas, have pairs share with the whole group. Record students' ideas on chart paper that you can put up and save for the rest of the module. (Note: it will be helpful for Activity 2 if at least one student says that they think it is fog). Have students copy any of their peers' ideas that they like into the first row. Tell students that they will be using this sheet to track their learning as they complete their investigation.

4. **July 9, 2018:** Tell students that a similar thing to what they see in left side of the picture happened in the DC area on July 9, 2018. Show them the picture in this link: https://tinyurl.com/DCCodeRed, which shows the White House under a hazy sky (note: it is not nearly as pronounced as in the earlier picture). Tell them that because of this haze, meteorologists called it a "Code Red Day." Have students imagine that they were in the city that day. What do they think it would have been like? Do they think it would be hot or cold? Rainy or cloudy? Do you think it would be okay to go outside and play on a day like that? Give students a chance to share their ideas about what they think it would have been like. Have them consider how they described what it is like outside today during their warmup, and have them compare this to their description what it would be like on that day in July.

    Tell students that during the next few activities, they are going to study this strange thing to see if they can figure out what is going on and whether it is a problem for people.

TEACHER NOTES

Modification

✓ During the I see, I think, I wonder, have students share whole group at the end of each section instead of only once at the end.

Teacher Tip

✓ The Investigation Tracker is designed to help students with sensemaking about big concepts from the module. Try to prevent students from just copying down what you write by always having them write first and then adding to their ideas.

Connection to Module 1

✓ If you have done Module 1 with students, they may already be making connections here to ozone pollution. This will accelerate their understanding of the phenomenon, but it won't affect the rest of the module.

TEACHER NOTES

Current events

✓ For some fascinating images of how the coronavirus lockdowns have altered the amount of smog in major cities around the world, check out this article from Insider: https://tinyurl.com/LockdownSmog

5. **Formative assessment:** Have students go back to the "I See, I Think, I Wonder" side of their sheets, and identify what big questions they need to answer to understand what's going on in the picture. Have them put a star or highlight those questions. They may also need to add a question based on what they've learned, which they can write in the "Big questions" space. Good big questions might be:
    - **What is causing the sky to look hazy in the picture?**
    - **What was the weather like that day?**
    - **Is there something in the air that is making the picture look that way?**

    Use students' I See, I Think, I Wonder sheets as a formative assessment, either by collecting them to evaluate students' thinking process, or by circulating at the end of class and taking note of what they have written.

STUDENT HANDOUT

Name_____

I See, I Think, I Wonder...

I see...
I think...
I wonder...
Big questions:

STUDENT HANDOUT

Investigation Tracker

What have I learned about what happened in Washington, D.C. on July 9th, 2018?	
Activity 1	
Activity 2	
Activity 3	
Activity 4	

Activity 5	
Activity 6	
Activity 7	
Activity 8	

TEACHER GUIDE

Investigation Tracker

What have I learned about what happened in Washington, D.C. on July 9th, 2018?	
Activity 1	It could be... • It is smoky because of a fire • It is foggy • It is snowing • There is something else falling from the sky (ex. volcanic ash) • The air is polluted
Activity 2	• The haze is not fog because the weather conditions were not right to make fog • It was unlikely to be natural, because there are no other good natural explanations • It is likely to be man-made
Activity 3	• The haze could be caused by humans because humans can affect the atmosphere by creating air pollution • It could be air pollution from things like coal power plants. • There are some power plants near DC, but not a lot • There are a lot of people in the DC area
Activity 4	• The haze is caused by ground-level ozone pollution (smog) • Ozone forms when certain air pollution is released from cars, power plants, and industrial facilities. These pollutants react with heat and sunlight, which makes ground level ozone.

Activity 5	• There are two kinds of ozone: ground-level ozone and stratospheric ozone • Ground-level ozone (tropospheric) is a harmful pollutant that can hurt people's lungs and damage crops • Stratospheric ozone (in the ozone layer) protects Earth from harmful radiation • Ground-level ozone is formed when certain kinds of air pollution react with heat and sunlight • You can prevent ozone from forming by using less electricity and driving less
Activity 6	• Air quality is measured using a scale call the Air Quality Index (AQI) • The main air pollutants in the DC-Baltimore area are particulate matter (PM) and ozone. • Air quality in the DC-Baltimore area is improving
Activity 7	• Air quality in the United States has improved a lot since 1980. • The Clean Air Act was a very important law that helped the US to clean up the air • People can have positive and negative impacts on the environment by polluting, or by working to stop pollution
Activity 8	• Air pollution (especially ozone) is strongly affected by the weather • Weather conditions like clear sunny skies and low wind are more likely to result in a bad ozone day • Rain can "wash" pollution out of the air resulting in less ozone. • Large human populations can result in more emissions and worse air quality if they don't do something to prevent it

Activity 2 (Explain): What is Weather?

ACTIVITY DETAILS

Time: 1-2 class periods

Objectives

- ✓ Students will understand the primary characteristics used to describe weather
- ✓ Students will use weather data to determine if the phenomenon is natural or man-made

Materials

- ✓ Computer & projector
- ✓ Resources for students to research weather terms (computers & internet, textbooks, library books, etc.)
- ✓ Markers (if students are using chart paper)
- ✓ I Have, Who Has cards (optional) – printed and cut

Handouts

- ✓ Visual vocabulary sheets (enough based on how many each student will do) OR chart paper for each entry

Activity summary: In this activity, students learn to interpret a weather forecast by learning about the different terms and units involved in weather such as temperature, humidity, wind, precipitation, sky condition, and air pressure. They use this information to determine if the hazy sky in the photograph could be naturally occurring fog.

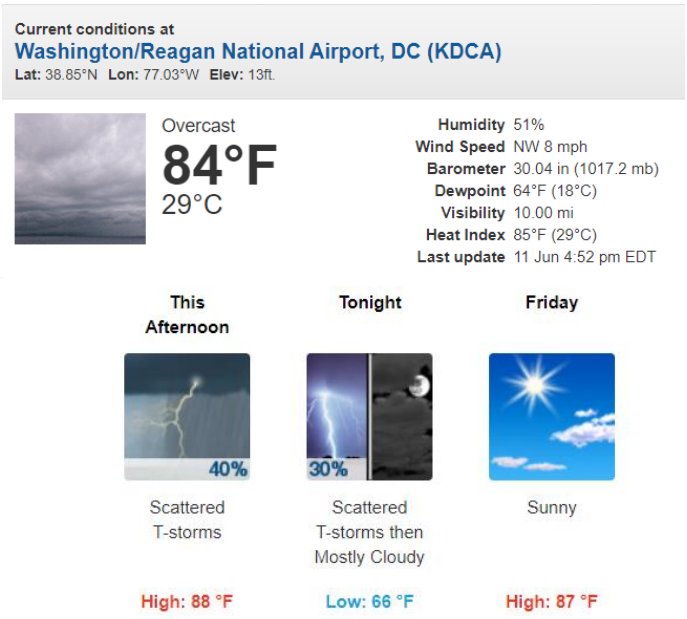
Standards Connection

DCI: ESS 2.D Weather & Climate
SEP: Obtaining, Evaluating, and Communicating Information
CCC: Systems & System Models

Important Note about this Activity

This activity provides a brief background in weather terminology and concepts to allow students to engage with the activities that follow. Ideally, students will have already explored these ideas in a prior unit, and this lesson can serve more as a refresher than new learning. If students have already studied weather before, you may choose to skip the first part of this activity, but make sure to do the "Return to the Phenomenon" section (step 5).

Warmup: Show students a current weather forecast like the one below from weather.gov and ask what information it provides (temperature, humidity, wind, precipitation, sky condition, dew point, etc.) Based on this information, have them write a definition for weather that uses some of these terms.



TEACHER NOTES

Have students share their definitions with a partner or group, and come to a consensus for a definition of weather. Their definitions do not need to be precise – you will come back to this question later. A possible student definition might be "Weather is what it is like outside: for example, what the temperature is and whether it is precipitating or not."

1. **Frame the activity:** Point out the chart paper list of students' ideas of what could be causing the haziness in Washington DC like in the left side of the image. Have them identify which causes are natural, and which would be man-made. For example, if it is caused by a fire/smoke, then it is likely man-made, and if it is fog or snow, it is natural. Once they have divided up the list, tell them that today they are going to investigate the "natural" list to see if any of these could be the cause. They will do this by learning about weather in order to determine how things like fog form.

2. **Parts of a Weather Model:** Remind students' that for this investigation they are taking on the role of meteorologists. Meteorologists study how weather works by building weather models. A weather model is not like a model of the solar system. It is a computer program based on math and science that takes information about the current weather, and uses it to make a prediction about what the weather will be. In order for them to understand whether the haze could be natural, they need to understand the parts of a weather model. Ask students what kinds of information they think needs to go into a weather model. Write students' responses to this question on the board to make a list of inputs to the weather model. Remind them of answers to their warm-up, and use additional follow-up questions as necessary.
    - Key inputs: temperature, wind speed/direction, time of year (season), humidity, precipitation, location, dew point

3. **Visual Vocabulary:** Tell students that in order to use these scientific terms to make predictions, it's important to make sure everyone has a common understanding of what they mean. To help with this, they are going to make a visual glossary of terms. Show students the example of the glossary entry for temperature below, and review the parts: the term, the definition, a picture to illustrate the term, an example of how it is used, the measuring tool used to measure it, and the units or scale that go with it.

Differentiation

- ✓ You can have all students do all the terms, divide up the terms and have each student do one or divide students into groups and have each group do all the terms. Suggest more complex terms (ex. temperature inversion) for more advanced students

Modification

- ✓ Instead of having students make the glossary on standard-sized paper, have groups each make an entry on chart paper to put up around the room. Have each group present their poster before they put it up.

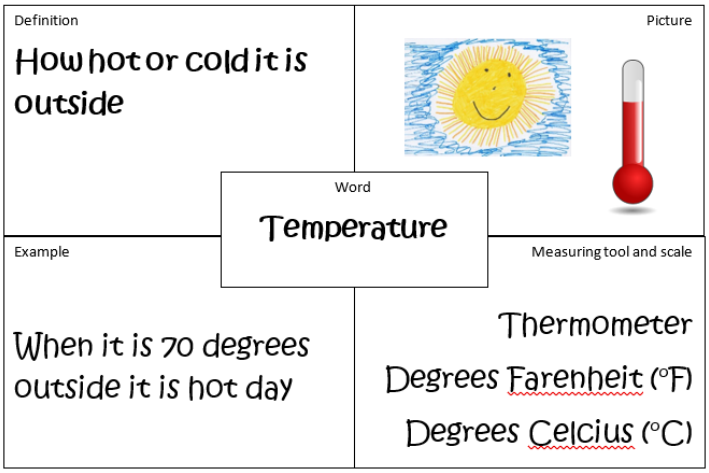
TEACHER NOTES

Differentiation

- ✓ For the first round of "I have, who has" pass the cards out in order so that students can go around the class as a review of the terms. Then recollect them and mix them up.

Modification

- ✓ The "I have, who has" template is easy to edit. Add or remove the "I have" and "Who has" entries for any terms, and adjust the table, making sure that the last "Who has?" you keep matches the next "I have". Then adjust the entries on the cards. Just make sure that the last card connects back to the first one.



Identify what terms you want students to include in their glossary.

- Required: temperature, precipitation, humidity, wind, sky condition (cloudy, sunny, etc.), dew point
- Optional: air pressure, season, temperature inversion (see: http://ffden-2.phys.uaf.edu/212_spring2007.web.dir/Amber_Smith/Effects_of_Inversions.htm)

You can divide up the terms so that each student has a few, or have all students do all the terms. Once students understand the directions, provide them with the resources to do their research. Age-appropriate books on weather, and weather websites such as weatherwhizkids.com are good choices.

After students have created their glossary terms, make sure they have had a chance to share with others so that all students have interacted with all the terms.

4. **I Have, Who Has (optional).** Tell students that you are going to play a game to help them remember the weather terms you learned about today. Pass out the "I have, who has?" cards (make sure each student has at least one card, and make sure all the cards have been passed out. Have students work in pairs if you have more students than cards). Go over the directions with students:
   - One student will begin by reading the "who has" portion of their card.
   - The student who has the "answer" to that card will say, "I have <the answer>. They will then read the "who has" portion of their card
   - Continue until all the cards have been read, and you've gotten back to the beginning of the circle.

While students are playing, listen for any errors, and support students in getting back on track if they make a mistake or get stuck. Students may have slightly different definitions based on their research, so it's important to follow along. Students should also follow along to help each other.

For more information on how to play, watch this video: https://www.youtube.com/watch?v=- v4JDPN8wec

5. **Return to the phenomenon:** Go back to the list of "natural" possibilities for what is causing the haziness in the photos. Some things students might have suggested for natural are snow, fog, and volcanic ash. Ask students what weather information they would need to know to determine if any of these are possibilities (only use the ones they suggested).
    - Snow: temperature and precipitation
    - Fog: temperature and dew point (students will likely not know this, so you can help them or look it up together)
    - Volcanic ash: (in the event students bring this up, you can ask students if there are any volcanoes in the DC area)

    Tell students that in order to find out what Washington DC was like on that July 9, 2018, they can look up historical weather information online. Go to: https://www.wunderground.com/history/daily/us/dc/KDCA/date/2018-7-9 and display the weather information for DC on July 9, 2018 (the "daily observations" section at the bottom has all the information they need).

    Have students consider whether the conditions are right for snow. They may already have realized that there wouldn't be any snow in July, but it is still useful to see that the low temperature was 65°F and there was no precipitation, so it couldn't be snow.

    Next have students think about fog. If you haven't already looked this up together, then make sure students know the requirements for fog to form: the temperature and the dew point need to be the same or very close (within a few degrees). Have students look at the data to determine whether fog could have formed that day. Have them turn to a partner and decide what they think.

    After a short time, have students share their analysis. They should recognize:
    - The dew point in DC on 7/9/18 ranged from 51°F - 59°F.
    - The low for the day was 65°F.
    - The closest the temperature and dew point ever got together was 10°F at 5:52 am.
    - Based on this information, fog would not have formed because the temperature and dew point never got close enough together.

TEACHER NOTES

Tech integration

✓ Websites such as quizlet.com and kahoot.com are another great way to help students develop understanding of the weather vocabulary. You can search "quizlet" or "kahoot" + "weather" to find premade resources, or go to the websites and create your own.

Modification

✓ You may want to print out this weather information in advance so students can look at it on their own.

Have students go back to their Investigation Tracker from Activity 1 and add new information in the space for Activity 2 based on what they learned today about the phenomenon. The most important information they learned is:

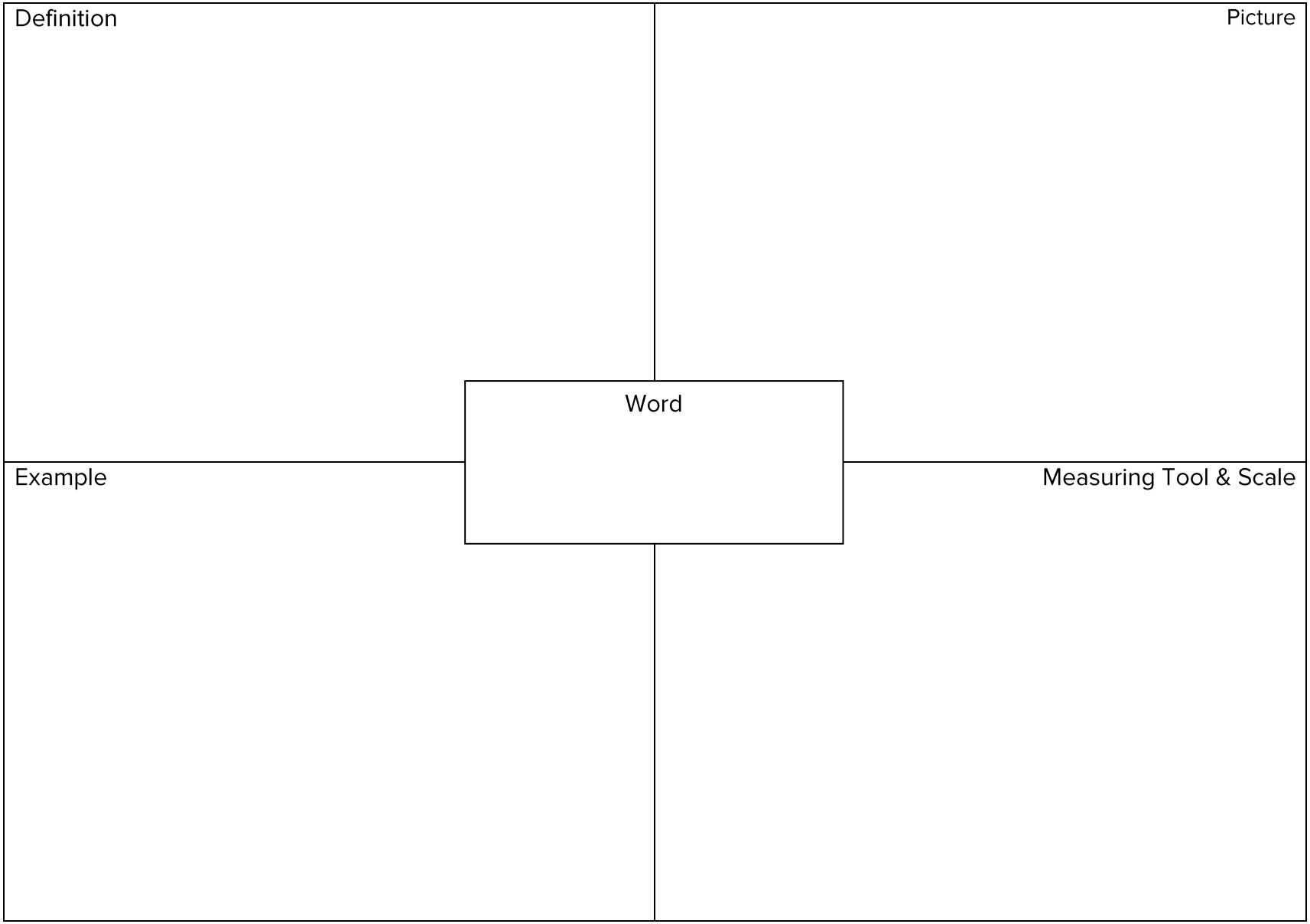
- The haze is not fog because the weather conditions were not right to make fog
- It was unlikely to be natural, because there are no other good natural explanations
- Therefore, it is likely to be man-made

6. **Defining weather:** Have students go back to their original definition of weather, and see if there is anything they want to add or clarify. Their definition should recognize that weather is a description of a variety of atmospheric conditions (temperature, precipitation, dew point, humidity, pressure, etc.) and that it refers to a short period of time because the weather can change quickly (as opposed to climate, which may only change over long spans of time). Either as a class or in their groups, reach a consensus definition. Then write the definition (or group definitions) in big letters on a piece of paper and post it prominently in the classroom.

7. **Formative assessment**. Have students Interpret a current weather forecast based upon the content that they learned today.
    - Option 1: Show a video weather forecast, and have students identify what each of the terms are and how they are used. (ex. temperature, humidity, cloud cover, etc.)
    - Option 2: Show a weather forecast from a website or newspaper and have students identify what each of the terms are and how they are used.

Looking ahead

✓ Students will use these weather terms in later activities, so you may want to have them study the terms for homework or review them before the next activity.


Definition
Picture
Word
Example
Measuring Tool & Scale

TEACHER GUIDE

I Have, Who Has Weather Terms

Answer Guide

	I have...	**Who has...**
1	Temperature	The units for wind speed
2	Knots, meters per second, or miles per hour	The tool for measuring humidity
3	Hygrometer	Moving air
4	Wind	The weight of air pressing down
5	Air pressure	Rain, snow, sleet, or hail
6	Precipitation	The scale and units for temperature
7	Degrees Fahrenheit or degrees Celsius	How cloudy the sky is
8	Sky condition	The tool to measure wind speed
9	Anemometer	The units for air pressure
10	Inches or mm of mercury or psi	The tool to measure temperature
11	Thermometer	The tool to measure amount of rain
12	Rain gauge	Winter, spring, summer, or fall
13	Seasons	The tool to measure wind direction
14	Wind vane or weather vane	The amount of water vapor in the air
15	Humidity	An example of sky condition
16	Partly cloudy	An example of temperature
17	75 degrees Fahrenheit	The tool to measure air pressure
18	Barometer	An example of relative humidity
19	48%	An example of wind direction
20	Northwest	The temperature at which water condenses
21	Dew Point	How hot or cold it is

To prepare for the game, print out the cards on the following pages and cut them along the dotted lines.

I have temperature Who has the units for wind speed?	I have knots, meters per second, or miles per hour. Who has the tool for measuring humidity?
I have hygrometer. Who has moving air?	I have wind. Who has the weight of air pressing down?
I have air pressure. Who has rain, snow, sleet, or hail?	I have precipitation. Who has the scale and units for temperature?
I have degrees Fahrenheit or degrees Celsius. Who has how cloudy the sky is?	I have a sky condition. Who has the tool to measure wind speed?
I have anemometer. Who has the units for air pressure?	I have inches or millimeters of mercury or pounds per square inch (psi). Who has the tool to measure temperature?
I have thermometer. Who has the tool to measure amount of rain?	I have rain gauge. Who has winter, spring, summer, and fall?

I have seasons. Who has the tool to measure wind direction?	I have wind vane or weather vane. Who has the amount of water vapor in the air?
I have humidity. Who has an example of sky condition?	I have partly cloudy. Who has an example of temperature?
I have 75 degrees Fahrenheit. Who has the tool to measure air pressure?	I have barometer. Who has an example of humidity?
I have 48%. Who has an example of wind direction?	I have northwest. Who has the temperature at which water condenses.
I have dew point. Who has how hot or cold it is?	

Activity 3 (Explore): Pollution, Power Plants, and People

Activity summary: In this activity, students look at maps of air pollution sources, air quality, and population to see how humans impact the environment. They will use this information to determine if the haze in their phenomenon photographs could be man-made.

Standards Connection

DCI: ESS 3.C – Human Impacts on Earth's Systems
SEP: Obtaining, Evaluating, and Communicating Information
CCC: Patterns

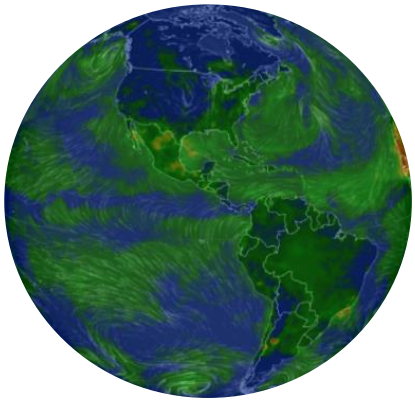
Warmup: What kinds of things do people do that affect the Earth? For example, we cut down trees to make room for farming. What other things do humans do that change the planet?

- Students answers may include: we build houses and other buildings, we pave over the grass, we put dams on rivers, we put pollution into the air and the water, we dig resources out of the ground, etc.
- Use this warmup to activate student prior knowledge on human activities that might affect the planet (and potentially cause our phenomenon)

1. **Frame the activity:** Remind students that in the last activity, they decided that the haze in the pictures is unlikely to be natural. That means that it's probably man made. But they still don't know what kind of activities could create a haze like that. In order to investigate how humans affect the planet, they're going to look at a series of maps to look for patterns in human activities and how they affect the atmosphere. Hand out the Human Activities and the Earth sheet.

2. **The World Air Quality Globe & Map.** Display the live world air quality globe for all students to see: www.iqair.com/earth, but don't tell them what it is.

   Rotate the globe to show students different parts of the world and zoom in to different places. Ask students what they think the globe shows. Some may say it has something to do with temperature, weather or air pollution (if they've done Module 1).



ACTIVITY DETAILS

Time: 45-60 minutes

Objectives

- ✓ Students will use maps to identify connections among air quality, population, and electricity production

Materials

- ✓ Computer & projector
- ✓ Chart paper (for research sources list)
- ✓ Student computers (optional)

Handouts

- ✓ Humans Activities and the Earth

Tech integration

- ✓ If student computers are available, you can have students look at these maps on their own devices.

TEACHER NOTES

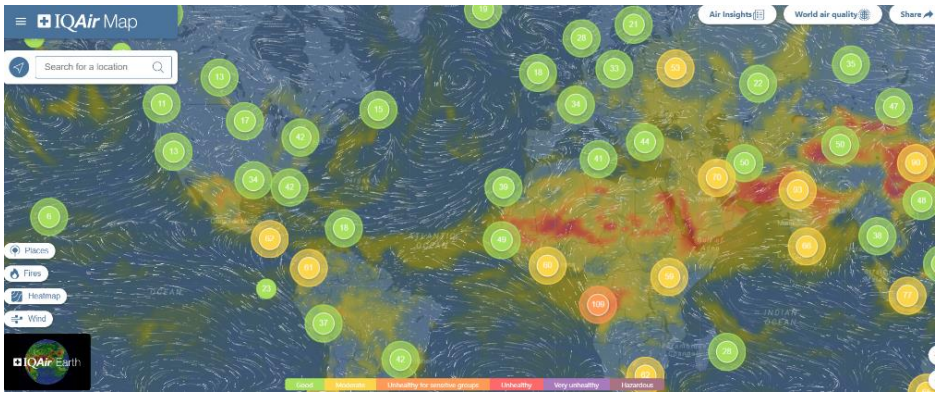
Teacher Tip

✓ The IQAir map shown here focuses on particulate matter pollution (PM). The World Air Quality Index project has another good world air quality map. It has more data and more options, but is somewhat less visually appealing. You can find that map at: http://www.waqi.info/ For ozone information, use the waqi map and choose ozone from the pollutant menu

Cultural awareness

✓ Different parts of the world are in different stages of development, and therefore are in different stages of pollution control. Keep this in mind when talking about parts of the world, especially if you have students from these regions. Having poor air quality is a challenge all developing nations have faced; it does not make them bad countries.

Next go to the World Air Quality map: www.iqair.com/air-quality-map.



Have students jot down some observations of what they see on the map on their handouts. Key observations:

- There are a lot of data points/numbers
- The data points have different colors
- Something is flowing around (if you have wind map on)
- The colors tend to be grouped together

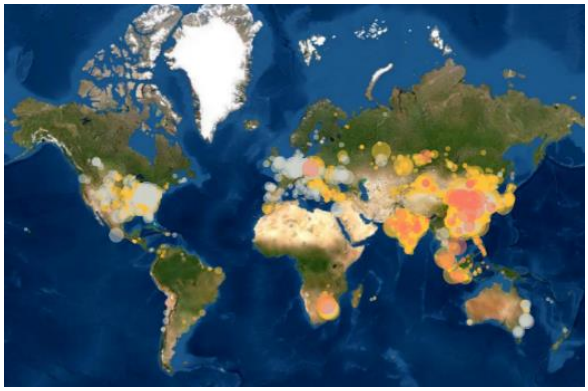
Ask the students why they think the data points are in different colors. Students may look at the scale at the bottom right, or they may think that green is good and red is bad because many scales use this coding.

If students haven't made the connection yet, tell them that this is a map of air pollution. Point out the scale and make sure students understand the scale in general (low numbers and green are good; high numbers and red/purple are bad). Have them add this information on their handouts.

3. **Identifying pollution sources:** Ask students what patterns they see in where the good and bad air quality is around the world. They should see that there is more air pollution in certain parts of the world compared to others. Have them write down what parts of the world have more air pollution (ex. China, India, and parts of Africa), and what parts have less (North and South America and Europe). Help students identify geographical areas and countries to use in their description. You may also need to zoom in to certain parts of the map to make this clearer.

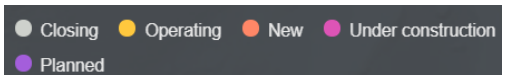
Have students turn and talk to a partner about why the air pollution might be better or worse in different parts of the world. After they've discussed, have groups share their hypotheses, but don't tell them whether their answers are correct or not. Use probing questions to help clarify their thinking.

Next, show students the map of world coal power plants from Carbon Brief: https://www.carbonbrief.org/mapped-worlds-coal-power-plants. Have students look at the scale to understand what the different size circles represent and the different colors. Have them use this information to answer the questions on their sheet.



Size of circles = capacity of power plant (bigger circle = more power)

Color = stage of operation



Next have students look at where power plants are opening vs. closing and ask them what they notice. Then have them look at the size of the power plants and ask them what they notice. Key takeaways:

- Most new and big coal plants are in India and China
- Many other parts of the world are closing their coal plants

Have students turn back to their partners to see if this new information confirms their hypotheses, or if they have new ideas about the cause of good/bad air quality in different parts of the world.

4. **Identifying large human populations:** Show students the map of world population (next page) and make sure they understand what the colors represent. https://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-density-rev11/maps

TEACHER NOTES

Personal connection

✓ Have students think about what it might be like to be a middle school student in these different places. Do they think that it would affect their health? How would they feel to live in a place that had high levels of air pollution?

Air pollution in Africa

✓ North Africa and sub-Saharan Africa have significant air pollution but few large power plants. Much of this pollution comes from Saharan dust storms, household fuel burning, and transportation. The large population sizes of sub-Saharan African countries result in significant burning of wood, charcoal, and kerosene for fuel. In other words, these countries burn fuel much like other countries, it just happens locally instead of in large power plants.

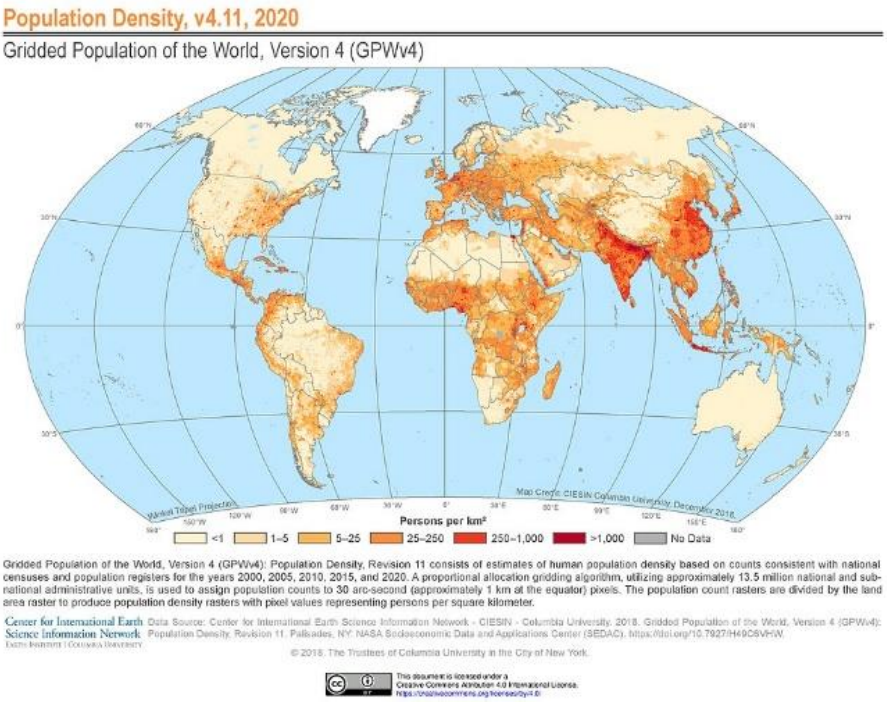
Teacher Tip

✓ If you follow the link provided for the population map, you will need to download the map needs before it can be shown

TEACHER NOTES

Math connection

- ✓ This map shows population density in persons/km^2, not raw population. If you have time, write the units for population density and take a moment to review with students what the unit means and how it can be used to show where there are large concentrations of people in one place.



Have students look at the scale and identify what the colors mean (lighter colors = less population, darker colors = more population). Have them answer the questions about the scale on their handouts. Then ask what they notice about the world population map. Key takeaways:

- There are large populations of people in India & China, sub-Saharan Africa, Europe, the eastern US, and parts of central America.

Have students write down on their handouts where there are large populations of people.

5. **Putting the Pieces Together**: Tell students that in order to think about how humans affect the Earth, they need to look for patterns across the three different maps they looked at. In small groups, have them look back at their notes and identify and patterns (similarities) that they see. Give students time to work. While they are talking, circulate and ask questions to help push their thinking. The key point that students should recognize:
   - In general, places where there are a lot of people and a lot of power plants, there is bad air pollution.

   After small groups have had a chance to talk, bring the whole group together and have them summarize what they noticed.

   This concept – that high population and power generation often results in air pollution – is an incredibly important point for students to grasp, so make sure that they understand before moving on.

TEACHER NOTES

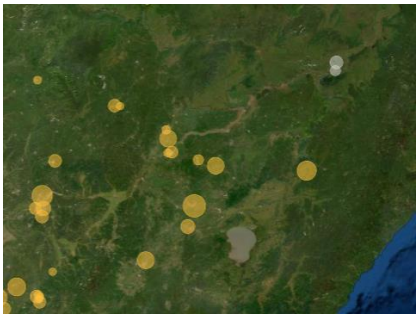
Use follow up questions to push their thinking on why the air pollution is worse in places where there are more people and more power plants. Students may not understand that coal plants emit large amounts of air pollution, and high population means other source of pollution like transportation, fires, etc. This connection will be much more explicit in the next activity, but get their minds thinking about this in the meantime.

Have students write a short summary about this pattern in the space on their handout.

Ask students if this pattern is true everywhere in the world. They should be able to recognize that in some parts of the world, there are higher populations (like Europe) that don't have a lot of air pollution. The US has coal power plants and a relatively high number of people, but not bad air pollution. Ask students why they think this is (there is a space for them to write some ideas on their handouts). As with the sources of air pollution, students likely will not know for certain, but tell them that they will try to figure out why that is on another day. *Note:* When talking about the Clean Air Act in later lessons, you may want to come back to this map to help them remember.

6. **Check for Understanding:** Show students the two portions of the Carbon Brief map below showing the location and size of coal power plants**.**

Area A



Area B

Ask students which area they would expect to have better air quality?

- Air quality will likely be lower in Area A because of the high number and concentration of coal power plants

Teacher Tip

✓ These two areas are both from northern China. If you bring up these maps (or any others) using IQAir, CarbonBrief, and the population density map, you can have students look for additional patterns in power plants, population, and AQI.

TEACHER NOTES

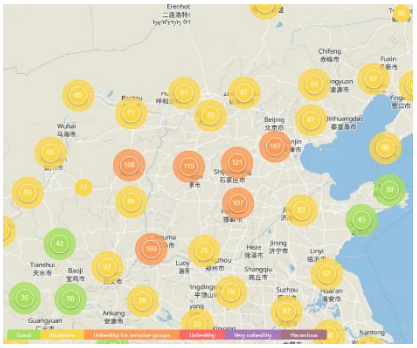
Data sources to keep track of

✓ Students will use a variety of data sources throughout this module. To help them keep track, you may want to create a poster that lists the data sources and what they're used for. In this activity, they looked at IQAir for AQI data, CarbonBrief for power plant data, and a NASA website for population data.

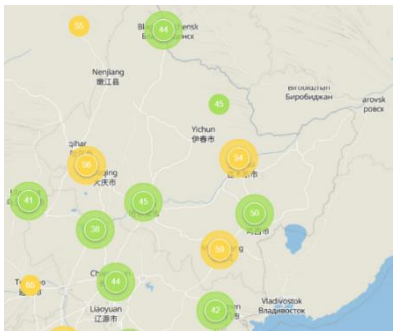
Differentiation

✓ If you are unsure that students will pick up on key points from the lesson before they write in their Investigation Trackers, have a short discussion about big takeaways before the formative assessment instead of after.

Actual air quality for these areas (as of June 2020):

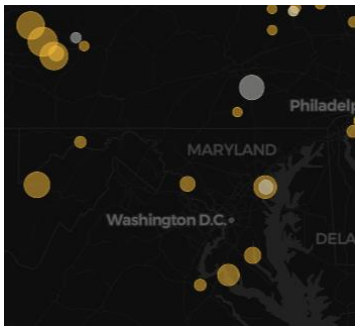


Area A



Area B

7. **Return to the phenomenon.** Remind students that they have been looking at these maps to determine whether the haze in their photos could be man-made. Tell students that the first picture from their phenomenon comes from China (the top right corner of Area A) and the second picture comes from Washington, D.C. Show students the CarbonBrief images of power plants in these two areas. Ask them: based on this information, do they think their hazy day could be cause by air pollution? Hold a short discussion to let students share what they think.



There is some evidence that it could be air pollution, but this is likely not enough. They will need more evidence to be sure.

8. **Formative assessment:** Return to your Investigation Tracker from Activity 1. Based on what you learned today, what important information can you add to your tracker that helps you to understand our hazy day? Key points students could add:
    - The haze could be caused by humans because humans can affect the atmosphere by creating air pollution
    - It could be air pollution from things like coal power plants.
    - There are some power plants near DC, but not a lot
    - There are a lot of people in the DC area

Afterwards, have students share what they wrote, and encourage them to add good ideas from their peers. You may want to highlight some of these based on the key takeaways above.

Name _____

STUDENT HANDOUT

Pollution, Power Plants, and People

AirIQ Map

What kinds of things do you see on this map?

What do the lower green numbers mean on this map?

What do the higher red and purple numbers mean?

What parts of the world have less air pollution?

What parts of the world have more air pollution?

CarbonBrief Map

What do the big circles on this map represent?

What do the grey/white circles represent?

What do the yellow and pink circles represent?

Where do you see more big power plants opening?

Where do you see more big power plants closing?

World Population

What do the light colors on the map mean?

What do the dark colors on the map mean?

Where are there large populations on the map?

Putting the Pieces Together

What similarities did you notice in terms of where there is pollution, power plants, and people?

Is this pattern the same everywhere in the world?

Why do you think the pattern might be different in some places?

Activity 4 (Explain): The Criteria Air Pollutants

Activity summary: In this activity, students learn about the 6 Criteria Pollutants defined by the Clean Air Act and the EPA, and they are introduced to sources of these pollutants. They use this information to think about what pollutant could be the cause of the haze in their pictures. Then they learn to look up current and historical AQI data to identify the pollutant that caused the haze in their picture.

Standards Connection

DCI: ESS 3.C – Human Impacts on Earth's Systems
SEP: Obtaining, Evaluating, and Communicating Information

Warmup: How would you define air pollution?

- After students have answered the warmup question for themselves, have them share ideas while you record on chart paper or on the board. Using their ideas, help them to create a class definition that everyone can agree on. Try not to use the word "pollution" in the definition. Sample definition: "Air pollution is things in the atmosphere that can be harmful to people." Put the definition in a prominent place in the classroom for the rest of the investigation. You may choose to revise it with students at the end of this activity or at any time during the module. The point of this warmup is less to have a perfect definition of air pollution, and more to get students thinking about what air pollution is and what they already know about it.

1. **Frame the Activity:** Remind students that at the end of the last activity, they decided that air pollution *could be* the cause of the haze in their photographs, but they weren't sure. In this activity, they will investigate different kinds of air pollution to see if they can figure out what specific kind of pollution could be causing the haze in their pictures.

2. **Types of Air Pollution.** Hand out the Types of Air Pollution graphic and put it up on the screen. Have students start by looking at the top row. Tell them that these are all different kinds of air pollution. See if students have ever heard of any of them**.** They may be familiar with ozone, carbon monoxide, or lead. Next have students look at the middle row. They are likely already familiar with the phases of matter. Tell students that air pollution doesn't need to be a gas. Ask them what other liquids they know that might be in the air (water) or what kind of solid (dust). *Note: The goal of this lesson is begin building students' background knowledge on air pollution types, sources, and trends. It is not necessary to go into depth on the types of air pollution at this time.*

ACTIVITY DETAILS

Time: 60 minutes

Objectives

- ✓ Students will define air pollution
- ✓ Students will know there are different kinds of air pollution, and some are more important for us to consider
- ✓ Students will identify the pollutant that caused the Code Red Day in DC

Materials

- ✓ Computer & projector
- ✓ Air pollution information stations (printed & cut)
- ✓ Sources of air pollution signs
- ✓ Scissors (optional for foldable)

Handouts

- ✓ The Criteria Pollutants (foldable or regular) – see note below
- ✓ Reading: The regions air quality…

Foldable handout (recommended)

- ✓ To use the foldable notes sheet, print it double-sided (**flipped on the short side**). See activity directions for folding.

TEACHER NOTES

Using the foldable

- ✓ Have students hold the sheet with the solid lines side facing up. Then have them fold the left and right sides into the middle so they meet at the center. You can also have them cut the dotted lines on the front (just to the fold) so they can open the flaps. They can then tape or glue the foldable into their notebooks if they choose. Make sure students know how to use the foldable to take notes.

Modification

- ✓ Take notes on one of the criteria pollutants together as a class before students begin the station work.

Modification

- ✓ Instead of having students rotate from one station to the next, have them pass the materials to the next group.

3. **Identifying the 6 Criteria Pollutants**. Tell students that the United States has a government agency called the Environmental Protection Agency (the EPA) that is responsible for monitoring and preventing pollution. In 1970, a law was passed called the Clean Air Act. That law requires the EPA to monitor 6 particular air pollutants. Ask students why they think these 6 pollutants were chosen (they can be harmful to human health, and they were a big problem when the law was passed in 1970). Tell students that they will learn more about the Clean Air Act later in their investigation.

   See if students can identify the 6 *criteria* pollutants using the graphic: sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulate matter (PM), and lead. If students have done Module 1, they will already be familiar with ozone, but the others are probably new to them. They will learn more about ozone in this module, and particulate matter in the Module 3.

4. **Where Does Air Pollution Come From?** Hand out "The Criteria Pollutants" notes sheet (either the foldable or the regular sheet) to students. If you are using the foldable (recommended), have them fold the notes sheet using the directions in the side bar. Tell students that they will be doing some research on the criteria pollutants to learn more about them and see if they can identify which pollutant caused the haze in Washington D.C. on July 9th. For each pollutant, they will write down a few details of what it is, and where it comes from. If they are using the foldable, they also have space to write down clues as to whether they think the pollutant could be the cause of the Code Red Day and why.

   Divide students up into six groups, and give each group copies of the pollutant information for one station. Have them take notes on that pollutant on their notes sheet. After all groups have finished, have them move to the next station to take notes. Repeat until all students have visited each station and taken notes.

5. **Summarizing criteria pollutants and sources:** Have students return to their original seats. Have them review and summarize what they learned together as a class by asking the questions below:
   - What did you notice about the sources of different air pollutants? (they tend to be the same or similar)
   - What are the major sources of most of these air pollutants?
     - Power plants (SO_2, NO_2, O_3, PM)
     - Vehicles (NO_x, CO, O_3, PM)
     - Industrial/Chemical plants (SO_2, O_3, PM, Lead)
     - Natural sources like forest fires (PM, NO_2)

     As students name these sources, put up the corresponding "Sources of Air Pollution" poster on the wall to go with it.

- Based on your research, what pollutant do you think could be causing the haze?
    - At this point, students should be able to identify ozone as the culprit (or possibly PM). It occurs during the summer months, and it looks like a "dirty fog". Other pollutants are the wrong color or colorless (NO_2, SO_2, Lead, CO) or are present in the winter (CO). PM could definitely be a possibility, but because ozone is referred to specifically by color, it is the better choice.

      Don't tell students whether they are right or wrong, but let them know they'll find out the truth in a moment.

6. **Story of a Code Red Day:** Tell students that on June 10, 2018 (the day after the Code Red Day from our picture) there were several news stories written about it. They are going to read a summary of one of those stories to see if they are right about their hypothesis. Hand out the double-entry journal article: *Region's air quality reached unhealthy Code Red levels on Monday.* If necessary, review with students how to complete the double-entry journal, and provide support while they read and answer the questions.

   Afterwards, review students' responses to the questions, and celebrate that they were able to figure out what was going on in the picture.

7. **Return to the investigation tracker:** Have students take out their Investigation Trackers, and add new information to show what they learned about the cause of the haze and the Code Red Day. They should add information about what the pollutant was (ozone) and where ozone comes from. They can get this information from their notes sheet.

8. **Formative assessment:** Go back to your definition of air pollution from the warm up, and add additional details to include what you've learned today about the criteria pollutants and where they come from.
    - Additional details students might add include the names of the criteria pollutants, the main sources of the criteria pollutants (in general) and why they were chosen as important.

TEACHER NOTES

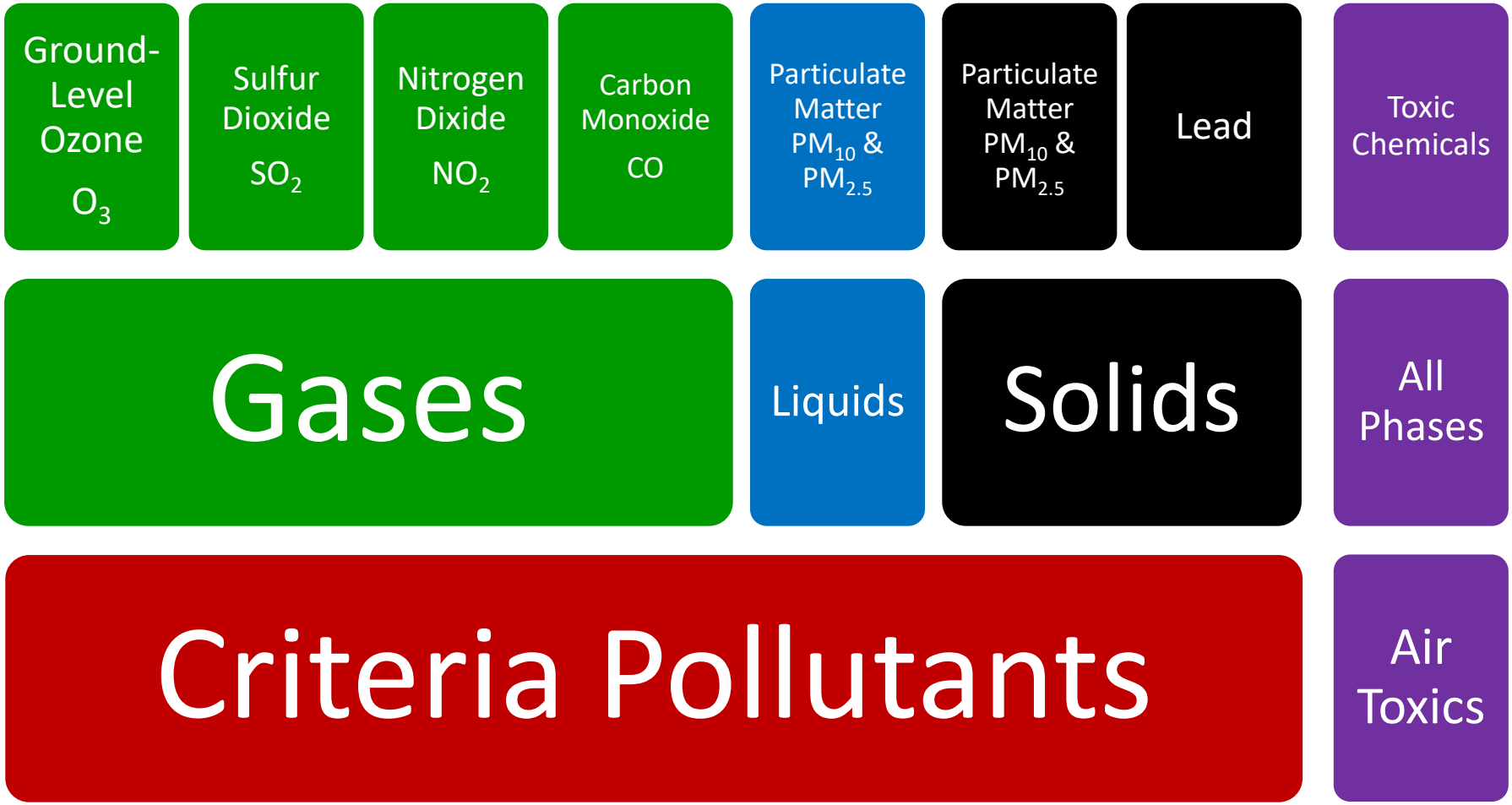
Differentiation

✓ Read the article out loud with students and give them time to answer the questions along the way.

Modification

✓ Instead of having students complete this formative assessment, you can use their Investigation Trackers as the formative assessment for this lesson

Types of Air Pollution



Station 1: Particulate Matter (PM)

What is it?
Particulate matter (PM) is very, very small particles of pollution like dust, pollen, soot, and other chemicals. Particulate matter can be a solid or a liquid that floats in the air.

Where does it come from?
Particulate matter comes from a variety of sources, such as factories, power plants, and vehicles like cars and trucks. It can also come from natural sources, such as forest fires and volcanoes. These particles may be emitted directly into the air, or they may be formed by chemical reactions in the atmosphere. Particle pollution can occur year-round.

Station 2: Ground-level Ozone (O_3)

What is it?
Ground level ozone is the main ingredient in urban and regional smog. Smog looks like a dirty fog that can blanket urban areas. Unhealthy levels of ground level ozone occur during the summer months, typically May through September.

Where does it come from?
Ozone does not come directly from pollution sources. Instead, pollution like Nitrogen Oxides (NOx) and other chemicals are released from cars, paint, gas-powered lawnmowers, boats, power plants, and industrial facilities. These pollutants react with heat and sunlight, which makes ground level ozone.

Station 3: Carbon Monoxide (CO)

What is it?
Carbon monoxide (CO) is a colorless, odorless gas that is produced by incomplete burning of fossil fuels like gasoline, natural gas, coal, oil, etc.

Where does it come from?
Over half of the CO emissions in the country come from motor vehicle exhaust. Other sources include construction equipment, boats, lawnmowers, woodstoves, forest fires, and industrial manufacturing processes. Carbon monoxide levels tend to be higher in the colder months.

Station 4: Sulfur Dioxide (SO_2)

What is it?
Sulfur Dioxide (SO_2) is a colorless gas that has a strong odor. SO_2 can dissolve in water vapor to produce acid rain.

Where does it come from?
Sulfur Dioxide comes from burning of fuels containing sulfur (such as coal and oil), petroleum refining, and smelting (extracting metals from ore), and it also occurs naturally from volcanic eruptions.

Station 5: Lead

What is it?
Lead is a metal found naturally in the environment as well as in manufactured products. When it is very fine, lead can be an air pollutant even though it is a solid. Lead particles in the air are usually too small to be seen.

Where does it come from?
Today, the major sources of lead pollution are smelters that purify lead from rocks (ore), waste incinerators, utilities, and lead-acid battery manufacturers. Lead used to be found in gasoline, which caused there to be high levels of lead pollution from cars and trucks that used leaded fuel. Now that leaded gasoline has been banned, lead levels have gone down dramatically.

Station 6: Nitrogen Dioxide (NO_2)

What is it?
Nitrogen dioxide (NO2) is a gas that has a reddish-brown color and pungent odor. It can dissolve in water vapor to form acid rain, and it can also react with other chemicals to make ground-level ozone.

Where does it come from?
Nitrogen dioxide comes from high-temperature burning of fossil fuels in automobiles, power plants, and other industrial, commercial, and residential sources. It can also occur naturally from lightning, forest fires, and bacteria in the soil.

Name _____

STUDENT HANDOUT

The Criteria Pollutants

Station 1: Particulate Matter What is it? Sources: Could it cause the haze?	Station 2: Ozone (O_3) What is it? Sources: Could it cause the haze?
Station 3: Carbon Monoxide (CO) What is it? Sources: Could it cause the haze?	Station 4: Sulfur Dioxide (SO_2) What is it? Sources: Could it cause the haze?
Station 5: Lead What is it? Sources: Could it cause the haze?	Station 6: Nitrogen Dioxide (NO_2) What is it? Sources: Could it cause the haze?

Particulate Matter (PM)

Sources

Could it cause the haze?

Why or why not?

Ozone (O_3)

Sources

Could it cause the haze?

Why or why not?

Carbon Monoxide (CO)

Sources

Could it cause the haze?

Why or why not?

Sulfur Dioxide (SO_2)

Sources

Could it cause the haze?

Why or why not?

Lead

Sources

Could it cause the haze?

Why or why not?

Nitrogen Dioxide (NO_2)

Sources

Could it cause the haze?

Why or why not?

Station 2

Ozone

What is it?

Station 1

Particulate Matter

What is it?

Station 4

Sulfur Dioxide

What is it?

Station 3

Carbon Monoxide

What is it?

Station 6

Nitrogen Dioxide

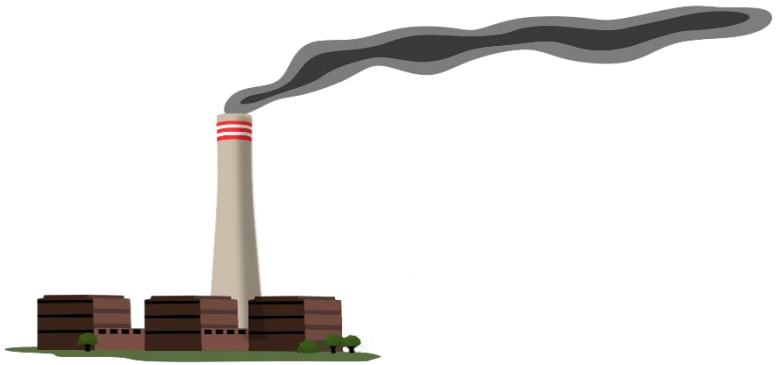
What is it?

Station 5

Lead

What is it?

Power Plant



Air Pollutants

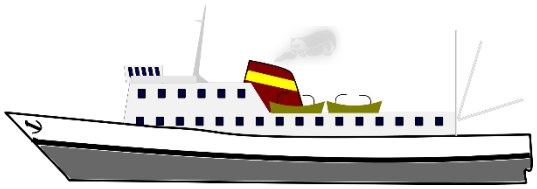
Sulfur Dioxide (SO_2)

Nitrogen Dioxide (NO_2)

Ground-Level Ozone (O_3)

Particulate Matter (PM)





Transportation

Air Pollutants

Nitrogen Dioxide (NO_2)
Carbon Monoxide (CO)
Ground-Level Ozone (O_3)
Particulate Matter (PM)

Manufacturing

Air Pollutants

Sulfur Dioxide (SO_2)
Ground-Level Ozone (O_3)
Particulate Matter (PM)
Lead

Natural Sources

Air Pollutants

Particulate Matter

Nitrogen Dioxide

Name _____

Region's air quality reached unhealthy Code Red levels on Monday

Jul 10, 2018
Washington, D.C. (July 10, 2018)

Ground-level ozone reached unhealthy air quality levels yesterday in metropolitan Washington, marking the first “Code Red” air day for the region this year—and the first since 2012.	**How many Code Red Days were there in the Washington, D.C. region between 2013 and 2017?**
Today is forecast to be a “Code Orange” day, unhealthy for sensitive groups, according to data from the Metropolitan Washington Council of Governments (COG) and Clean Air Partners. Code Orange days are one step safer than Code Red days.	**Was the air quality on July 10, 2018 better or worse than the day before?**
Monday had sunny skies and low wind, which can lead to bad air pollution. The high temperature was 88° F. When the air is stagnant, pollution can become more concentrated than when the air is moving quickly.	**What is the meaning of the word “stagnant” in this paragraph?**
During times of Code Red unhealthy air, all people should limit their outdoor activity. Sensitive groups like children, older adults, and people with respiratory and heart ailments may experience more serious health effects. Residents can check current air quality conditions at www.mwcog.org.	**What kinds of people are considered “sensitive” to air pollution?**

Exposure to air pollution can have many different health effects on people. Air pollution can irritate lungs, and may trigger asthma attacks. Long-term exposure to air pollution can also increase your risk of a heart attack or lung cancer.	**Why is air pollution harmful?**
According to the U.S. Environmental Protection Agency (EPA), "emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources" of the pollution that is causing the Code Red day.	**Name three major sources of air pollution:**
On unhealthy air days, COG advises area residents to take the following actions: • Download the free air quality app at www.cleanairpartners.net for current air quality information. • Turn off lights and electronics when not in use and follow tips from your electric utility about how to use less electricity to cool your home. • Avoid lawn mowing or use an electric mower. • Fill your vehicles' gas tank after sunset. • Take transit, carpool, or work from home.	**Name three things you can turn off to help with air quality:**

Adapted from: *Region's air quality reached unhealthy Code Red levels on Monday*, Metropolitan Washington Council of Governments, https://www.mwcog.org/newsroom/2018/07/10/regions-air-quality-reached-unhealthy-code-red-levels-on-monday/

Name _____

TEACHER'S GUIDE

Region's air quality reached unhealthy Code Red levels on Monday

Jul 10, 2018
Washington, D.C. (July 10, 2018)

Ground-level ozone reached unhealthy air quality levels yesterday in metropolitan Washington, marking the first "Code Red" air day for the region this year—and the first since 2012.	**How many Code Red Days were there in the Washington, D.C. region between 2013 and 2017?** **There were zero Code Red days in the D.C. area between 2013 and 2017**
Today is forecast to be a "Code Orange" day, unhealthy for sensitive groups, according to data from the Metropolitan Washington Council of Governments (COG) and Clean Air Partners. Code Orange days are one step safer than Code Red days.	**Was the air quality on July 10, 2018 better or worse than the day before?** **The air quality was better.**
Monday had sunny skies and low wind, which can lead to bad air pollution. The high temperature was 88° F. When the air is stagnant, pollution can become more concentrated than when the air is moving quickly.	**What is the meaning of the word "stagnant" in this paragraph?** **Not moving or still**
During times of Code Red unhealthy air, all people should limit their outdoor activity. Sensitive groups like children, older adults, and people with respiratory and heart ailments may experience more serious health effects. Residents can check current air quality conditions at www.mwcog.org.	**What kinds of people are considered "sensitive" to air pollution?** **Children, older adults, and people with respiratory or heart problems**

Exposure to air pollution can have many different health effects on people. Air pollution can irritate lungs, and may trigger asthma attacks. Long-term exposure to air pollution can also increase your risk of a heart attack or lung cancer.	**Why is air pollution harmful?** **Air pollution can cause many different health problems like asthma attacks, heart disease, and lung cancer.**
According to the U.S. Environmental Protection Agency (EPA), "emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources" of the pollution that is causing the Code Red day.	**Name three major sources of air pollution:** **Many possible answers including:** **Cars, trucks, power plants (electric utilities), chemical plants, gasoline, and factories (industrial facilities)**
On unhealthy air days, COG advises area residents to take the following actions: • Download the free air quality app at www.cleanairpartners.net for current air quality information. • Turn off lights and electronics when not in use and follow tips from your electric utility about how to use less electricity to cool your home. • Avoid lawn mowing or use an electric mower. • Fill your vehicles' gas tank after sunset. • Take transit, carpool, or work from home.	**Name three things you can turn off to help with air quality:** **Many possible answers including:** **Computer, television, lights, video games, phone, etc.**

Adapted from: *Region's air quality reached unhealthy Code Red levels on Monday*, Metropolitan Washington Council of Governments, https://www.mwcog.org/newsroom/2018/07/10/regions-air-quality-reached-unhealthy-code-red-levels-on-monday/

Activity 5 (Explain): O_3, Oh My! Getting to Know Ozone

ACTIVITY DETAILS

Time: 30 minutes

Objectives

- ✓ Students will understand what ozone is from both a general and chemical perspective
- ✓ Students will understand the different between beneficial (stratospheric) and harmful (tropospheric) ozone

Materials

- ✓ Computer & projector
- ✓ Speakers (for video)
- ✓ Student computers (optional)
- ✓ Chart paper (optional)

Handouts

- ✓ Ozone: Good up High, Bad Nearby Venn diagram

Activity summary: This shorter activity begins an opportunity for students to share what they know or have heard about ozone. After this, they watch a video and interpret an infographic to build their background knowledge about ozone. Students organize their understanding using a Venn diagram about different forms of ozone.

Standards Connection

DCI: ESS 3.C – Human Impacts on Earth's Systems
DCI: ESS2.D – Weather & Climate
SEP: Obtaining, Evaluating, and Communicating Information

Warmup: Primary air pollutants are pollutants that are released directly into the air from pollution sources. Ozone is not a primary pollutant, it is a secondary pollutant. Based on what you learned yesterday, why do you think ozone is called a secondary pollutant?

- Ozone is a secondary pollutant because it is formed from a chemical reaction between different primary pollutants
- The purpose of this warmup is to reinforce the idea that ozone is not emitted directly. This can be confusing for students, so it is worth emphasizing.

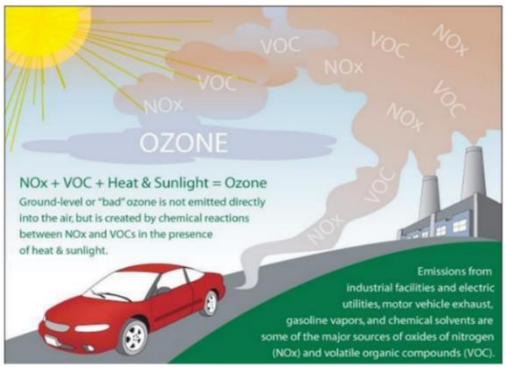
1. **Frame the activity:** Tell students that now that they know that ground-level ozone was the cause of the haze in Washington on the Code Red day, we need to learn more about it as a pollutant. By learning where it comes from, we can work on ways to predict and prevent bad ozone days in the future. Today they're going to study ozone in more depth to see what they can uncover.

2. **What Do You Think?** Prepare a piece of chart paper (or a place on the board) to record student responses for this part of the activity. Then ask students what they know about ozone. Some may have heard about it, and it may be new to others. Record each answer on the board where all students can see. If students get stuck, prompt them with questions such as: "Is ozone good or bad?", or "Where does ozone come from?" Don't tell students which statements are accurate or inaccurate, just focus on letting them share. When students are finished sharing, tell them that you will come back to this list later as a class to see what they've learned.

   The purpose of this part of the activity is to activate students' background knowledge, and to see what students know about ozone. Students may have heard of the ozone layer before, and it is important to begin helping them to differentiate between ground-level ozone and stratospheric ozone.

3. **Ozone: Good Up High, Bad Nearby.** Hand out the ozone Venn diagram "Ozone: Good Up High, Bad Nearby" for students to take notes during the ozone video, and give students some time to consider what information they are looking for. Show them the video *Ground Level Ozone: What is It?* (or have them watch it using student computers): www.youtube.com/watch?v=THYoUULn_2U. You may want to show it twice so students can fill in additional information on their graphic organizers. After they have finished, review the information on the graphic organizer to clear up any student misconceptions.

4. **Connecting Ozone to Emissions**. Show students the graphic below from the US EPA:



Source: US

Have students read the graphic and look at the pictures. Use the graphic to help strengthen the fact for students that ozone does not come directly from pollution sources like factories and power plants. Instead, the chemicals that come from these sources react using sunlight and heat to make ozone. Afterwards, have students add any additional information to the Venn diagram that is helpful.

5. **I used to think, but now I think.** Return to the "What Do You Think?" activity from the beginning of the lesson. Go through each of the statements you wrote down, and have students decide if it is true, partially true, or not true. If it is only partially true, have students turn to a partner and fix the statement by saying, "I used to think...<then the statement> but now I think...<what they've learned now>". For example:
    - I used to think that ozone was bad for you, but now I think that only some ozone is bad for you and some is good for you.
    - I used to think that ozone was a layer high in the sky, but now I think that ozone can also be low to the ground.

    Students can also add new statements if they want to show what they've learned during this activity.

TEACHER NOTES

Differentiation

✓ For advanced students: Give students a blank Venn diagram, have them take their own notes from the video, and then organize them using the diagram

Teacher Tip

✓ Use the "I used to think..." part of the activity to prepare students to complete the formative assessment on the next page.

TEACHER NOTES

Teacher Tip

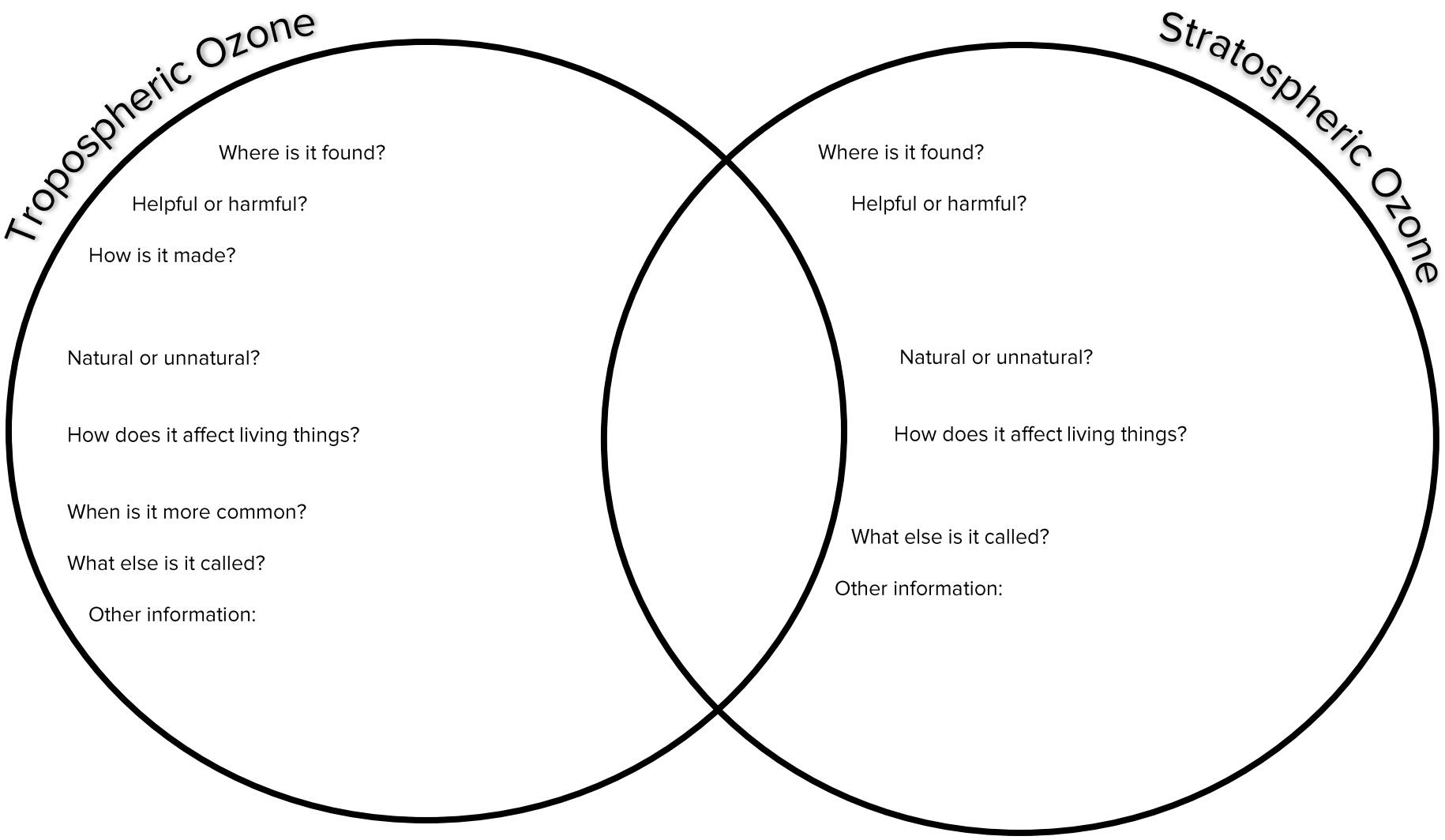
✓ Checking students' completed Venn diagrams is another way to assess their understanding of ozone.

6. **Formative assessment: return to the investigation tracker:** Have students return to their Investigation Trackers to add what they've learned about ozone. Key ideas:
    - There are two kinds of ozone: ground-level ozone and stratospheric ozone
    - Ground-level ozone (tropospheric) is a harmful pollutant that can hurt people's lungs and damage crops
    - Stratospheric ozone (in the ozone layer) protects Earth from harmful radiation
    - Ground-level ozone is formed when certain kinds of air pollution react with heat and sunlight
    - You can prevent ozone from forming by using less electricity and driving less

STUDENT HANDOUT

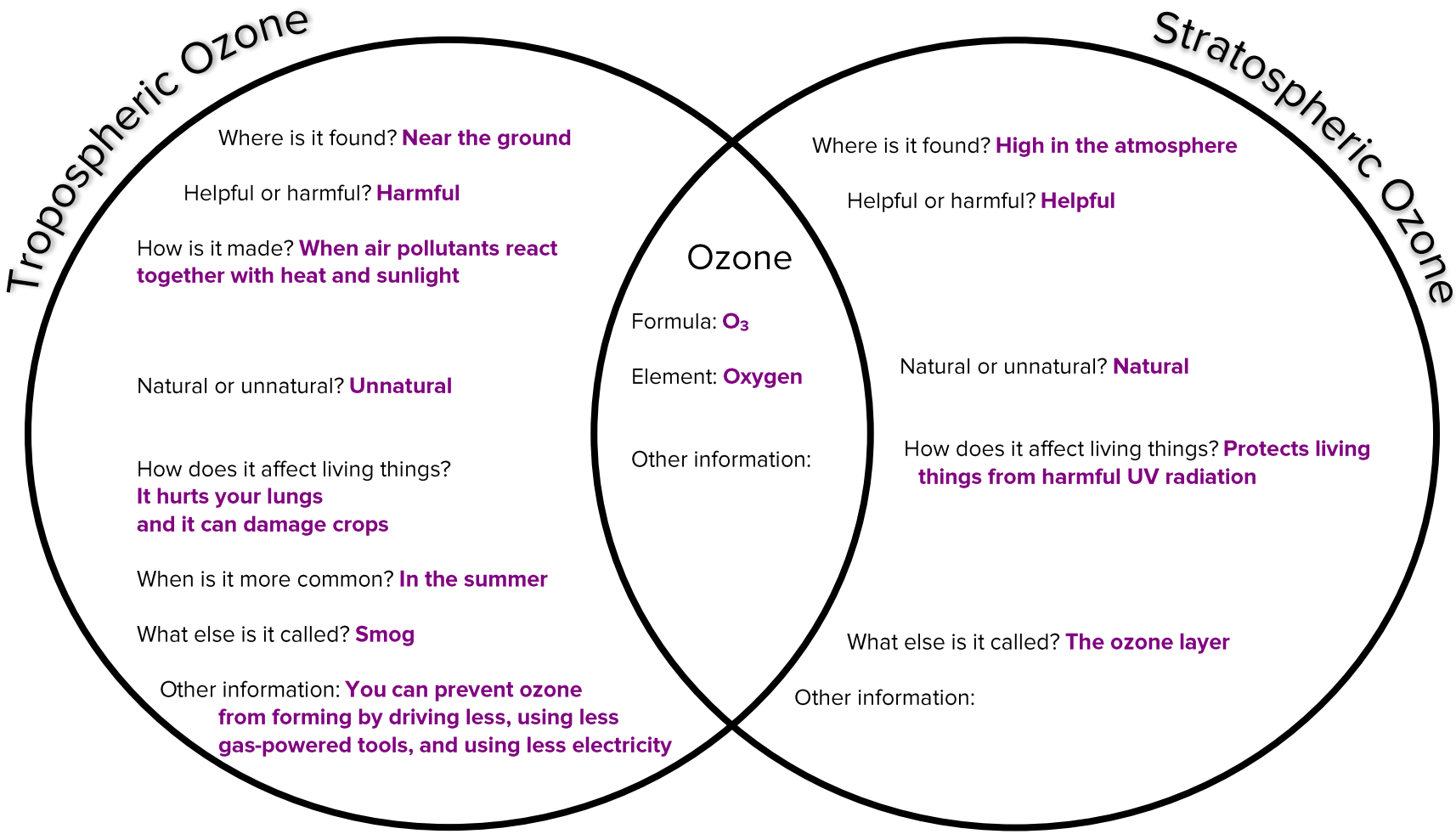
Name_____

Ozone: Good Up High, Bad Nearby



TEACHER GUIDE

Ozone: Good Up High, Bad Nearby



Activity 6 (Explore): Air Quality in the DC/Baltimore Region

Activity summary: In this activity, students learn about what the Air Quality Index (AQI) is to better understand what a Code Red Day is. They use the Clean Air Partners website to research the history of air quality in the region to see patterns in how it has changed over time.

Standards Connection

DCI: ESS 3.C – Human Impacts on Earth's Systems
SEP: Obtaining, Evaluating, and Communicating Information
CCC: Patterns

Warmup: Look at the definition we created for air pollution earlier in this investigation. Based upon what we have learned so far, how would you define the term "air quality"?

- After students have completed the warmup, have them share with a small group to come up with a common definition. Then have groups share out, and develop a common class definition of air quality. Put this definition up on the wall with the definition for air pollution, and revisit it as necessary in the module to add detail.
- Sample definition: "How clean the air is based on how little air pollution there is"

1. **Frame the Activity:** Tell students that they now have a good understanding of what happened in Washington, D.C. on July 9, 2018. That day was called a Code Red Day. Ask students why they think it might have been called "Code Red"? They will likely say something like – because it is dangerous, and red is a color that means danger. Acknowledge their suggestions, but don't tell them if they are right or not. Ask them if they think there have been other Code Red Days in the area. After they have a chance to respond, tell them that today they are going to learn about why that day was called a Code Red day, and they'll learn about how air pollution in the area has changed over time.

2. **The Air Quality Index (AQI).** Tell students that they are going to start by reading an article that explains what a Code Red Day is. Pass out the double-entry journal article "The Air Quality Index". Review the directions, then have students read and complete the questions. Afterwards, review the answers to check for student understanding. In particular, make sure students understand why the day was called a Code Red Day.

ACTIVITY DETAILS

Time: 2 class periods

Objectives

- ✓ Students will learn to interpret the Air Quality Index (AQI)
- ✓ Students will research current and historical AQI data from the DC/ Baltimore area
- ✓ Students will identify the major air pollutants in the DC/Baltimore area and analyze data to show how they have changed over time

Materials

- ✓ Computer & projector
- ✓ Student computers (highly recommended)
- ✓ "The air quality today in <blank> is…" (see activity)

Handouts

- ✓ Air Quality Index reading (double-entry journal)
- ✓ Historical AQI Data Investigation
- ✓ AQI Through the Years
- ✓ Graph paper (optional)

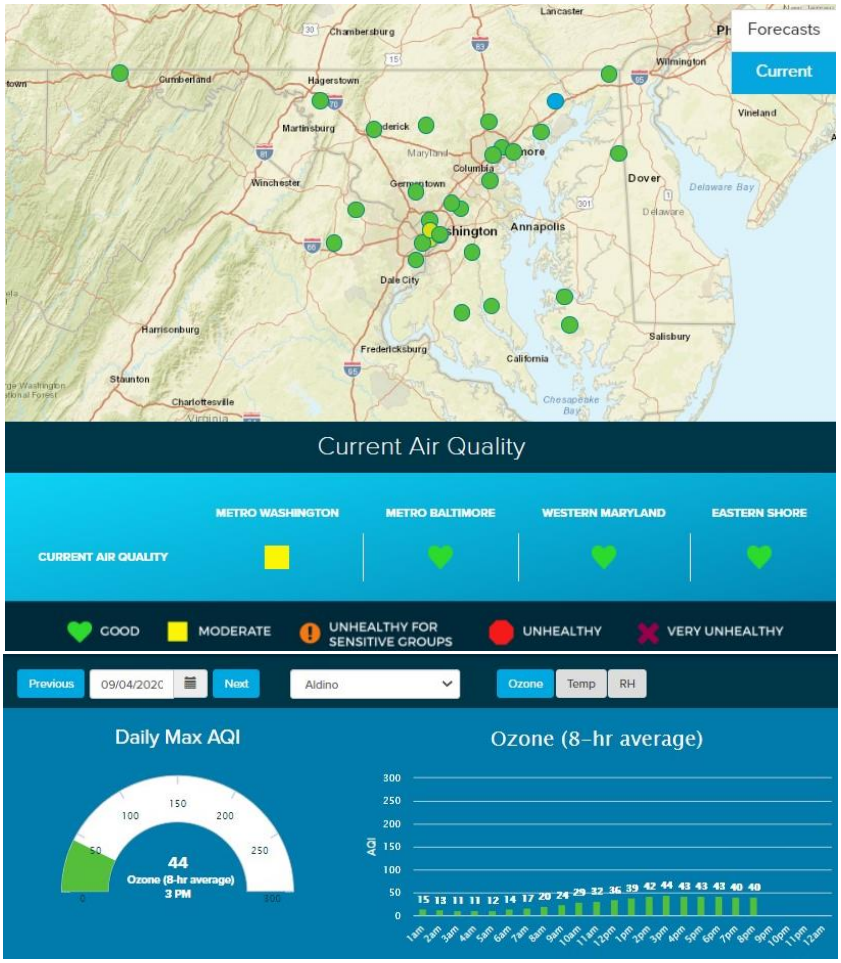
TEACHER NOTES

Connection to Module 1

✓ If you have done Module 1 with students, you may want to skip over the AQI portion of the activity, or use this time to review what students have already learned about the AQI.

Show students a color version of the scale (either printed out or projected) to review the different colors and what they mean, including the numbers and what you should do if the level of pollution on the index is reached.

3. **Looking up the current AQI:** Tell students that there are a lot of different ways to find out what the current air quality is in their neighborhood or around the world. Pass out student computers (if available) or project a web browser were all students can see. With students, go to the Clean Air Partners website for current and forecasted AQI: https://www.cleanairpartners.net/current-and-forecasted-air-quality. Click on "current" at the top right corner of the map to see the AQI color in different places in the area. Click on the point on the map closest to where the school is. The page will scroll to the bottom where there is specific AQI data. You can also switch pollutants to see how the AQI changes.

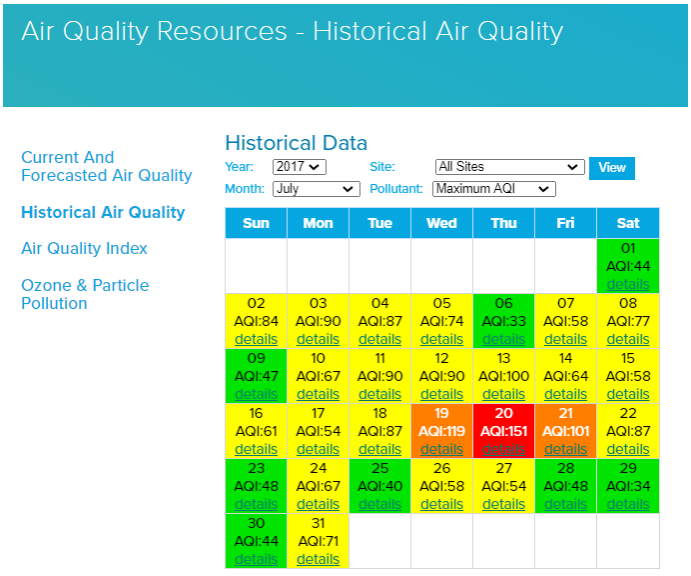


If you have not already, put up the "The air quality today in <blank> is…" signs (see sidebar) somewhere in the classroom. Choose a student to write in the AQI for the school location, including what the AQI is due to (ozone, PM, etc.). Next, have students go to the World Air Quality Index website: http://www.waqi.info/. Students can use the map to find and click on another city to look up its AQI, or they scroll down and type a city into the search bar. As a class, choose a few more cities to look up the AQI for. Put these city names into your other signs, and have students put in the AQI information including what it is due to. Try to pick cities that are in different parts of the world and that have different AQIs. Every day at the beginning of class, have students look up the AQI in those cities to update the signs.

Before moving on, share other ways that students can look up the AQI, for example using apps on their phones such as Clean Air Partners Air Quality app, and the Air Visual app. If students are allowed to use their smartphones at school, show them how they can add these apps to their phones to look up the AQI.

4. **Researching Historical AQI Data.** Remind students of when you asked them earlier about whether there have been other Code Red Days in the area besides July 9, 2018. Tell them that in this next part of the activity, they are going to find out. Pass out the AQI Data Investigation sheet, and tell students that they are going to research Code Red days from the past to look for patterns in how air pollution in the area has changed over time.

   Read the directions at the top of the sheet with students to bring them back to the Clean Air Partners website where they can look at looking at the historical air quality data: https://www.cleanairpartners.net/historical-air-quality



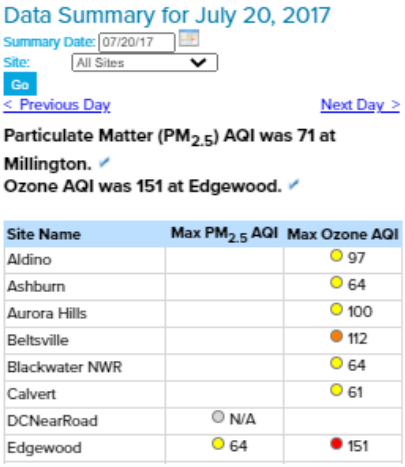
TEACHER NOTES

The Air Quality Today in <blank> is…

✓ To give students practice looking up the AQI, create a series of signs that say "The air quality today in <blank> is…<blank> due to <blank>" that students can change the numbers on (ex. with a taped-on notecard or using a dry erase board). Make one sign for the location of the school. Also have students choose cities they want to look up the AQI for each day (preferable cities around the world). Start each day by having students update the numbers on the sign and compare what it would be like to be a middle school student in different cities on that day.

TEACHER NOTES

Start by having all students look up the same date: July 20, 2017 is a good choice since it was a Code Red Day. Once students have navigated to the correct month, they can bring up the data from specific monitors for that date by clicking on the "details" for July 20:



Data Summary for July 20, 2017

Summary Date: 07/20/17

Site: All Sites

Go

< Previous Day Next Day >

Particulate Matter ($PM_{2.5}$) AQI was 71 at Millington.

Ozone AQI was 151 at Edgewood.

Site Name	Max $PM_{2.5}$ AQI	Max Ozone AQI
Aldino		97
Ashburn		64
Aurora Hills		100
Beltsville		112
Blackwater NWR		64
Calvert		61
DCNearRoad	N/A	
Edgewood	64	151

Using this information, have students answer the questions on their handouts.

- What was the AQI for this date? **151**
- What was the Particulate Matter (PM) AQI? **71**
- Where was the PM AQI the highest (what site name)? **Millington**
- What was the Ozone AQI? **151**
- Where was the Ozone AQI the highest? **Edgewood**
- Why was this a Code Red day in the area? **Ozone over 150**

After this example, have students go to 3 other dates that each have a different AQI color (green, yellow, and orange), and have them answer the questions on their handout for those dates. Note that going back in time will likely lead to worse pollution days, and the summer has worse pollution than other seasons. July 2017 has four different levels, so students can also stay on that month.

Once students are finished with the historical research, they can answer the questions at the bottom of the sheet. Review the answers when all students are finished:

- Most poor air quality days in the DC/Baltimore region are caused by particulate Matter (PM 2.5) and Ozone (in fact, many sensors in the area only measure these two pollutants)
- The pollutant which caused the Code Red Day on July 9, 2018 was ozone with an AQI of 166 in Beltsville, MD

Once students have finished with this part of the activity, you can collect their computers.

Timing note

✓ If you are doing this activity over the course of two (or more) days, this is a good point to break up the activity.

5. **AQI Through the Years.** Ask students if they think the air quality in the area has been getting better or worse since you were a kid. Listen for student responses (students generally think that it has gotten worse), then tell them that they are going to be looking at data to see if their predictions are right or not. Pass out the sheet "AQI Through the Years." Have students read the top part of the sheet, and then review with them what information is shown (it is the July AQI calendars every 5 years 1995-2020). Have students count and graph (optional) the number of days for each AQI level (color).

Year	Green	Yellow	Orange	Red	Purple
1995	0	7	7	11	6
2000	8	11	8	4	0
2005	1	16	6	6	2
2010	2	14	7	8	0
2015	1	29	1	0	0
2020	8	20	2	1	0

A Note about Data Analysis & Math Integration

There are many ways to analyze these data. The most complex analysis would be to make a scatter plot for each color, then draw a line of best fit and determine the slope to see how the number of days of each color is changing over time. Depending on students' grade level and current math ability this may be too advanced. You can also have students average the first three years for each color and the last three years and compare the averages to see how the number of days is changing in general. You can have students find the average of all the numbers for a particular color and then compare the numbers in 1995 and 2020 to the average. The point is, use whatever math skills your students have (or are working on) to look for a pattern in the way the numbers are changing.

Once they are finished counting/graphing, discuss with students how they can analyze patterns in these data (see note below for ideas). When you have decided on an option (or options) have students complete the analysis and answer the questions on the back of their sheet.

Basic analysis: How have the number of each of the days changed?

- Green: stayed about the same
- Yellow: went up a lot
- Orange: went down a little
- Red: went down
- Purple: went down

TEACHER NOTES

Teacher Tip

✓ If students are working off of a black & white copy of the handout, it will be hard to count the number of days of each AQI (they can see the numbers, but they are small). It will help if you project a copy of the handout so students can more easily count the colors

Digging into the Data

✓ There was only one Code Red day in July, 2020. Did you notice what day it was? The AQI was in the yellow or green for almost all locations except for two, where it was in the red for PM. What could have added PM to the air on this date?

Data Analysis

✓ There are two types of "Analysis" answers here based on two different analysis methods. Each method will still provide enough information to draw conclusions for the end of the activity.

TEACHER NOTES

Research sources

✓ If you are using chart paper to make of list of research sources for the module, you can add the Clean Air Partners website and the World Air Quality Index website as sources of AQI data.

Advanced Analysis: How have the number of each of the days changed?

- Green
  - average of 1995-2005: 3
  - average of 2010-2020: 3.7
  - change: +0.7
- Yellow
  - average of 1995-2005: 11.3
  - average of 2010-2020: 21
  - change: +9.7
- Orange
  - average of 1995-2005: 7
  - average of 2010-2020: 3.3
  - change: -3.7
- Red: went down
  - average of 1995-2005: 7
  - average of 2010-2020: 3
  - change: -4
- Purple: went down
  - average of 1995-2005: 2.7
  - average of 2010-2020: 0
  - change: -2.7

When students are finished with their analysis, discuss what *trends* they see in the data. In other words, patterns of change are not always smooth (linear), but they may still go in one direction or another. For example, 2000 was a pretty good July for air quality, but it is more likely the exception than the rule. Make sure that students understand that overall, the air quality is getting better, but there can still be good or bad years for various reasons.

6. **Reaching a conclusion:** After the discussion, have students answer the conclusion question using data from this activity.

   Sample response: The amount of air pollution in the DC area in July has gone down since 1995. In 1995, there were 6 days in the purple range (very unhealthy), but there were 0 purple days in 2010, 2015, and 2020. The number of red days (unhealthy) has gone down as well. The number of yellow days (moderately unhealthy) has gone up, but this is because there are less red and purple days.

7. **Return to the Investigation Tracker:** Have students make notes in their investigation tracker based on big ideas they learned during this activity. Key takeaways:
    - Air quality is measured using a scale call the Air Quality Index (AQI)
    - The main air pollutants in the DC-Baltimore area are particulate matter (PM) and ozone.
    - Air quality in the DC-Baltimore area is improving

8. **Formative Assessment.** Show students this calendar and tell them that this is the July AQI data from the DC area for some time between 1995 and 2020. Based upon what they learned today, what year would they predict this data is from? How did they choose that year? How confident are they in their prediction?

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						01 AQI:105 details
02 AQI:150 details	03 AQI:150 details	04 AQI:147 details	05 AQI:61 details	06 AQI:44 details	07 AQI:46 details	08 AQI:77 details
09 AQI:93 details	10 AQI:122 details	11 AQI:161 details	12 AQI:136 details	13 AQI:48 details	14 AQI:105 details	15 AQI:54 details
16 AQI:61 details	17 AQI:212 details	18 AQI:221 details	19 AQI:187 details	20 AQI:136 details	21 AQI:147 details	22 AQI:54 details
23 AQI:51 details	24 AQI:122 details	25 AQI:90 details	26 AQI:97 details	27 AQI:136 details	28 AQI:46 details	29 AQI:129 details
30 AQI:87 details	31 AQI:154 details					

Answer:

- The actual month is **July, 2006.**
- Students should be able to predict that this is likely in the 2005-2010 range (though they may also go as far as 2015) because it has 5 red/purple days (similar to 2005 & 2010) and 22 yellow/orange days (similar to 2015 & 2010)
- They should also be fairly uncertain about the year, partly because they don't know what year it is in the range, and partly because they know that conditions can vary from year to year.

Homework suggestion

✓ Have students show their parents or guardians how to find the AQI at home (using a computer or phone) and explain what it means.

Name _____

STUDENT READING

The Air Quality Index

What is the AQI? The Air Quality Index or "AQI" is a tool used to report daily air quality. The AQI uses color-codes and a numerical scale to report how clean or polluted the air is and what associated health effects might be of concern. The AQI focuses on health effects people may experience within a few hours or days after breathing polluted air. A different AQI is calculated for each of the major pollutants regulated by the Clean Air Act except for lead: particulate matter, ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide. The overall AQI for a day is equal to the worst AQI score for any of the 5 pollutants. For example, if the AQI for ozone is 52, and the AQI for PM is 86, then the overall AQI for the day is 86.	**What are the two ways that the AQI reports air quality information?** **How long might a person feel the effects of breathing polluted air?** **What are the pollutants that are included in the AQI?**
How Does the AQI Work? Think of the AQI as a yardstick that runs from 0 to 300. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little potential to affect public health, while an AQI value over 200 represents very unhealthy air quality. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level the Environmental Protection Agency (EPA) has set to protect public health.	**What AQI value matches with the EPA limit for a pollutant?**

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered good, and air pollution poses little or no risk.
Moderate	51-100	Air quality may pose a moderate health risk, especially for those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups, children and adults with respiratory and heart ailments, may experience health effects and should limit time spent outside. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may experience health effects and should limit their outdoor activity; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Everyone may experience more serious health effects and should avoid outdoor activities, especially individuals with heart and breathing ailments, children, and older adults.

The Air Quality Index

AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy – at first for certain sensitive groups of people, then for everyone as AQI values get higher.	**What is the range of air quality that is unhealthy for everyone?** **What do you think the level of Air Quality was on the Code Red day we read about?**
Air quality can impact your day as much as the weather and traffic can — which makes checking daily air quality forecasts an equally important part of your routine. Visit the Clean Air Partners Current Air Quality webpage or download the Clean Air Partners Air Quality App to have air quality information at your fingertips.	**How can you find information about the current AQI where you live?**

Source: Adapted from *Air Quality Index* (Clean Air Partners) https://www.cleanairpartners.net/aqi

Name _____

TEACHER GUIDE

The Air Quality Index

What is the AQI?

The Air Quality Index or "AQI" is a tool used to report daily air quality. The AQI uses color-codes and a numerical scale to report how clean or polluted the air is and what associated health effects might be of concern. The AQI focuses on health effects people may experience within a few hours or days after breathing polluted air.

A different AQI is calculated for each of the five major pollutants regulated by the Clean Air Act: particulate matter, ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide. The overall AQI for a day is equal to the worst AQI score for any of the 5 pollutants. For example, if the AQI for ozone is 52, and the AQI for PM is 86, then the overall AQI for the day is 86.

What are the two ways that the AQI reports air quality information?

As a color-code and a number.

How long might a person feel the effects of breathing polluted air?

For hours or days

What are the pollutants that are included in the AQI?

PM, ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide.

How Does the AQI Work?

Think of the AQI as a yardstick that runs from 0 to 300. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little potential to affect public health, while an AQI value over 200 represents very unhealthy air quality. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level the Environmental Protection Agency (EPA) has set to protect public health.

What AQI value matches with the EPA limit for a pollutant?

100

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered good, and air pollution poses little or no risk.
Moderate	51-100	Air quality may pose a moderate health risk, especially for those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups, children and adults with respiratory and heart ailments, may experience health effects and should limit time spent outside. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may experience health effects and should limit their outdoor activity; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Everyone may experience more serious health effects and should avoid outdoor activities, especially individuals with heart and breathing ailments, children, and older adults.

The Air Quality Index

AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy – at first for certain sensitive groups of people, then for everyone as AQI values get higher.	**What is the range of air quality that is unhealthy for everyone?** **151-300** **What do you think level of Air Quality was on the Code Red day we read about?** **Red, unhealthy, 151-200**
Air quality can impact your day as much as the weather and traffic can — which makes checking daily air quality forecasts an equally important part of your routine. Visit the Clean Air Partners Current Air Quality webpage or download the Clean Air Partners Air Quality App to have air quality information at your fingertips.	**How can you find information about the current AQI where you live?** **From websites (like the Clean Air Partners website) or using an app on your phone.**

Source: Adapted from *Air Quality Index* (Clean Air Partners) https://www.cleanairpartners.net/aqi

Name _____

STUDENT HANDOUT

Historical AQI Data Investigation

Directions

1. Open a web browser and go to the Clean Air Partners website for historical air quality data: https://www.cleanairpartners.net/historical-air-quality
2. Use the date dropdown menus to choose the date you are looking for
3. Click on the date "details" to see a summary of the data for that date

Date #1: July 20, 2017
What was the AQI for this date? What was the Particulate Matter (PM) AQI? Where was the PM AQI the highest (what site name)? What was the Ozone AQI? Where was the Ozone AQI the highest? Why was this a Code Red day in the area?

Date #2:
What was the AQI on this date? (color & number): What pollutant had the highest AQI? What was the AQI for this pollutant? What recommendations would you make for people if you were an air quality expert on this day?

Date #3:
What was the AQI on this date? (color & number): What pollutant had the highest AQI? What was the AQI for this pollutant? What recommendations would you make for people if you were an air quality expert on this day?

Date #4:
What was the AQI on this date? (color & number): What pollutant had the highest AQI? What was the AQI for this pollutant? What recommendations would you make for people if you were an air quality expert on this day?

What pollutant or pollutants cause(s) the most bad air quality days in our area? _____

_____

_____

What was the cause of the Code Red Day from our article? (July 9, 2018) _____

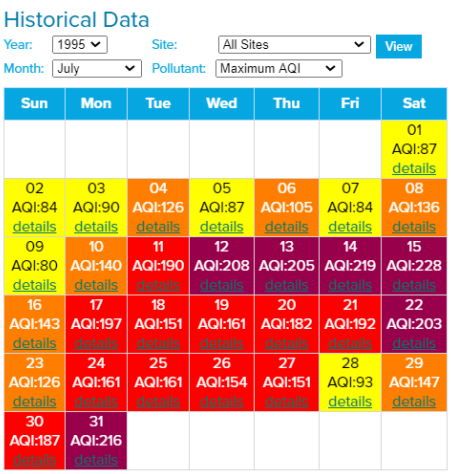
What was the AQI for that pollutant on July 9, 2018? _____

Name _____

STUDENT HANDOUT

AQI Through the Years

Look at the calendars below that show the AQI for the month of July every five years starting in 1995:

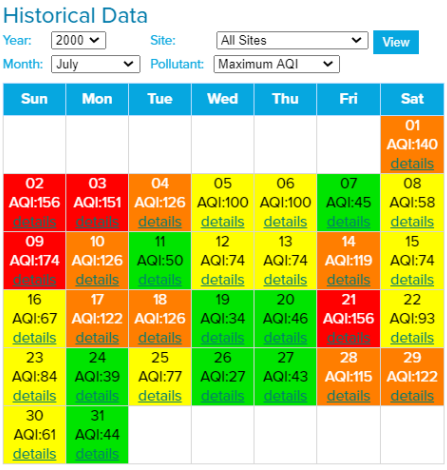


Historical Data

Year: 1995 Site: All Sites View

Month: July Pollutant: Maximum AQI

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						01 AQI:87 details
02 AQI:84 details	03 AQI:90 details	04 AQI:126 details	05 AQI:87 details	06 AQI:105 details	07 AQI:84 details	08 AQI:136 details
09 AQI:80 details	10 AQI:140 details	11 AQI:190 details	12 AQI:208 details	13 AQI:205 details	14 AQI:219 details	15 AQI:228 details
16 AQI:143 details	17 AQI:197 details	18 AQI:151 details	19 AQI:161 details	20 AQI:182 details	21 AQI:192 details	22 AQI:203 details
23 AQI:126 details	24 AQI:161 details	25 AQI:161 details	26 AQI:154 details	27 AQI:151 details	28 AQI:93 details	29 AQI:147 details
30 AQI:187 details	31 AQI:216 details					

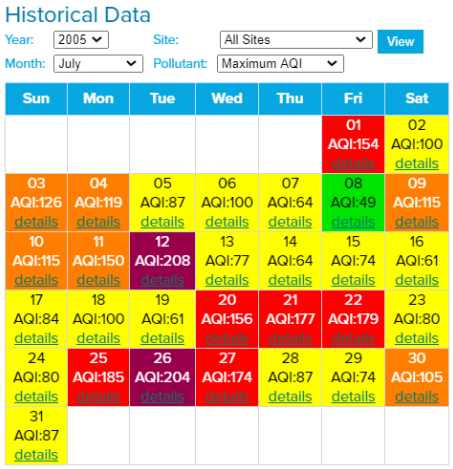


Historical Data

Year: 2000 Site: All Sites View

Month: July Pollutant: Maximum AQI

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						01 AQI:140 details
02 AQI:156 details	03 AQI:151 details	04 AQI:126 details	05 AQI:100 details	06 AQI:100 details	07 AQI:45 details	08 AQI:58 details
09 AQI:174 details	10 AQI:126 details	11 AQI:50 details	12 AQI:74 details	13 AQI:74 details	14 AQI:119 details	15 AQI:74 details
16 AQI:67 details	17 AQI:122 details	18 AQI:126 details	19 AQI:34 details	20 AQI:46 details	21 AQI:156 details	22 AQI:93 details
23 AQI:84 details	24 AQI:39 details	25 AQI:77 details	26 AQI:27 details	27 AQI:43 details	28 AQI:115 details	29 AQI:122 details
30 AQI:61 details	31 AQI:44 details					

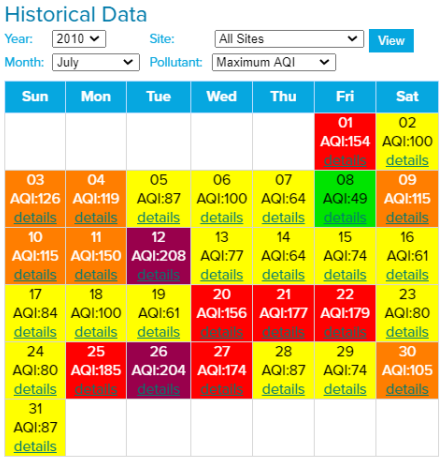


Historical Data

Year: 2005 Site: All Sites View

Month: July Pollutant: Maximum AQI

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					01 AQI:154 details	02 AQI:100 details
03 AQI:126 details	04 AQI:119 details	05 AQI:87 details	06 AQI:100 details	07 AQI:64 details	08 AQI:49 details	09 AQI:115 details
10 AQI:115 details	11 AQI:150 details	12 AQI:208 details	13 AQI:77 details	14 AQI:64 details	15 AQI:74 details	16 AQI:61 details
17 AQI:84 details	18 AQI:100 details	19 AQI:61 details	20 AQI:156 details	21 AQI:177 details	22 AQI:179 details	23 AQI:80 details
24 AQI:80 details	25 AQI:185 details	26 AQI:204 details	27 AQI:174 details	28 AQI:87 details	29 AQI:74 details	30 AQI:105 details
31 AQI:87 details						

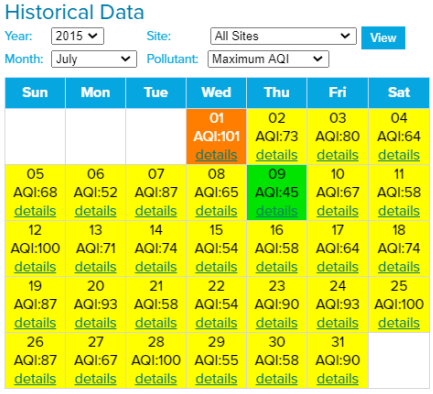


Historical Data

Year: 2010 Site: All Sites View

Month: July Pollutant: Maximum AQI

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					01 AQI:154 details	02 AQI:100 details
03 AQI:126 details	04 AQI:119 details	05 AQI:87 details	06 AQI:100 details	07 AQI:64 details	08 AQI:49 details	09 AQI:115 details
10 AQI:115 details	11 AQI:150 details	12 AQI:208 details	13 AQI:77 details	14 AQI:64 details	15 AQI:74 details	16 AQI:61 details
17 AQI:84 details	18 AQI:100 details	19 AQI:61 details	20 AQI:156 details	21 AQI:177 details	22 AQI:179 details	23 AQI:80 details
24 AQI:80 details	25 AQI:185 details	26 AQI:204 details	27 AQI:174 details	28 AQI:87 details	29 AQI:74 details	30 AQI:105 details
31 AQI:87 details						

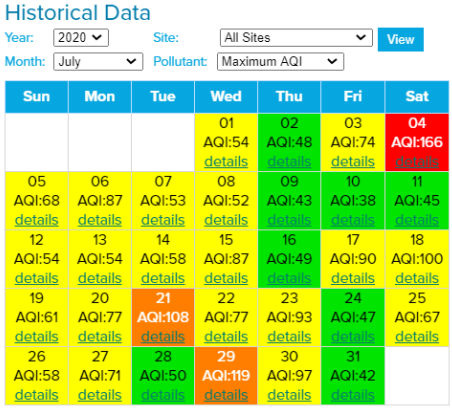


Historical Data

Year: 2015 Site: All Sites View

Month: July Pollutant: Maximum AQI

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			01 AQI:101 details	02 AQI:73 details	03 AQI:80 details	04 AQI:64 details
05 AQI:68 details	06 AQI:52 details	07 AQI:87 details	08 AQI:65 details	09 AQI:45 details	10 AQI:67 details	11 AQI:58 details
12 AQI:100 details	13 AQI:71 details	14 AQI:74 details	15 AQI:54 details	16 AQI:58 details	17 AQI:64 details	18 AQI:74 details
19 AQI:87 details	20 AQI:93 details	21 AQI:58 details	22 AQI:54 details	23 AQI:90 details	24 AQI:93 details	25 AQI:100 details
26 AQI:87 details	27 AQI:67 details	28 AQI:100 details	29 AQI:55 details	30 AQI:58 details	31 AQI:90 details	



Historical Data

Year: 2020 Site: All Sites View

Month: July Pollutant: Maximum AQI

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			01 AQI:54 details	02 AQI:48 details	03 AQI:74 details	04 AQI:166 details
05 AQI:68 details	06 AQI:87 details	07 AQI:53 details	08 AQI:52 details	09 AQI:43 details	10 AQI:38 details	11 AQI:45 details
12 AQI:54 details	13 AQI:54 details	14 AQI:58 details	15 AQI:87 details	16 AQI:49 details	17 AQI:90 details	18 AQI:100 details
19 AQI:61 details	20 AQI:77 details	21 AQI:108 details	22 AQI:77 details	23 AQI:93 details	24 AQI:47 details	25 AQI:67 details
26 AQI:58 details	27 AQI:71 details	28 AQI:50 details	29 AQI:119 details	30 AQI:97 details	31 AQI:42 details	

Use the information in these calendars to fill in the table below:

Year	Green Days	Yellow Days	Orange Days	Red Days	Purple Days
1995					
2000					
2005					
2010					
2015					
2020					

Data Analysis

Use the information in the table to look for trends in the data. In other words, how have the number of different AQI days changed over time for each color?

The number of green days has _____

The number of yellow days has _____

The number of orange days has _____

The number of red days has _____

The number of purple days has _____

Conclusions

Based on your data analysis, how would you say the level of air pollution in the Washington, DC area in July has changed since 1995? In your answer, be sure to use data and your analysis to support your conclusion.

Activity 7 (Explore): Air Pollution Trends and the Clean Air Act

ACTIVITY DETAILS

Time: 1-2 class periods

Objectives

- ✓ Students will interpret graphs to determine how air quality in the US has changed over time
- ✓ Students will use the Clean Air Act to discuss whether humans have a positive or negative impact on the planet

Materials

- ✓ Computer & projector
- ✓ Speakers (for video)
- ✓ Pollutant trends graphs

Handouts

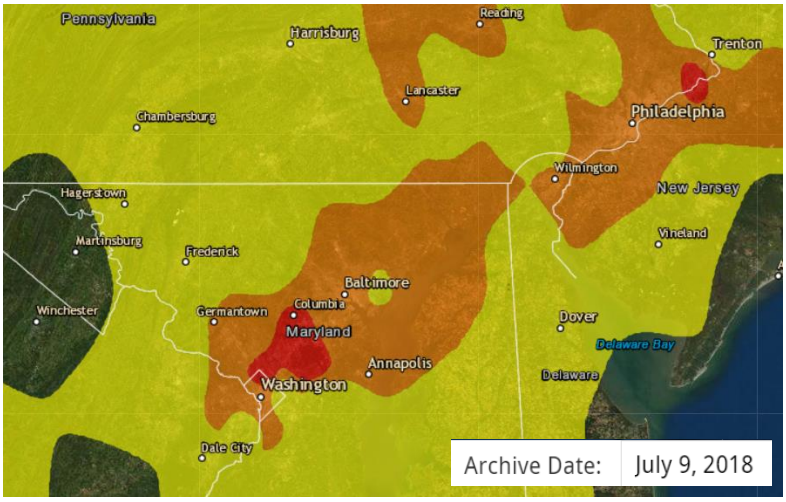
- ✓ Air Pollution Summary Sheet
- ✓ How Much Pollution is Too Much? (optional)

Activity summary: In this activity, students use graphs based on EPA data to analyze national and regional trends in the 6 Criteria Pollutants defined by the Clean Air Act. In the second half of the activity, students learn more about the Clean Air Act and how humans can have a positive impact on the environment.

Standards Connection

DCI: ESS 3.C – Human Impacts on Earth's Systems
SEP: Obtaining, Evaluating, and Communicating Information
CCC: Patterns

Warmup: Show students the map of the DC/ Baltimore/Philadelphia area below and tell them that it is a map of the area on the Code Red Day (July 9, 2018).



Questions:

1. Where is the AQI unhealthy or unhealthy for sensitive groups on this map? (between Washington and Philadelphia)
2. Why do you think the AQI is bad in this area (because there are a lot of people in DC, Baltimore, and Philadelphia; because there is a lot of transportation between these cities)

If students struggle with Question 2, have them consider what the land might be like between Washington and Philadelphia as opposed to western Maryland. Is it farmland? Are there a lot of roads? Are there a lot of people?

TEACHER NOTES

1. **Frame the activity:** Ask students what they learned in the last activity about how ground-level ozone air pollution has changed in the area over the last 25 years. They should recall that air quality in the region is generally getting better. Next, ask them if they think that's true for other pollutants or other parts of the country. Why? They may have reasons to think that air quality has improved or declined around the country, so give them time to share their ideas. Finally, tell students that during their activity today, they are going to look at a series of graphs to see how air quality has changed over the last 40 years, and then they will learn about why that change has happened.

How Much Pollution Is Too Much?

Optional Literacy & Math Extension

If you have time, consider using this literacy and math extension here. It will help build students' background knowledge about the EPA and the pollution limits, and also improve their understanding about scale, quantity, and proportion. The directions are below, and the handout is at the end of the activity.

Hand out the reading "How Much Pollution Is Too Much?" Provide a reading strategy to help students identify key ideas and questions they have. For example, have students highlight the key ideas, and put a question mark by things they want to ask about. When students are done reading, have them share key points, and use peer discussion to help answer their questions.

Animated Part-per-million (optional). Show students the animated video "How to Visualize One Part Per Million" found at: https://www.youtube.com/watch?v=aa-m8a-jZ0k

Review the table of pollutants and limits with students, and then have them do the first math problem. Support as necessary in comparing the fractions. Then read the second problem together. Have them setup the problem on their own or with a partner, and then have them do the calculations on their own. Review together as a class.

2. **Air pollution Over Time:** There are two different options for how to do this activity, based upon time, logistics, etc. In both options, student groups will look at graphs of how the criteria pollutants have changed over time, and answer a few questions about each graph. Adapt the directions below based upon which option you choose.
   - Option 1 (Stations). Student groups travel to each station, study all pollutants, and answer all the questions themselves.
   - Option 2 (Expert Groups). Each group studies one pollutant, answers the questions for their pollutant, and then each group presents their answers to the class so all groups get all the answers.

Tech-integration

✓ The air pollution trends graphs are easily accessible on the EPA website. Instead of printing out the maps, have students look at them online using the EPA's air trends page: https://www.epa.gov/air-trends

TEACHER NOTES

Modification

- ✓ For the Air Pollution Over Time activity, instead of stations, keep materials in folders and pass the folders from group to group instead of having students move.

Teacher Tip

- ✓ For more information on how to interpret the trends graphs, go to: https://www.epa.gov/air-trends/air-quality-trends-how-interpret-graphs

Modification

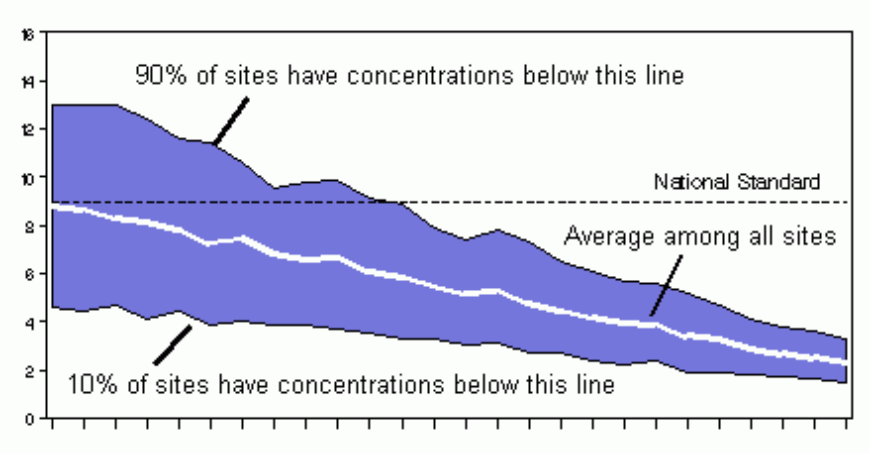
- ✓ The trends graphs at the bottom of each page show the trends for the NE region and the SE region of the US. Graphs for all other US regions are available from the EPA pollution trends pages: https://www.epa.gov/air-trends

Hand out the air pollution summary sheet. The sheet has the six criteria pollutants listed, and a few questions to answer about each one:

- What is the EPA limit for this pollutant?
- How has the amount of this pollutant changed over time?
- Is this pollutant still a problem where we live? (NE region or SE)

Display the sample graph below so all students can see it, and go over the information it contains. The important things to point out are:

- The National Standard (dotted line). This is the same as the EPA limit. Make sure to show students how to read the y-axis for this measurement
- The average for all places where they collected data (the white line)
- The range that includes 80% of all sites (the blue area)



The graphs that students will be using also have a statistic that describes the trend over time.

If you think it is necessary, you can use the ozone trends graph as an example for students.

Review the directions with students for how they will collect and/or share their data. When you are confident that students understand how to read the graphs, and fill in their summary sheets, release them to begin their research. Most of the information students get from the graphs is straightforward, but they may need help using the scales if they have decimals.

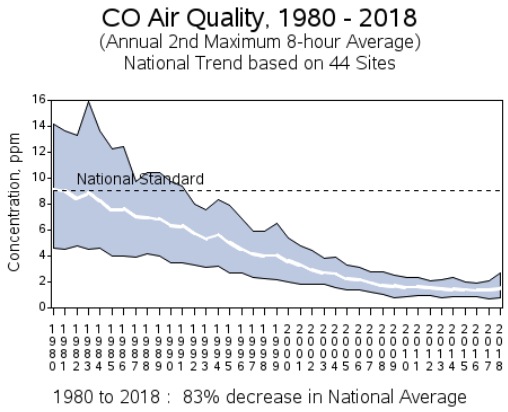
When students have finished all stations, or presented their research to the rest of the class, begin the summarizing section below.

TEACHER NOTES

3. **Summarizing Patterns in Air Pollution Trends.** Ask students to consider their predictions from earlier in class. Were they right or wrong? Most students are surprised to find out that air pollution has dropped significantly in the last 40 years. There are a variety of other summarizing questions you can ask students such as:
    - Which pollutant dropped the most? (lead)
    - What pollutants are still the biggest problems (ozone and PM)
    - Do these graphs mean that air quality is good everywhere? (no – use this as an opportunity to point out that the blue line shows were 80% of the data fall. 10% of the data sites had pollution above the line, so there are still some places where pollution is bad – we call this hyperlocal pollution)

    Feel free to add your own summarizing questions to this list. This is also a good time to revisit the class definition of "air quality" if necessary to include the idea that air has better quality when it is below the EPA limit.

4. **The Clean Air Act:** Display one of the air pollution graphs (such as Carbon Monoxide) and ask students why the think air pollution dropped so dramatically in the United States.



    Students may remember that you mentioned The Clean Air Act in Activity 4, or they may say that the EPA sets rules for how much pollution can go into the air. Remind students that their graphs began in 1980. Based on the trends in the graph, what do they think the air pollution was like in 1970 (it was even worse). Ask students what they would have done if they were alive in 1970 and the air was very unsafe to breathe? They may say things like they would protest or stay inside. Tell students that people in the 1960s were very upset about air quality and water quality, so they decided to do something about it. Tell students that you are going to show them a video about what people did to fix the problem of air pollution. While they watch, they should look for things that people did to have a positive impact on the planet. Show students the video: "The Clean Air Act of 1970" https://www.youtube.com/watch?v=yk8NN4nNgs4

    Note: some parts of the video will likely be over students' heads, but there are some powerful images and concepts that make it worthwhile.

The US Without the Clean Air Act

- ✓ This short video simulates what US cities would be like without the Clean Air Act. It can be a powerful visual to show students about how we can have both a positive and negative impact on the planet: https://www.youtube.com/watch?v=8s5kRxFwssw)
- ✓ This old video about air pollution (made in 1962) shows just how bad the air pollution actually was: https://www.youtube.com/watch?v=hBAFjjwcn3g

TEACHER NOTES

Connections to current events

✓ Students may make connections between protests that they see in the video with protests that they see today (climate change, BLM, etc.). These are important and valuable connections for them to see about how people can advocate for change. With this said, be mindful of the fact that some of these movements are very different, and require thoughtfulness when leading the discussion.

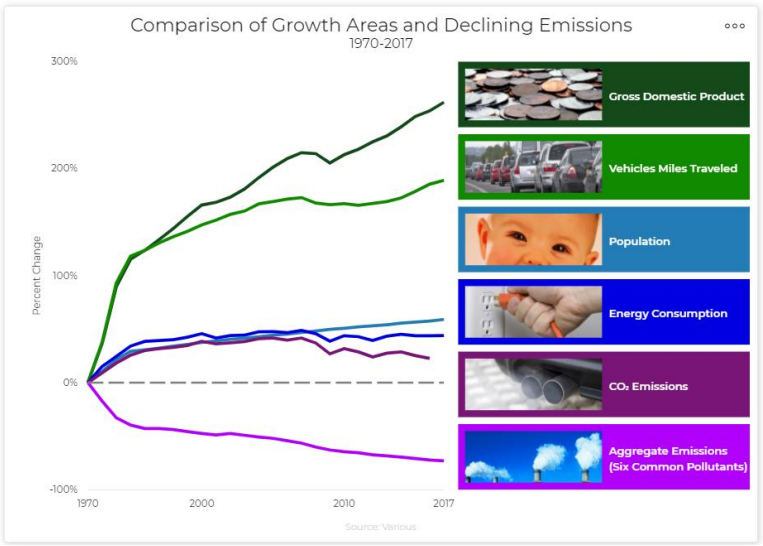
Suggestion

✓ To have this discussion, you may choose to have students form a circle so they can talk directly to one another and debate their positions.

After the video, ask students what things they heard or saw people doing to have a positive impact on the planet. Some things they may say:

- They held protests (dressed up, made signs, marched, etc.) and held the first Earth Day
- They wrote about pollution (ex. Rachel Carson's book Silent Spring)
- The passed laws to protect the environment (the Clean Air Act)
- They worked together

If you find it useful, you can also choose to show students this graph, which shows how successful the Clean Air Act has been, despite the fact that we drive more, use more energy, and have a larger population than we did in 1970.



Source: US EPA

5. **Do humans have a positive or negative impact on the environment?** Now that they have learned about air pollution, trends in air quality, and the Clean Air Act, ask students if they think humans have a positive or negative impact on the environment. Have them start by turning to a partner to discuss what they think. There are many good points to be made on each side. Humans have done a lot of environmental damage, but we have also done a lot to clean up the environment. After students have been able to discuss with a partner, bring the whole class back together to discuss. Allow students to drive the debate, but use questioning to push their thinking.

You may also want to display the air quality map at IQAir: https://www.iqair.com/air-quality-map to remind students that the US air quality used to be like it is now in China and India. The Clean Air Act changed that. What do they think people in China and India are doing right now to begin cleaning up their air?

6. **Return to the Investigation Tracker:** Have students make notes in their investigation tracker based on big ideas they learned during this activity. Key takeaways:
    - Air quality in the United States has improved a lot since 1980.
    - The Clean Air Act was a very important law that helped the US to clean up the air
    - People can have positive and negative impacts on the environment by polluting, or by working to stop pollution

7. **Formative Assessment.** Is the air in the United States safe to breathe? Use the research you gathered about air pollution during class today to support your answer.
    - Student responses will vary, but the important thing to note is how students use the data from the graphs to support their answers. For example, they may say no because ozone is still high, but they may also say yes because most of the criteria pollutants are below the national standard. Students may also say it is safe in some places but not others.

Homework idea

From *Air, Air Everywhere* curriculum (Wisconsin): Have students interview an older family member (ex. grandparent) about their experience with air pollution as a child. If students don't have a grandparent to ask, connect them with an older staff member or have them reach out to someone else in their community. Then have students compare their interview answers with their own perspectives to see how times have changed. Students can then share what they learned with their classmates.

Find the activity and interview questions here titled "Clean Air – How Far We've Come" http://eeinwisconsin.org/Files/eewi/2020/Air,Air,EverywhereActivity5CleanAir-HowFarWeveCome.pdf

Extension

✓ This discussion about whether humans have a positive or negative impact on the environment can easily be extended if you have the time to dig deeper. For example, is it considered a positive impact if we simply stop doing something that has a negative impact? What about conservation efforts? Consider what source materials students might need to more fully explore this issue.

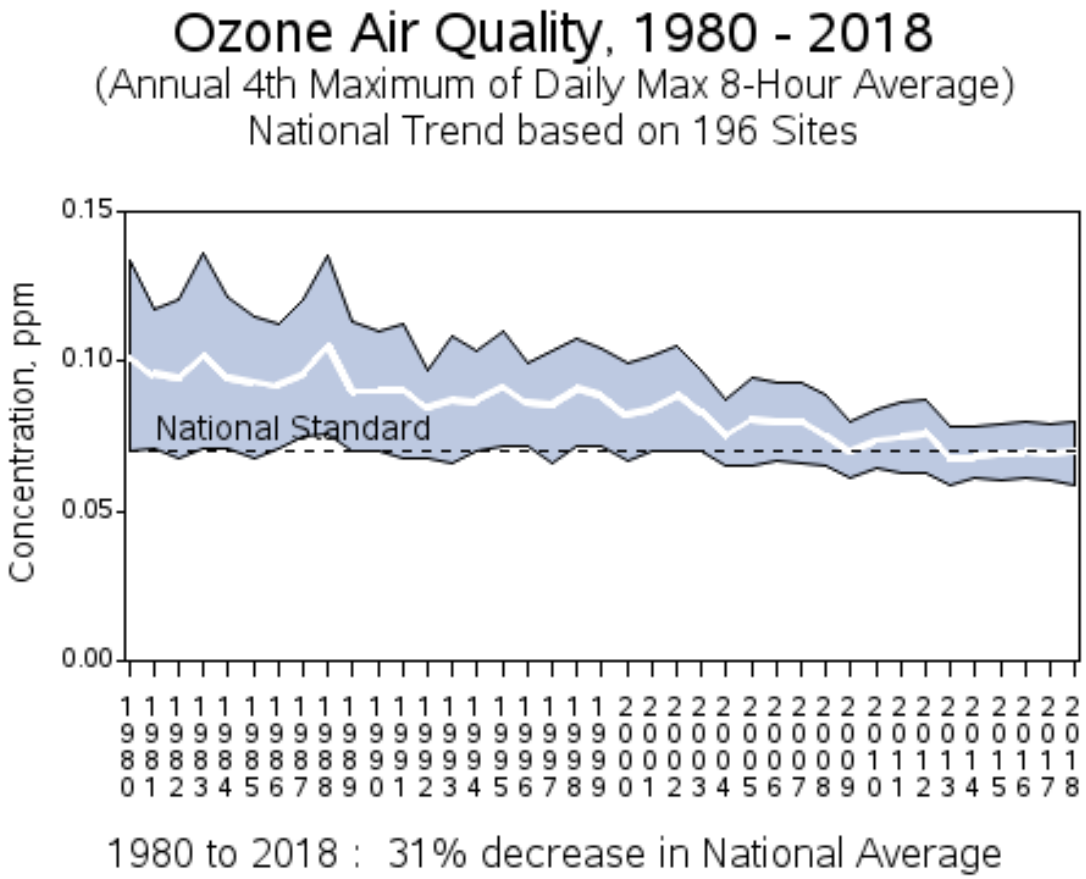
STUDENT HANDOUT

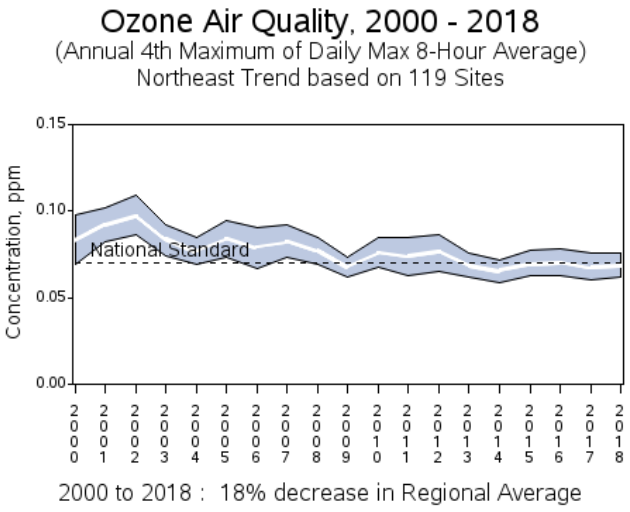
Name _____

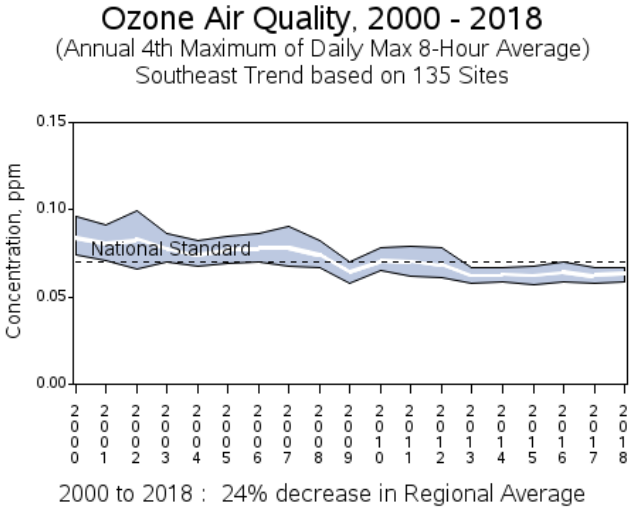
Air Pollution Summary

Pollutant	What is the EPA limit for this pollutant?	How has the amount of this pollutant changed since 1980?	What was the level of this pollutant in 2018?	Is this pollutant still a problem where we live?
Ground-level Ozone				
Carbon monoxide				
Nitrogen dioxide				
Sulfur dioxide				
Particulate matter 2.5		(since 2000 for this graph)		
Lead		(since 2000 for this graph)		**Use national graph data**

Ground-Level Ozone Trends





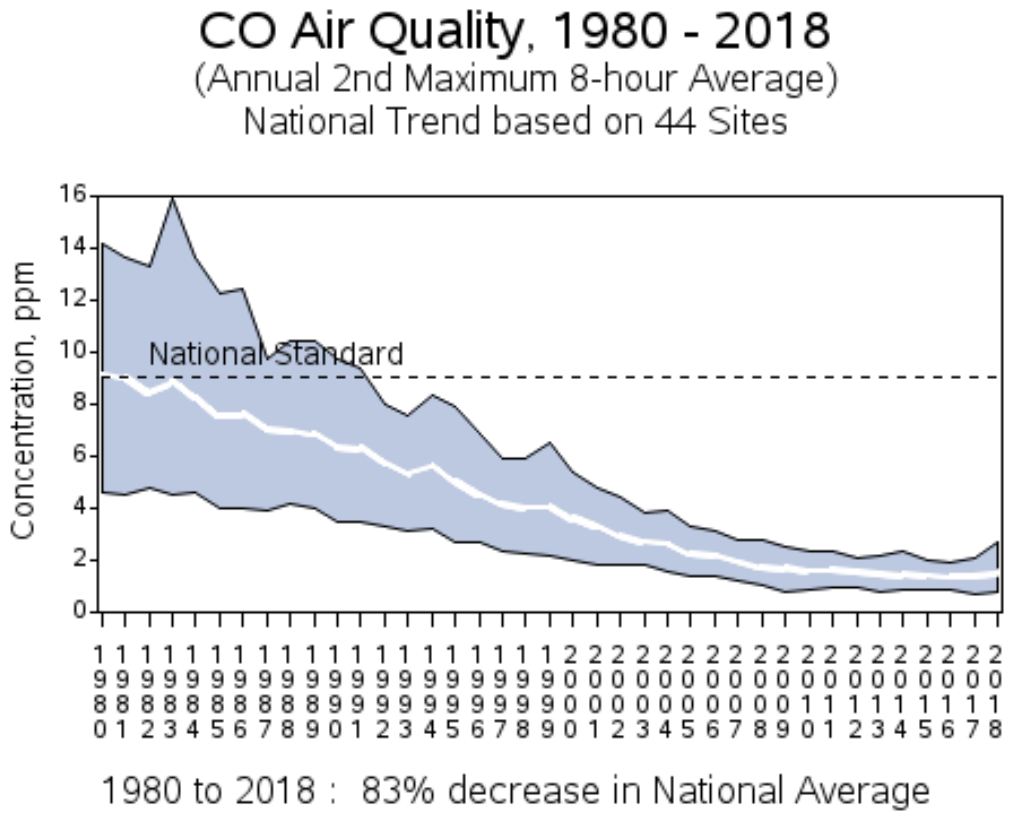


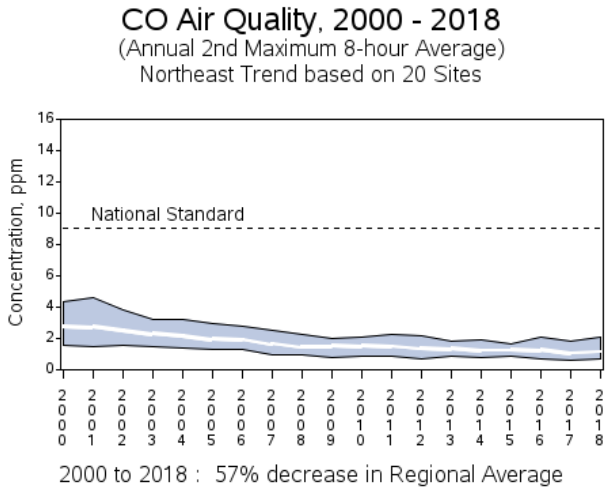
Northeast: ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD

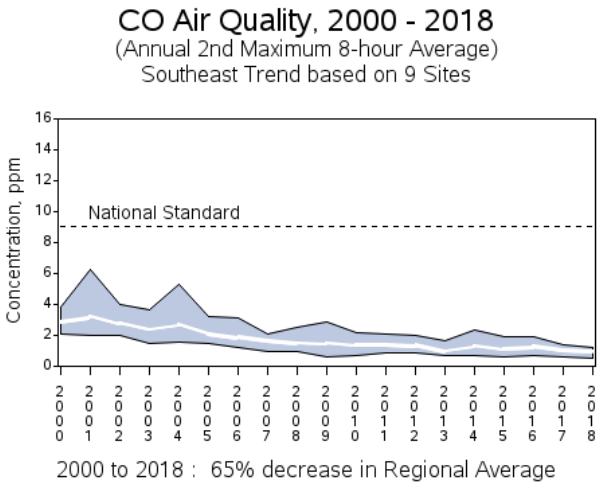
Southeast: VA, NC, SC, AL, GA, FL

Source: https://www.epa.gov/air-trends/ozone-trends

Carbon Monoxide Trends





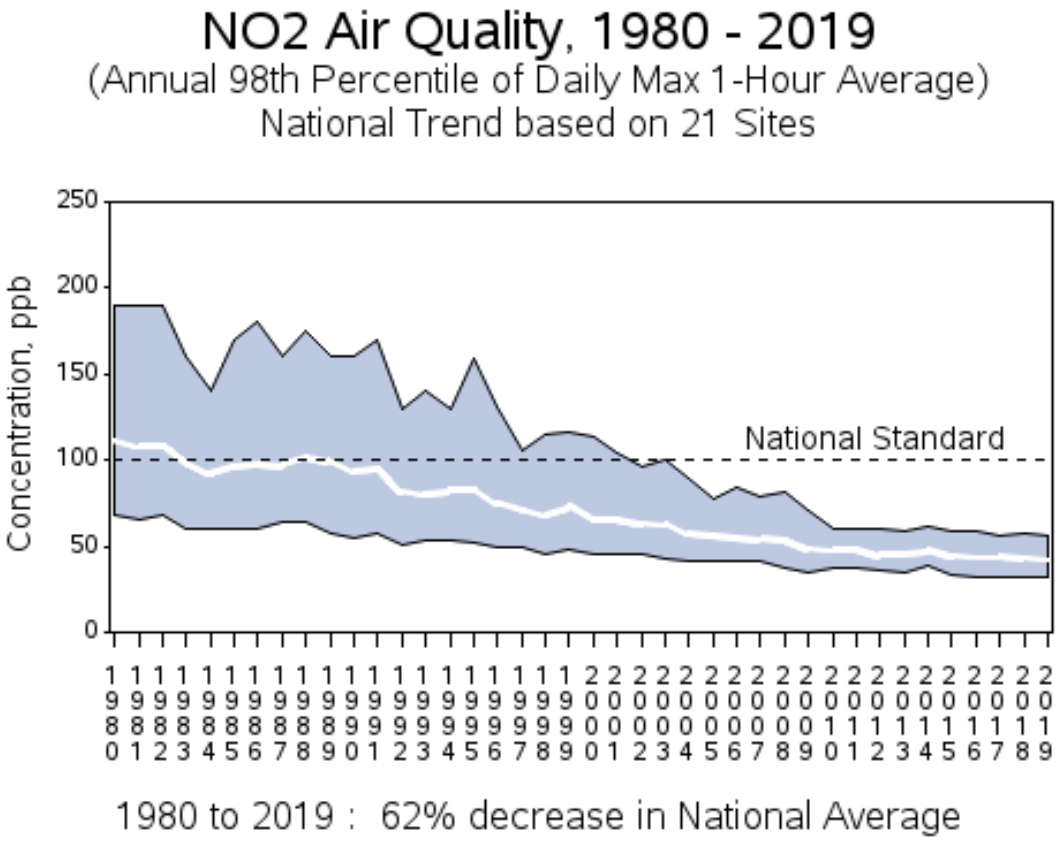


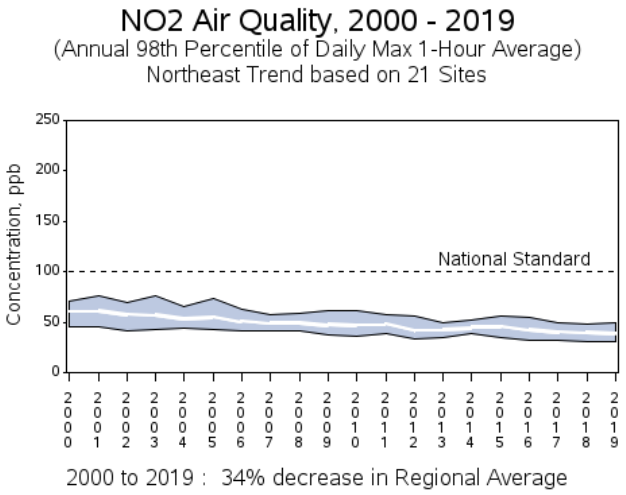
Northeast: ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD

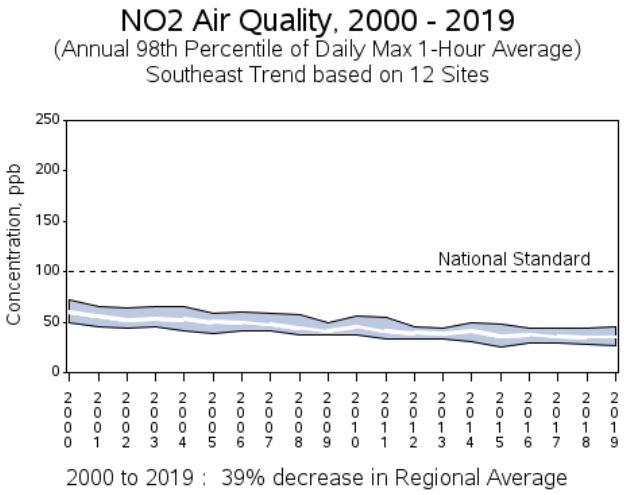
Southeast: VA, NC, SC, AL, GA, FL

Source: https://www.epa.gov/air-trends/carbon-monoxide-trends

Nitrogen Dioxide Trends





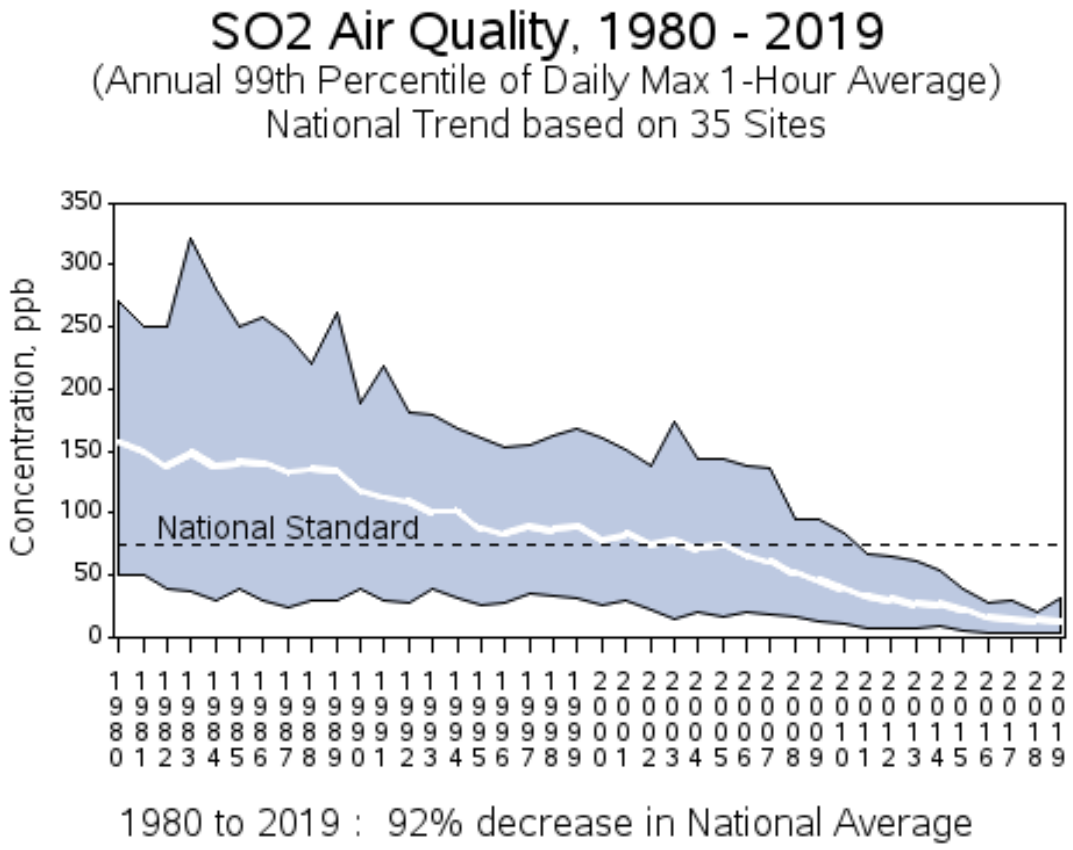


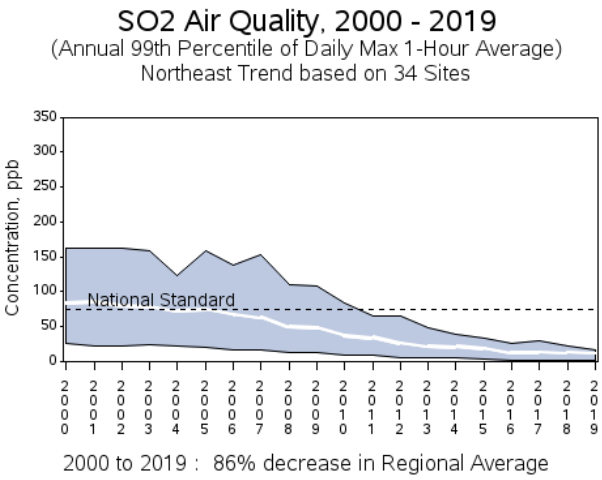
Northeast: ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD

Southeast: VA, NC, SC, AL, GA, FL

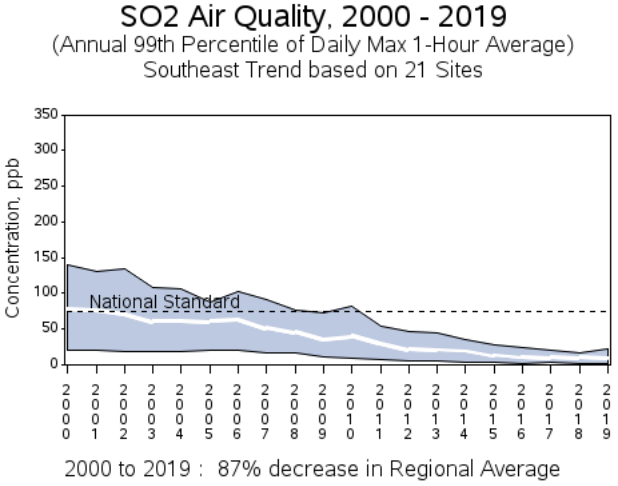
Source: https://www.epa.gov/air-trends/nitrogen-dioxide-trends

Sulfur Dioxide Trends





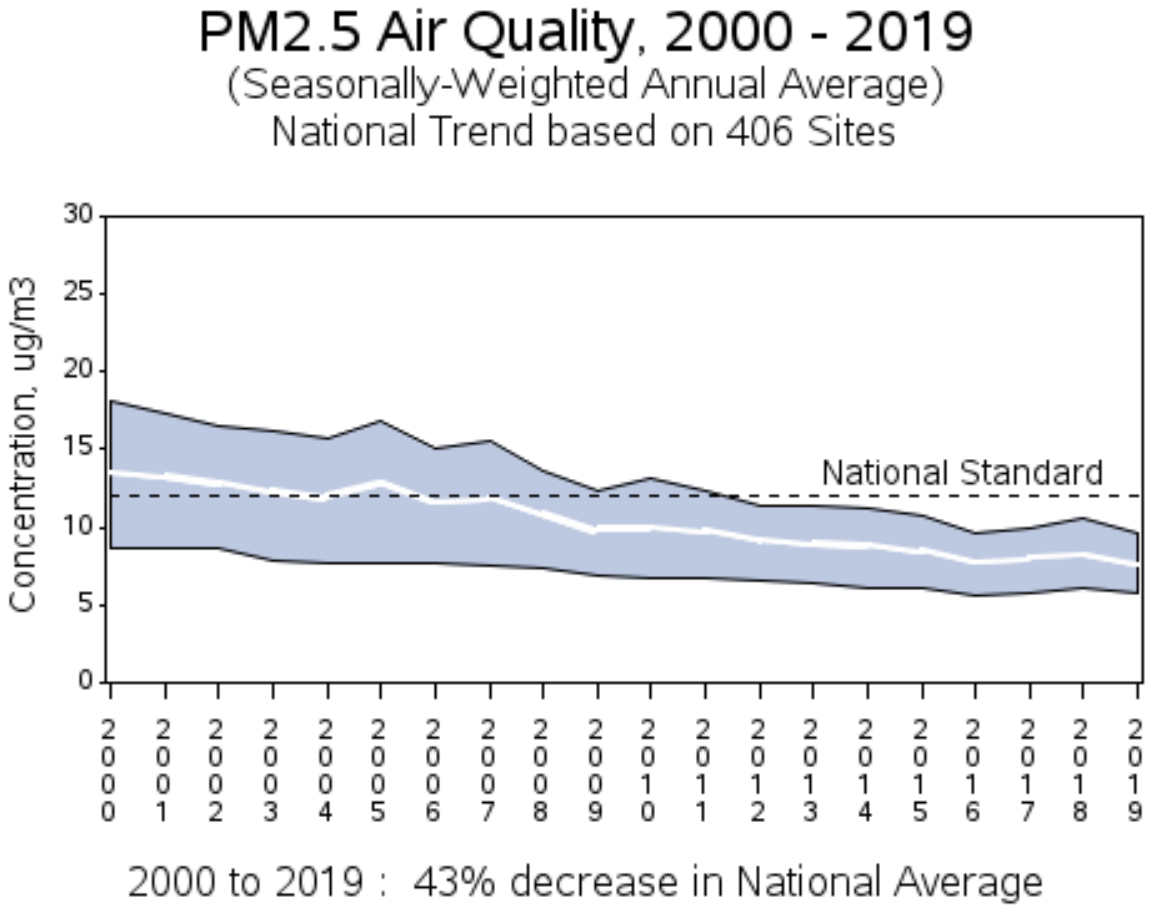
Northeast: ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD

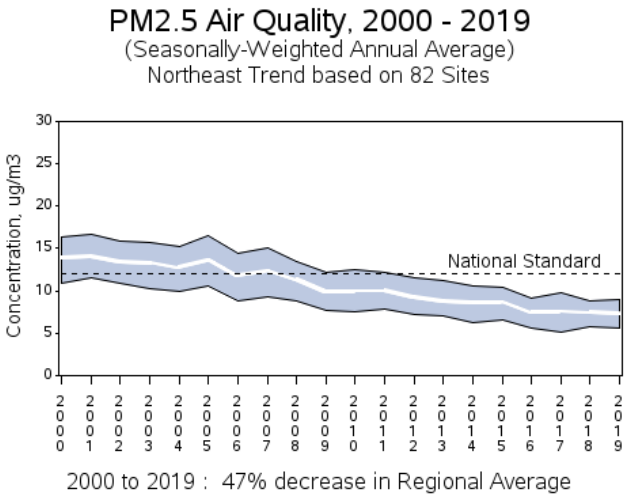


Southeast: VA, NC, SC, AL, GA, FL

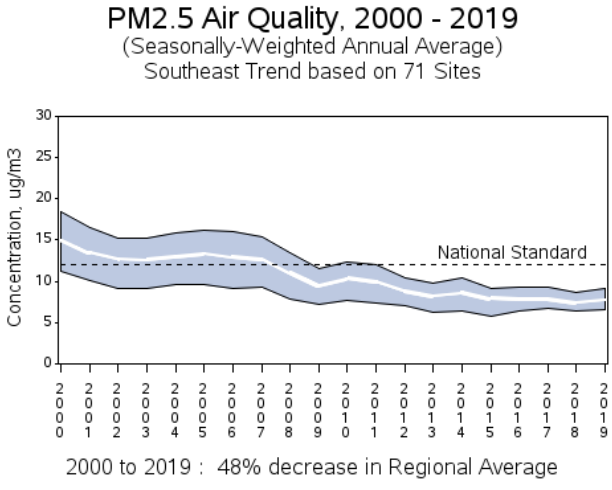
Source: https://www.epa.gov/air-trends/sulfur-dioxide-trends

Particulate Matter 2.5µ Trends





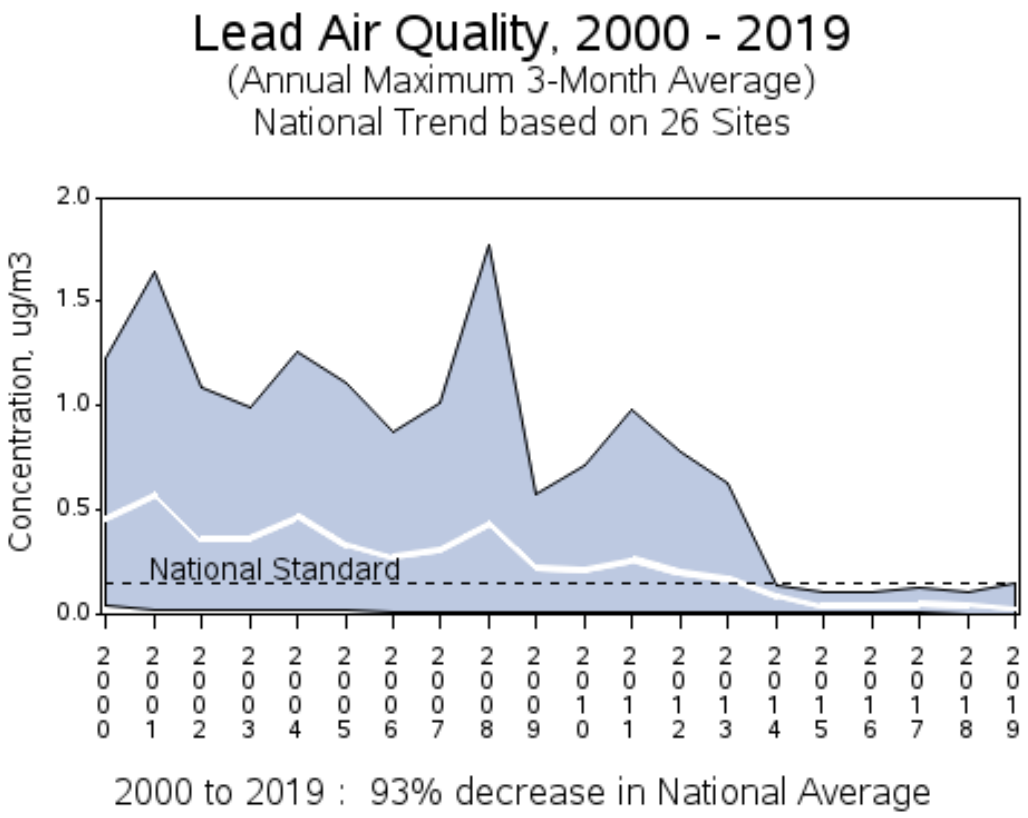
Northeast: ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD



Southeast: VA, NC, SC, AL, GA, FL

Source: https://www.epa.gov/air-trends/particulate-matter-pm25-trends

Lead Trends



Source: https://www.epa.gov/air-trends/lead-trends

Name _____

STUDENT HANDOUT

How Much Pollution Is Too Much?

The United States Environmental Protection Agency (EPA) is a part of the government that is responsible for making sure the air we breathe is safe. Scientists at the EPA decide how much pollution in the air is harmful to human health or the environment. It would be safest if there were no pollution in the air at all, but many of the things we like to use such as cars and computers either make pollution, or use electricity that is often made in way that creates pollution. For example, gasoline-powered cars create air pollution, and power plants that burn fuel to make electricity also make air pollution.

The EPA sets limits for the amount of air pollution that is harmful people to breathe into their lungs. There are different limits for each kind of air pollution based on how harmful each kind of pollution is. Very harmful pollutants have very low limits because even very, very small amounts of these chemicals can be harmful. The units that the EPA uses for these limits are "parts-per-million" or ppm and "parts-per-billion" or ppb. These are units just like inches or miles or meters. One part-per-million means one molecule of pollution in 1 million molecules of air.

How many is one part-per-million? Think how long one day is. One day in a million days is the same as one day in 2,737 years!

How about one part-per-billion? Imagine an Olympic-sized swimming pool like the one in the picture below. One part-per-billion is the same as one drop of water in the whole swimming pool.

One part-per-billion

We can also write units such as percent, parts-per-million and parts-per-billion as fractions to help compare them. Look at the three fractions below:

1 percent (1%) = $\frac{1}{100}$ 1 ppm = $\frac{1}{1{,}000{,}000}$ 1 ppb = $\frac{1}{1{,}000{,}000{,}000}$

One percent pollution would mean 1 molecule of pollution for every 100 molecules of air. 1 ppm is 1 molecule of pollution for every 1,000,000 molecules of air, and 1 ppb is 1 molecule of pollution for every 1,000,000,000 molecules of air.

Even though these amounts of pollution seem very small, they can have a big effect because humans breathe so much air. The average human breathes 10,000 liters of air a day, so even small amounts of pollution can cause a big problem for us.

How much pollution is too much? The EPA limits for a few common air pollutants are shown in the table below:

Pollutant	Limit of "safe" amount	Limit in fraction form
Sulfur dioxide	75 parts-per-billion (ppb)	$\frac{75}{1{,}000{,}000{,}000}$
Nitrogen dioxide	100 parts-per-billion (ppb)	$\frac{100}{1{,}000{,}000{,}000}$
Carbon monoxide	9 parts-per-million (ppm)	$\frac{9}{1{,}000{,}000}$
Ozone	75 parts-per-billion (ppb)	$\frac{75}{1{,}000{,}000{,}000}$

Compare the EPA limits for the four different pollutants listed. The write them in order from smallest to largest, using the symbols >, <, and =. Label each one using the ppm and ppb notation.

The average human breathes 10,000 liters of air a day (2,641 gallons). If you breathe 10,000 liters of air in a day, how many liters of ozone would you breathe **in a year** if the air had the EPA limit of ozone in it?

TEACHER GUIDE

Compare the EPA limits for the four different pollutants listed. The write them in order from smallest to largest, using the symbols >, <, and =. Label each one using the ppm and ppb notation.

$$\frac{9}{1{,}000{,}000} > \frac{100}{1{,}000{,}000{,}000} > \frac{75}{1{,}000{,}000{,}000} = \frac{75}{1{,}000{,}000{,}000}$$

9pmm > 100 ppb > 75 ppb = 75 ppb

Carbon monoxide | nitrogen dioxide | sulfur dioxide | ozone

The average human breathes 10,000 liters of air a day (2,641 gallons). If you breathe 10,000 liters of air in a day, how many liters of ozone would you breathe **in a year** if the air had the EPA limit of ozone in it?

$$\frac{10{,}000\ liters\ of\ air}{day} \times \frac{75\ liters\ of\ ozone}{1{,}000{,}000{,}000\ liters\ of\ air} \times \frac{365\ days}{year} =$$

$$0.27\ liters\ of\ ozone\ per\ year$$

Activity 8 (Elaborate): Smog City: How Weather Affects Air Quality

ACTIVITY DETAILS

Time: 45 minutes

Objectives

- ✓ Students will understand how different weather conditions affect AQI
- ✓ Students will understand how emissions from various sources and population affect AQI

Materials

- ✓ Computer & projector
- ✓ Student computers (highly recommended)

Handouts

- ✓ Save Smog City from Ozone!

Teacher Tip

- ✓ Ideally, students will do this activity on their own or in pairs using student computers. If computers are not available, the activity can be done together as a class using a projector.

Activity summary: This activity is based on the EPA's air quality and weather simulation "Smog City 2". After a brief introduction to the simulation, students explore how different variables centered around emissions, weather, and population affect air quality. This if followed by a discussion to summarize what they learned from the simulation.

Standards Connection

DCI: ESS3.C – Human Impacts on Earth Systems
DCI: ESS2.D – Weather & Climate
SEP: Developing & Using Models
CCC: Patterns; Systems & System Models

Important Technology Note about this Activity

Smog City 2 uses Flash, which is not supported in newer browsers. You will need to click the option to allow Flash to run in your browser in order to launch Smog City. If this does not work, you may need to use a downloaded copy, so be sure to try the simulation out on student computers before using it with a class. You can download a copy of Smog City 2 by signing up here: http://www.smogcity2.org/download.cfm

Warmup: Have students take out the visual glossary they created in Activity 2. Then have them describe today's weather today using these scientific terms. Students may look up the details using computers (which will be used today) or from a handout/ projection of a current weather report.

1. **Frame the activity:** Remind students that for this investigation they have taken on the role of meteorologists. So far in the investigation, they have been learning how to explain the weather. Now that they understand more about how weather and air pollution work, it is time for them to learn how to predict the air pollution so that they can keep people in the community safe from air pollution. To do this, they need to understand how weather affects air quality. Today they are going to use a computer simulation of a real city to see how weather affects air quality.

2. **Smog City 2.** Display the Smog City simulation on a projector where all students can see it: http://www.smogcity2.org/

Show students how to launch the simulation, and briefly review the controls with them. Pass out the Save Smog City from Ozone! sheets and student computers. Then support students in following the directions on the handout and answering the questions.

3. **Smog City Summary Discussion.** Lead a discussion with students on how different weather factors affect the level of pollution. Create an anchor chart based on students' responses that you can leave up in the room (this will help with later activities in the module). As students answer, ask why they think this weather factor changes the AQI in the way it does. Make sure to leave room at the bottom to add other factors.
    - Sky condition/cloud cover: more clouds = lower AQI because there is less sunlight to generate ozone
    - Wind: more windy = lower AQI because the ozone is blown away
    - Inversion (optional): an inversion = higher AQI because pollution is trapped near the surface
    - Temperature: higher temperature = higher AQI because the chemical reaction that makes ozone goes faster (this is generally true but not always)

4. **Additional Weather Factors**: Remind students that there are a few other weather factors from their glossary that may also affect air pollution. Ask students how they think the following factors affect air pollution and why. As they discuss, add these to the anchor chart:
    - Precipitation: more precipitation = lower AQI because the precipitation essentially washes out the pollution
    - Humidity (optional): higher humidity = lower AQI because it helps O_3 to convert back to O_2

5. **Return to the investigation tracker:** Have students make notes in their investigation tracker based on big ideas they learned during this activity. Key takeaways:
    - Air pollution (especially ozone) is strongly affected by the weather
    - Weather conditions like clear sunny skies and low wind are more likely to result in a bad ozone day
    - Rain can "wash" pollution out of the air resulting in less ozone.
    - Large human populations can result in more emissions and worse air quality if they don't do something to prevent it

TEACHER NOTES

Differentiation

✓ Pair students for the simulation in a way that allows more advanced students to support struggling students.

Teacher Tips

✓ In general, increased temperatures cause higher AQIs. The Smog City 2 simulation includes some complex modeling that makes this somewhat unclear. It is helpful to simplify this during the discussion.

Modification

✓ Use an alternative discussion technique to engage students after the simulation. For example, have students stand up and move to one side of the room based on whether they think the variable will make the AQI go up or down, and have each side make an argument based on where they moved.

TEACHER NOTES

Research sources

✓ If you are keeping track of research sources, you can add Smog City to the list for ways to see how different weather conditions affect air quality.

6. **Formative assessment**. Based upon what you learned during Smog City, what do you think the weather was like on July 9, 2018 – our Code Red Day?
    - Students should suggest low wind, high temperature, clear skies, low humidity, no rain, and possibly an inversion. The actual weather matches this well: (go back to the weather you looked up in Activity 2 for exact information) https://www.wunderground.com/history/daily/us/dc/KDCA/date/2018-7-9
        - High temp: 86°F
        - Fair skies throughout the day
        - Wind speed under 10mph most of the day
        - 0 precipitation

    You can also put up the weather report from the warmup (or have students consider today's weather). Based on this weather, would you expect there to be an ozone problem today?
    - To check students' predictions, you can look up the current ozone information for the DC-Baltimore region by going to https://www.cleanairpartners.net/current-and-forecasted-air-quality and clicking on "current"
    - Generally speaking, the ozone levels will be low unless it is a hot day with little wind and low humidity

Name _____

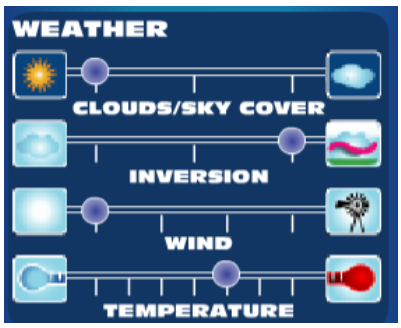
STUDENT HANDOUT

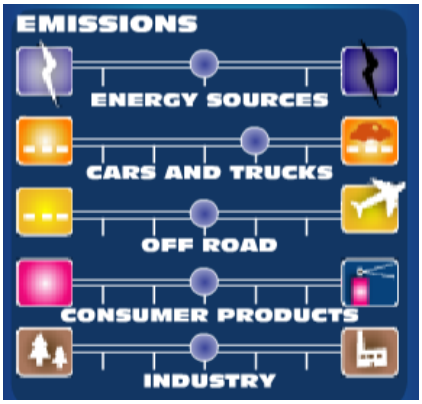
Save Smog City from Ozone!

Adapted from *Save Smog City 2 From Ozone*

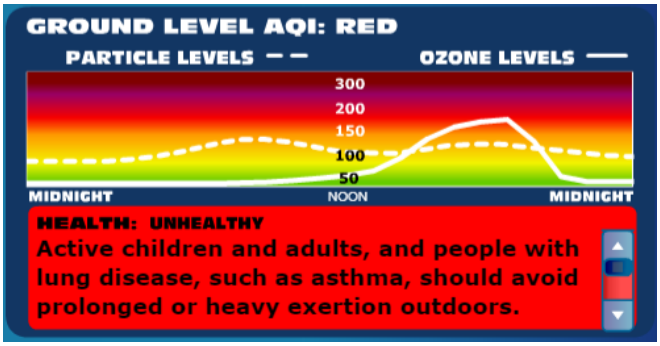
Directions:

1. Go to the website www.smogcity2.org
2. Click on the link "Save Smog City 2 from Ozone" in the bottom left
3. Look at your controls on the left side of the screen. You have controls for weather, emissions, and population. Try out the controls to make sure you know how they work.

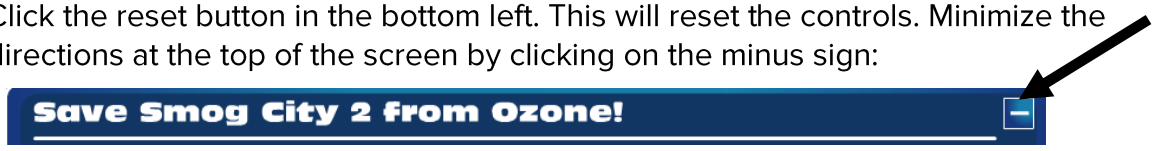




4. Look at the information about air quality you have. Find the temperature and AQI information and the ground-level AQI information:

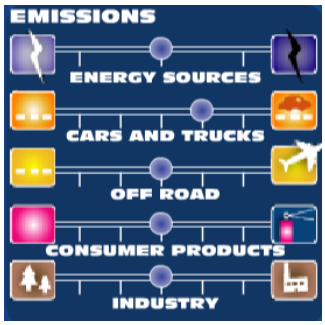


5. Find the information box at the bottom of the screen. When you click on any of the controls, you will find information about it.
6. Click the reset button in the bottom left. This will reset the controls. Minimize the directions at the top of the screen by clicking on the minus sign:



You're now ready to save Smog City from Ozone!

Scenario 1: Emissions



What is the AQI at the start of the scenario? _____

What color does this AQI represent? _____

Change some of the emissions controls. What happens to the AQI when the emissions go up or down?

_____

_____

Which kind of emissions changes the AQI the most? _____

Why do you think this is? _____

_____

_____

Change the emissions controls so the AQI is in the yellow zone. Draw your settings on the chart below:

Energy Sources:

Cars & Trucks:

Off Road:

Consumer Products:

Industry:

Now change the emissions controls so the AQI is in the green zone. Draw your settings on the chart below:

Energy Sources:

Cars & Trucks:

Off Road:

Consumer Products:

Industry:

Scenario 2: Weather

Click the reset button in the bottom left to set the controls back to their defaults.
Adjust each of the weather controls, and notice how the AQI changes with the weather. Circle how the AQI changes with each weather change:

When it gets **more cloudy,** the AQI goes up OR goes down (circle one)

When there is a **high altitude inversion** (a layer of warm air), the AQI goes up OR goes down

When there is **high wind**, the AQI goes up OR goes down

When there is **high temperature**, the AQI goes up OR goes down

Find a setting for weather that has an AQI at the green level. Describe what the weather is like:

_____

_____

_____

Find a setting for weather that has an AQI at the red level. Describe what the weather is like:

_____

_____

_____

Look at the graph in the bottom right that shows AQI at different times of day. When is the AQI the worst during the day? _____ Why do you think this is? _____

_____

Scenario 3: Population

Click the reset button in the bottom left to set the controls back to their defaults.
Use the population settings to raise and lower the population.

When there is **higher population,** the AQI goes up OR goes down (circle one)

Why do you think population has such a big effect on AQI?_____

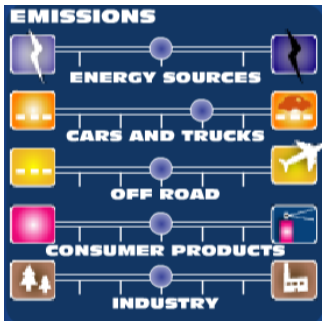
_____

_____

_____

TEACHER GUIDE

Scenario 1: Emissions



What is the AQI at the start of the scenario? 175

What color does this AQI represent? Red

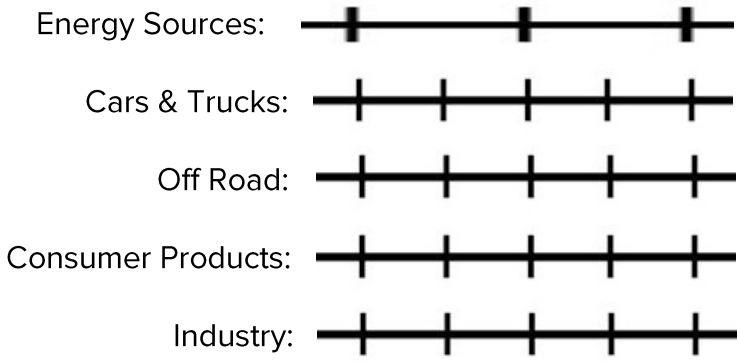
Change some of the emissions controls. What happens to the AQI when the emissions go up or down?

When the emissions go up, the AQI goes up, and when the emissions go down, the AQI goes down

Which kind of emissions changes the AQI the most? Cars and trucks

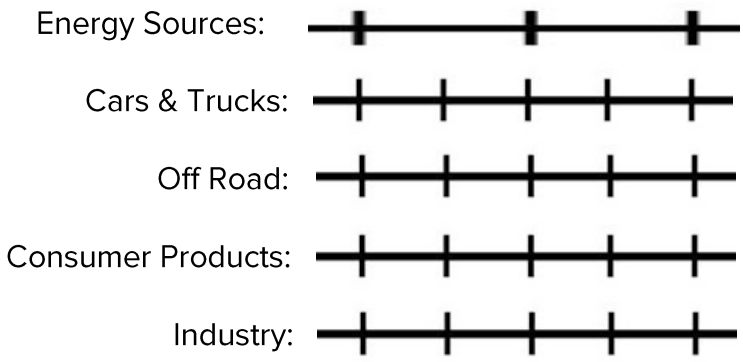
Why do you think this is? There are a lot of cars and trucks on the road, and they produce a lot of pollution, so reducing the number of cars can have a big effect on the AQI

Change the emissions controls so the AQI is in the yellow zone. Draw your settings on the chart below:



Answers will vary. Cars and trucks will likely be at the lowest or near lowest level.

Now change the emissions controls so the AQI is in the green zone. Draw your settings on the chart below:



Answers will vary, but will generally be at or near the lowest levels

Scenario 2: Weather

Click the reset button in the bottom left to set the controls back to their defaults.
Adjust each of the weather controls, and notice how the AQI changes with the weather. Circle how the AQI changes with each weather change:

When it gets **more cloudy,** the AQI goes up OR goes down (circle one)

When there is a **high altitude inversion** (a layer of warm air), the AQI goes up OR goes down

When there is **high wind**, the AQI goes up OR goes down

When there is **high temperature**, the AQI goes up OR goes down

Both are true depending on other weather conditions

Find a setting for weather that has an AQI at the green level. Describe what the weather is like:

Answers will vary, but in general, the weather will be windy, with no inversion. It may be cloudy, and the temperature may be moderately warm

Find a setting for weather that has an AQI at the red level. Describe what the weather is like:

Answers will vary, but in general, the weather will not be windy, and there will be a high-altitude inversion. It may be sunny, and the temperature may be either very cold or very hot.

Look at the graph in the bottom right that shows AQI at different times of day. When is the AQI the worst during the day? In the afternoon Why do you think this is? AQI is worst in the afternoon because it is hotter and the sun is more directly overhead

Scenario 3: Population

Click the reset button in the bottom left to set the controls back to their defaults.
Use the population settings to raise and lower the population.

When there is **higher population,** the AQI goes up OR goes down (circle one)

Why do you think population has such a big effect on AQI? Population has a big effect on AQI because it affects all the other emissions. When there is a bigger population, there are more cars and truck, more electricity is needed, and there are more factories. So population makes all the other emissions factors go up.

Activity 9 (Elaborate): Making an Air Quality Prediction

ACTIVITY DETAILS

Time: 45-60 minutes

Objectives

- ✓ Students will be able to make an AQI prediction using data from a variety of information sources including weather conditions

Materials

- ✓ Computer & projector
- ✓ Student computers (highly recommended)

Handouts

- ✓ AQI prediction guide

Teacher Tip

- ✓ This activity will be more engaging if students have computers to use. If computers are not available, the activity can be done together as a class using a projector.
- ✓ This activity is complex, and students will likely be more successful if they work with a partner, either the whole time, or by checking it at times along the way.

Activity summary: In this activity, students learn how meteorologists make air quality predictions based on air pollution and weather modeling. Then they use what they have learned to make their own an air quality forecast.

Standards Connection

DCI: ESS3.C – Human Impacts on Earth Systems
DCI: ESS2.D – Weather & Climate
SEP: Developing & Using Models; Obtaining, Evaluating, and Communicating Information

Warmup: What kinds of information do you think a meteorologist would need in order to make a weather forecast?

- Students will likely think of what they have learned in the past few activities, but if they are stuck, use prompts to get them started
- Possible answers: temperature, precipitation, wind speed and direction, humidity, etc.

1. **Frame the activity:** Tell students that making a weather prediction depends on knowing what the current weather is like and using that information to make an informed guess as to what will happen next, just like you might make a guess about what will happen next in a movie or a book based on what you've already read. Meteorologists put the weather information into a computer program that models what might happen next. They do the same thing for air quality. Today we are going to be meteorologists and make an AQI forecast for ozone so we can tell people whether to plan for a good or bad air day, just the way professional meteorologists do.

2. **Introduction to AQI Prediction:** Hand out the AQI Prediction Guide. Tell students that when a scientist wants to make an air quality prediction, they follow a series of steps. We're going to use steps just like the scientists do to make our own forecast together.

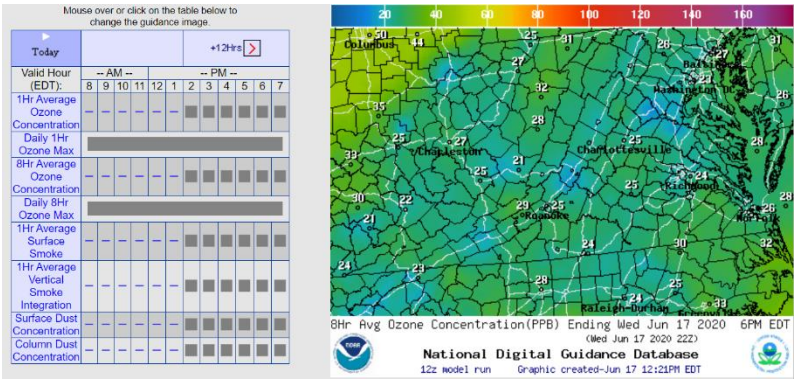
   Preview the parts below with students. Ask students why each part is necessary for their forecast:

   - Part 1: Start with the National Weather Service's (NWS) air quality computer model prediction – *a computer model is needed as a starting point based on the huge amount of air quality data*

- Part 2: Learn about what the weather will be using the National Weather Service's weather forecast – *local weather will affect the air quality*
- Part 3: Adjust the Weather Service's air quality model based on the upcoming weather – *making adjustments based on weather will make the AQI prediction closer to reality*
- Part 4 (optional): Look for any pollution which may be blowing into the area – *a lot of pollution blowing in can affect the AQI*

3. **Part 1: The NWS Air Quality Computer Model:** Hand out student computers (if available) and start by going to the National Weather Service's computer model of what the air quality will be: airquality.weather.gov. This model takes some variables into account, but it needs to be adjusted for local weather conditions.

   Once you get to the website, click on the area of the area of the map where the school is. Continue clicking until you are zoomed into a state-level view that looks like this:



   Ask students what kind of information they see in the model. Key observations:

   - The map on the right is color-coded for AQI based on a single pollutant (it usually starts with ozone). It also has AQI numbers.
   - The date for this information is at the bottom. It will likely be some time in the future since this is a forecast
   - The left side has a list of different pollutants (ex. ozone, smoke, and dust)
   - The left side also has times of day (AM & PM) and some buttons for changing the time of day

   If you hover over the different gray boxes on the left (make sure "Table MouseOver Effect" is on, you can see the pollution prediction change over time on the map.

TEACHER NOTES

Teacher Tip

✓ An important thing to keep in mind during this activity is that the ultimate accuracy of students' AQI predictions is less important than the thought process they go through to make the prediction. With this said, seeing which student(s) can get closest to the actual AQI for the day they are forecasting could be a great motivator for them to try their hardest.

Explicit Language

✓ Students are using a lot of computer models in this activity. Be sure to consistently use the word "model" and "modeling" to drive this point home.

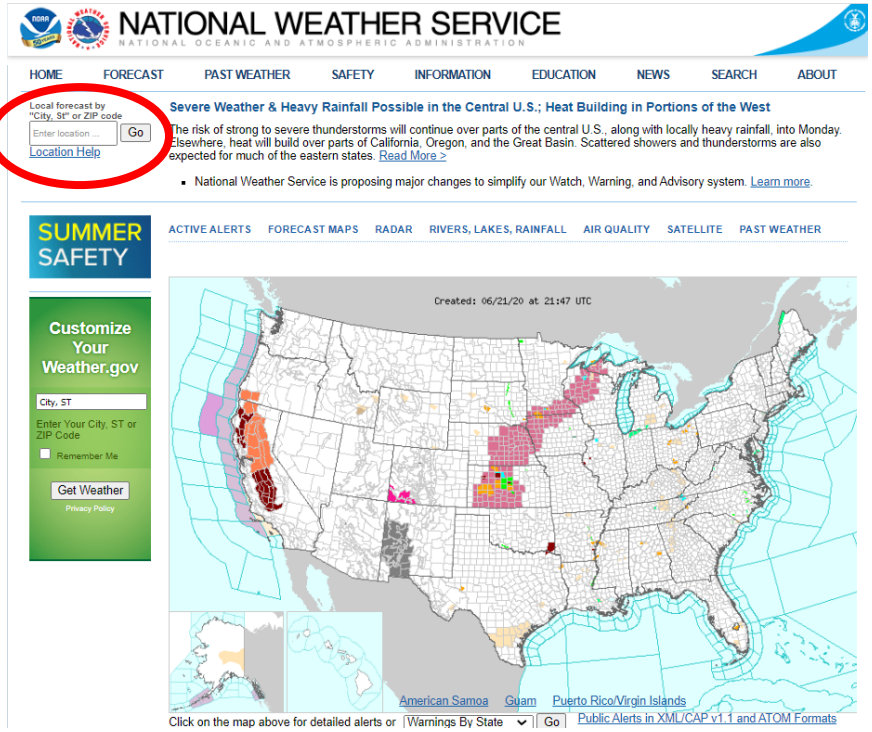
Modifications

✓ There are a lot of interesting features on the NWS air quality page. For example, the "Loops" tab allows you to watch the map change over time. You and students can explore these other features to learn a lot more about how AQI changes over time.

TEACHER NOTES

Click on the +12 hour button twice. Ask students why you need to do this (to get to this time tomorrow). Then click on the gray bar for "Daily 8Hr Ozone Max". This will show the maximum ozone prediction (over an 8-hour span) in parts-per-billion that we will use to start our own forecast. Have students use the scale at the top to determine what the ozone levels will be like tomorrow. What is the maximum ozone for the area closest to the school? Have students record this information on their sheets in parts-per-billion. To convert the ozone level to AQI, go to: https://www.airnow.gov/aqi/aqi-calculator-concentration/ and enter the relevant information.

4. **Part 2: NWS Weather Forecast:** Go to the National Weather Service's weather forecast page: https://www.weather.gov. At the top left of the page, there is a place to input your location to get the local forecast. Once on that page, find the **Detailed Forecast** and enter the relevant information on the AQI prediction guide. To find the relative humidity tomorrow (optional), scroll down on the page and click "Hourly Weather Forecast" to bring up a set of line graphs showing the forecast. Find relative humidity and record it for the early afternoon when it is likely to be hottest.



5. **Part 3: Adjusting the forecast based on the weather:** Have students transfer their AQI from Part 1 into the first box of the table. Then have them use what they've learned about how the weather affects AQI to decide if each weather factor will make the AQI go up, stay the same, or go down. Once they've finished filling in the table, they can make a final AQI prediction (number and color). Students may have questions about how much the AQI will change. You can provide some guidance and/or have them think back to the Smog City simulation. The AQI may go up or down from the model, but it won't go from 50 to 100 because of weather adjustments. In reality, meteorologists draw upon years of experience, intuition, and education to make these adjustments, and even they don't always agree on the changes.

6. **Part 4: Adjusting the forecast for incoming pollution (optional extension):** Sometimes events occurring upwind such as wildfires or power plant emissions can affect the air quality in an area. To investigate how incoming pollution might affect the AQI, have students first determine where the air is coming from. They can do this by going to windfinder.com and zooming in on the area where the school is located. Next, have them go to airnow.gov to look up the current AQI in the area where the wind is coming from. They can do this by putting in the school's city, state or zip code. The page that comes up will have a map of the area. If you click on this map, it will bring you to a larger map. Switch the map to show the monitors for ozone using the menu on the left side. From here, you can see if there is any ozone coming into their area based on current wind patterns. If the AQI upwind is particularly bad, students may want to adjust their AQIs up.

7. **Discuss adjustments in small groups:** Once students have made their adjustments to the forecast, have them get together in small groups to discuss what changes they made and talk through why they made their decisions. If some students got stuck on certain parts of the modeling, this will give them a chance to get support from their peers. You can also choose to hold this discussion as a whole group and allow students to debate their adjustments, ex. whether one factor is more important than another in affecting the AQI. While students are discussing (either whole group or small group), listen in and push their thinking, especially to have them explain **why** they made certain adjustments.

   If you think it will provide extra motivation, remind students that you will check to see whose AQI prediction is closest to the actual AQI for the date they are predicting. Some students may enjoy this mini-competition aspect of the prediction process. Have them post their predictions, and be sure to check later on to see how students did.

TEACHER NOTES

Differentiation

✓ If you teach some advanced students, have them follow the directions for the incoming pollution adjustment as an extension.

Authentic learning

✓ This activity mirrors very closely what actual meteorologists do when preparing an AQI forecast. During "ozone season" in the summer months, meteorologists across the region hold regular phone calls to discuss and debate their daily predictions.

Teacher Tip

✓ Both the AirNow and the Clean Air Partners websites have predictions for air quality. Students may want to use these sites to adjust their own predictions, and if so, remind them that you want *their* predictions, not the EPA's.

TEACHER NOTES

Research sources

- ✓ Add the websites you used today to your research sources chart paper: NWS Air Quality Computer Model and NWS Weather Forecast. If you used them also add Windfinder, and AirNow.

8. **Formative assessment.** The next and final activity in this module asks students to create a weather forecast focused on air quality based on what they've learned during this module. That may serve as the formative assessment for this activity. Alternatively, you can provide students with a fictional AQI and weather scenario and have them adjust it using the table like the one in their prediction guide:

Starting AQI (National Weather Service)	The temperature will make the AQI...	The wind will make the AQI...	The precipitation will make the AQI...	The sky condition will make the AQI...	The humidity will make the AQI go...
	Go up	Go up	Go up	Go up	Go up
	Stay the same	Stay the same	Stay the same	Stay the same	Stay the same
	Go down	Go down	Go down	Go down	Go down

Name _____

STUDENT HANDOUT

AQI Prediction Guide

Overview

- Part 1: Look up the National Weather Service's (NWS) air quality prediction.
- Part 2: Look up the weather forecast from the National Weather Service.
- Part 3: Adjust the Weather Service's air quality prediction based on the weather forecast.
- Part 4 (optional): Check for pollution blowing into the area, and adjust your prediction if necessary

Part 1: The National Weather Service air quality computer model

1. Go to NWS air quality computer model at: airquality.weather.gov
2. Click on the part of the map where you live to zoom in. You will need to click at least twice to get as zoomed in as you can go.
3. Look at tomorrow's forecast by clicking the +12Hrs button twice. You should see tomorrow's day of the week.
4. Click on the gray bar where it says "Daily 8Hr Ozone Max."
5. What does the map show about the ozone levels for tomorrow?

   _____

   _____

6. What is the maximum ozone level closest to you? _____ppb

7. To covert this to AQI, go to: https://www.airnow.gov/aqi/aqi-calculator-concentration/ and enter the information.
8. What is the AQI for this amount of ozone? _____

Part 2: The National Weather Service weather forecast

1. Go to the NWS weather forecast page: https://www.weather.gov/
2. At the top left where it says, "Local forecast by "City, ST" or ZIP code, enter your location and click Go
3. Find the **Detailed Forecast** and look at the forecast for tomorrow. Record the necessary information for the forecast:

   - High temperature: _____
   - Wind speed:_____ and wind direction: _____
   - Precipitation: _____
   - Sky condition: _____
   - Humidity: _____
     Note: humidity graph can be found on the graphs for Hourly Weather Forecast under Additional Resources

Part 3: Adjusting the AQI forecast based on the weather

1. Write the ozone AQI from the National Weather Service Model in the box below.
2. Look at tomorrow's predicted temperature. Using what you know about how weather affects air pollution, decide if this will make the AQI go up, go down, or stay the same. Circle the correct choice in the column for temperature.
3. Repeat step 2 for all the other weather factors.

Starting AQI (National Weather Service)	**The temperature will make the AQI...**	**The wind will make the AQI...**	**The precipitation will make the AQI...**	**The sky condition will make the AQI...**	**The humidity will make the AQI go...**
	Go up	Go up	Go up	Go up	Go up
	Stay the same	Stay the same	Stay the same	Stay the same	Stay the same
	Go down	Go down	Go down	Go down	Go down

4. Based on the weather forecast, decide how the AQI will change. Will it go up or down? Will it change a lot or just a little?

   I predict that the AQI for ozone tomorrow will be: _____

   The color for this AQI is: _____

Part 4: Adjusting the AQI forecast for pollution blowing into the area (optional)

1. Look up the wind speed and direction by going to windfinder.com and zooming in on the area where the school is located
2. What direction is the wind blowing (ex. from east to west)? _____
3. Look up the current AQI for ozone by going to airnow.gov and typing in your city, state or zip code. When the new page comes up, click the map where it says "Current Air Quality."
4. When the map comes up, use the "Monitors" menu on the left to change the pollutant to ozone. Then zoom in on the area that the wind is coming from.
5. What is the AQI in that area? _____
6. If the AQI is very high, then pollution from the area may increase your AQI prediction. Go to the space above and adjust your prediction based on this information.

Activity 10 (Evaluate): Creating an Air Quality Report

Activity summary: To demonstrate what they've learned in this module, students create an air quality report including a forecast of future air quality conditions and recommendations for the public.

Standards Connection

DCI: ESS3.C – Human Impacts on Earth Systems
DCI: ESS2.D – Weather & Climate
SEP: Developing & Using Models; Obtaining, Evaluating, and Communicating Information
CCC: Patterns; Systems & System Models

Warmup: Go to the Clean Air Partners website to show students the current AQI: https://www.cleanairpartners.net/current-and-forecasted-air-quality. Click on "Current" then choose the monitor closest to the school. Click on it to see the ozone AQI, and have students answer these questions:

- How close was our prediction (from Activity 9) to the actual AQI?
- Based on the time of day, do you expect the AQI to go up or down later today? Why?

If students' predictions are very close to the actual AQI, be sure to celebrate their success as meteorologists.

1. **Frame the activity:** Remind students that their goals from the beginning of this unit were:
   - To be able to explain the Code Red Day that happened in Washington, DC in 2018
   - To be able to predict other bad air quality days to help keep people safe

   To show that they've met these goals, they are going to use what they've learned about air pollution and weather to create a weather forecast that is focused on air quality.

Important Note about this Activity

There are a variety of options for how to have students create and share their weather reports. For example, you may choose to have students work in groups, and have them present their work like a television weather forecast. You can also have students create posters of their forecasts. You may have students create a report based on the prediction they made in the last activity, or you can have them use new data that they gather on their own. Choose whichever methods work best for you and your students, or give students options to show what they know in their preferred way.

ACTIVITY DETAILS

Time: Two or more class periods (90-120 minutes)

Objectives

- ✓ Students will show what they've learned from the module by creating an air quality report

Materials

- ✓ Students computers (highly recommended)
- ✓ Video recording devices (optional)

Handouts

- ✓ Project guidelines (adapted for your specific project)
- ✓ Grading rubric

Technology Tip

- ✓ If student computers are not available, you will need to print out relevant information for students to use to complete their projects, ex. data for them to make AQI predictions.

TEACHER NOTES

Teacher Tip

- ✓ If you expect this project to take multiple days to complete, consider when you want students to make their predictions for. In other words, if the project will take 3 class days, consider having students make their predictions for the day the project will end (or the day after) instead of the first day after you start the project. Many weather websites have 7-day forecasts, and the NWS air quality forecast goes 36-hours ahead. If their prediction is for a day before the projects ends, you can have them evaluate their prediction as a part of the project.

Modification

- ✓ If you have concerns about students all doing the same prediction for the same day, you can have them choose different days, or different locations. The AirNow website provides air quality data and predictions for the entire United States.

2. **Introduce the project.** Pass out the project guidelines for students and go over the requirements for the project. Answer any questions that students have about what the expectations are. Be sure to go over the timeline for the project as well, and what resources students will have available to them. You may also choose to share the project rubric with students in advance, or at some point during their work time.

3. **During the project.** Support students by suggesting resources, reminding them when they learned certain pieces of information, or being a thought-partner as they figure out how to present their information. Keep in mind that their goal in this project is to synthesize what they've learned and present it in an authentic way. Support them in their efforts to do this work, but do not do the work for them.

4. **Student presentations (optional).** If students are presenting their work, either as an oral report or presenting posters, provide time for them to practice their presentations and get feedback from you or from their peers using the peer feedback form on the On the Air 2020 website or the presentation rubric for the activity (see below). If you are short on time, consider letting students record their presentations using laptop cameras, phones, or other digital recording devices. This way students can present, but you don't need to use class time to watch all the presentations.

5. **Evaluation and feedback.** Modify the attached grading rubric to match the type(s) of reports students have created. Be sure to use the rubric to provide feedback to students on their projects.

Name _____

STUDENT HANDOUT

Final Project: Creating an Air Quality Report

Project Guidelines

For this project, you will be creating a weather report based upon what you have learned during this module. You will be working (individually/as a group) to complete this project. Your weather report will be in the form of a (written report/poster/presentation). Your report will require you to do some research on predicted weather and air quality conditions. You will also likely need to use your materials from throughout the module to help you.

Your weather report must include the following information:

- A description of the predicted weather conditions including the temperature, sky condition, wind, and any precipitation, along with brief explanations of what each of these means in your own words
- A prediction for the ozone AQI color for tomorrow, including a recommendation for whether people need to adjust their behavior or not based on the air quality
- An explanation the process you went through to make your prediction, including specifics about why you made adjustments to the AQI.
- An explanation of what ground-level ozone is, where it comes from, and why we care about it as a pollutant.
- A comparison of tomorrow's predicted AQI with the AQI from the same date during some year in the past (you can choose any year you like). Comparison must include a comment on whether the difference is in line with historical trends or not.

Your report does not need to include this information in this order. You can be creative about how your present your information, and you are encouraged to use visuals as a part of your report.

The audience for your report is a person who does not know much about weather or air quality, so make sure to explain any technical terms you use, such as AQI.

You have _____ days to complete the project.

Available resources:

Student Name_____

Air Quality Report Project Rubric

Project area	Beginning	Needs Improvement	Proficient	Advanced
Description and explanation of predicted weather conditions	Several descriptions of required weather conditions are missing, and/or are inaccurate. Explanations are missing or have significant inaccuracies.	Descriptions of most required weather conditions are included and are mostly accurate. Explanations have minor inaccuracies.	Descriptions of all required weather conditions are included and accurate. Explanations are accurate but not thorough.	Descriptions of all required weather conditions are included and accurate. Explanations are accurate and thorough.
Ozone AQI prediction	Ozone AQI prediction is unreasonable, and color does not math number. Recommendation does not match color rating or number, or is missing.	Ozone AQI prediction is somewhat unreasonable or color does not match number. Recommendation matches color rating or number.	Ozone AQI prediction is reasonable, and color matches number. Recommendation matches color rating, and uses generic language.	Ozone AQI prediction is reasonable, and color matches number. Recommendation matches color rating, and includes original suggestions.
Ozone AQI prediction process	Ozone AQI prediction process is explained incorrectly and/or information may be incorrect. Adjustments likely do not align with accepted scientific reasoning.	Ozone AQI prediction process is explained in very general terms, without specific steps described. Information may be missing. Adjustments may not align with accepted scientific reasoning.	Ozone AQI prediction process explains the steps for adjusting the AQI based on weather conditions, although steps may be lumped together or information may be missing. Adjustments align with accepted scientific reasoning.	Ozone AQI prediction process thoroughly explains each step for adjusting the AQI based on weather conditions, including adjustments for each weather condition. Adjustments align with accepted scientific reasoning.
Explanation of Ground-level ozone	Explanation of ground-level ozone is incomplete, and contains significant inaccuracies.	Explanation of ground-level ozone is missing some required aspects, or contains some inaccuracies.	Explanation of ground-level ozone is complete and accurate, with all required aspects addressed.	Explanation of ground-level ozone is thorough and detailed, with all required aspects addressed accurately

Comparison of predicted AQI with historical AQI	Historical AQI is incorrect.	Historical AQI is correct, but comment about fitting in with historical trend is inaccurate or illogical.	(see proficient)	Historical AQI is correct, and comment about fitting in with historical trend is accurate and logical.
Presentation quality	Presentation is generally unprofessional (ex. mostly ad lib) and strays from the topic. Presenter does not use scientific terms, and may stray from established time limits.	Presentation is led in a slightly unprofessional manner and may stray of topic or presenter gets easily distracted. Presenter occasionally uses scientific terms incorrectly and may stray from established time limits.	Presentation is mostly led in a “professional” manner and generally stays on topic. Presenter uses some scientific terms appropriately, and stays close to established time limits.	Presentation is led in a “professional” manner and stays on topic. Presenter uses scientific terms appropriately and stays within established time limits.
Craftsmanship	Poster/report has significant errors in grammar, spelling and/or formatting that make it difficult to understand. The product uses scientific terms incorrectly or not at all, and may have a sloppy look to it.	Poster/report has a few errors in grammar, spelling, and/or formatting. The product occasionally uses scientific terms incorrectly, and may a somewhat sloppy look to it.	Poster/report is well-made with attention to details such as grammar, spelling, and formatting, although there may be minor errors. The product uses some scientific terms appropriately.	Poster/report is well-made with attention to details such as grammar, spelling, and formatting. The product uses scientific terms appropriately and looks appealing.

Doing Our Part

- Plant an ozone garden at your school to identify whether ozone reaches harmful levels in your community. Specific species of plants are particularly sensitive to ozone and can indicate whether your community has an ozone problem. Learn more here: https://www.earthsciweek.org/classroom-activities/plant-ozone-monitoring-garden

- Look up the AQI using a computer or install an air quality app on your phone or your parents' phone. Use the AQI so you know when and how to avoid air pollution, especially on bad days.

- Be prepared for bad air quality situations, especially if you have asthma or other respiratory difficulties. For example, take your inhaler with you when the AQI is bad, and think about how you can get home from school if the air quality is bad.

- Avoid places where you know the air quality is likely to be bad, such as near roadways with lots of traffic (especially big trucks) or near power, cement, and chemical plants that are in your neighborhood. When walking to school, choose a route that stays away from busy streets.

- If you sometimes have difficulty breathing, talk to your parent(s) or doctor so they can make sure you get the help you need.

About this section

This section in included in every module either as a list or as part of an activity. It describes actions students can take to mitigate the effects of air pollution in their lives, and to help prevent air pollution from getting into the atmosphere. Many of these suggestions are the same from module to module, but there are variations depending on the focus of the module.

While the actions from this section are not explicitly built into the curriculum, they can be used in various ways to motivate students and provide them opportunities to take action to make a difference in their community. For more information, see the "Doing Our Part" section in "How to Use this Curriculum"

Air Quality Champion in Our Community

Name: Amelia Draper
Title: Meteorologist, StormTeam 4
Organization: NBC

How does your work relate to air quality?
As a television meteorologist, I am considered the station scientist. I am knowledgeable on most scientific topics, especially as they relate to climate, nature and natural disasters. As people plan their day, knowing the air quality is important and it is my job to tell them that information. Is it a day to stay indoors with poor air quality? Is the air quality impacting people with health issues like asthma and heart disease, or is the air clean and safe to breathe?

What is your workday like?
My time each day is spent forecasting the weather, building weather graphics, doing school visits or virtual visits, putting together a climate story and of course giving the forecast on NBC Washington, on social media as well as on WTOP radio. If there is severe weather I run weather crawls and alert the public to the current watches and warnings over social media and nbcwashington.com.

What motivates you to come to work every day?
I love my job! Knowing the forecast and effectively communicating the forecast are two different things. I am always looking to improve my communication of weather so non-meteorologists know what to expect when they step out their door. I also love the creative aspect of making new graphics.

What education and career path did you pursue to have the position that you have today?
I have a degree in meteorology from Penn State University. If you love math, science and communication, meteorology may be the career for you! I started working in a small television market more than 10 years ago, moved to a medium size television market then got a job in my hometown market of Washington, DC...my dream job!

Describe your workspace.
No lab for me! I rely heavily on computers and the internet to make my forecast and weather graphics. I use special websites to look at weather computer models, make weather graphics and create social media posts. After that, it is lights, camera, microphones and green screen!

What accomplishment are you most proud of?
I am most proud of making it back to my hometown market of Washington DC. I am also proud of a moment where I lost all of my typical weather graphics during a severe weather event and improvised ... viewers barely noticed!

Is there something important that you want to share that we haven't asked?
Dream big and ask for help! Get an internship, take some classes that push you out of your comfort zone and don't be afraid to try new things.

Glossary

anemometer – a scientific instrument for measuring wind speed

AQI (Air Quality Index) – a scale for reporting daily air quality. The AQI tells you how clean or polluted the air is in a given location, and what the associated health risks are. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air.

barometer – a scientific instrument for measuring air pressure

carbon monoxide (CO) - an odorless, colorless gas formed by the incomplete combustion of fuels. Can lead to poisoning because CO molecules will displace the oxygen in red blood cells.

Code Red Day – a day when the air quality index (AQI) is in the red zone (151-200) meaning that the air is unhealthy for everyone to breathe.

criteria pollutant – any one of the six air pollutants that are regulated by the EPA as required by the Clean Air Act. The criteria pollutants are carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide.

dew point - the atmospheric temperature below which water droplets begin to condense and dew can form

humidity – a measure of the amount of humidity in the atmosphere

hygrometer – a scientific instrument for measuring humidity

Inversion – a weather condition wherein a layer of cool air is trapped at the surface by a warmer air layer over it. Inversions can trap air pollution near the surface because the cool air will not rise into the warmer air. Also known as a temperature inversion.

nitrogen dioxide (NO_2) – a highly reactive gas that is a common air pollutant. Nitrogen dioxide primarily comes from burning fossil fuels in power plants, cars, trucks, and other vehicles.

ozone (O_3) - a natural and a man-made gas made of three oxygen atoms that occurs in the Earth's upper atmosphere (the stratosphere) and lower atmosphere (the troposphere). Depending on where it is in the atmosphere, ozone affects life on Earth in either good or bad ways.

particulate matter (abbreviation: PM) **-** a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Larger particles are called PM 10, smaller particles are called PM 2.5, based on their diameter in micrometers.

parts-per-billion (abbreviation ppb) – a unit of measure equal to 1 in 1 billion, or 0.0000001%. 1 ppb is also equivalent to 1 µg/liter.

parts-per-million (abbreviation ppm) – a unit of measure equal to 1 in 1 million, or 0.0001%. 1 ppm is also equivalent to 1 mg/liter.

sky condition – a measure of the percentage of the sky covered by opaque clouds.

smog – a haze caused by air pollution. Smog that is made of ground-level ozone is created when sunlight shines on particular kinds of air pollution and nitrogen oxides, especially from automobile exhaust. Smog can also refer to a haze caused by particulate matter pollution.

stratosphere - the layer of the earth's atmosphere above the troposphere, extending from about to about 4-8 miles above the Earth's surface to about 32 miles (50 km)

sulfur dioxide (SO_2) **–**a toxic gas that is often released when coal that contains sulfur is burned in a power plant

troposphere - the lowest region of the atmosphere, extending from the earth's surface to a height of about 4-8 miles (6–10 km), which is the lower boundary of the stratosphere.