GLOBE Educator One-Week Pacing Guide: *Air Quality (Aerosols)*

Phenomenon: Air Quality (Aerosols) **Grade Level:** 6-12	**Guiding Question:** How do aerosols affect my sky?	**Contact:** Reach out to the NASA Langley Research Center GLOBE Air Quality team if you have questions.
Further Investigation: NASA Langley Research Center GLOBE Air Quality team or GLOBE Mission Earth Air Quality Initiative		
Optional: Become a GLOBE Trained Teacher: GLOBE Clouds Protocol Training		
Access GLOBE Pacing Guides: https://www.globe.gov/web/nasa-langley-research-center/home/resources		
Revision Date: 2-27-2022		

Standards - These standards are supported by the activities in this guide but not completely covered.		
Middle	**Performance Expectations:** • MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. • MS-ESS3-3 Apply scientific principles to design a method for *monitoring* and minimizing a human impact on the environment. • 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.	**Disciplinary Core Ideas:** • ESS2.A Earth's Materials and Systems • ESS3-C Human Impacts on Earth Systems
	Science and Engineering Practices: • Developing and Using Models • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence	**Crosscutting Concepts:** • Stability and Change • Cause and Effect

This work was supported by GLOBE Mission Earth, award No. NNX16AC54A, in collaboration with NASA Earth Science Education Collaborative.

Air Quality (Aerosols) One-Week Pacing Guide

High School	**Performance Expectations:** ● HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. ● HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.	**Disciplinary Core Ideas:** ESS2.D Weather and Climate ESS3.A Natural Resources ESS3.B Natural Hazards ESS3.D Global Climate Change
	Science and Engineering Practices: Constructing Explanations and Designing Solutions ● Using Mathematics and Computational Thinking	**Crosscutting Concepts:** ● Cause and Effect ● Systems and System Models

Background Information and NASA Connection

What is air quality?

Air quality is a measure of the pollution level in the air. Polluted air can be caused by many things. There are manmade and natural sources of emissions. Man made emissions include factories, power plants, oil refineries, and combustion of oil and gas. Natural emissions include smoke from fires, gases and ash from volcanic eruptions, blowing dust, and hydrocarbon emissions by some vegetation. Worldwide, air quality is monitored by a network of environmental agencies. These agencies monitor the levels of both primary and secondary pollutants in the atmosphere. The major air pollutants that are monitored include:

- particulate matter, or aerosols, which are a mixture of solid particles and liquid droplets suspended in the air. Particulate matter, or PM, are in a range of sizes. Examples of larger particles include dust, pollen and mold. Smaller particles come from combustion or organic compounds. Particulate matter can be both primary and secondary pollutants.
- ground level ozone, a secondary pollutant that forms when nitrogen oxides and volatile organic compounds (emitted by factories, power plants, vehicles, and vegetation) react in sunlight.
- carbon monoxide, a primary pollutant, caused by combustion of fossil fuels.
- sulfur dioxide, a primary pollutant emitted from power plants, factories, and volcanos.
- nitrogen dioxide, a primary pollutant, also caused by combustion of fossil fuels.

This guide focuses on particulate matter, or aerosols.

Air Quality Index

The overall air quality in an area is measured using the Air Quality Index, or AQI. AQI is a unitless number, from 0 to 500, that communicates the health risk caused by the amount of pollution in the air. A reported AQI value can be based on particulate matter levels only, ozone levels only, or a combination of the two.

What affects air quality?

The weather plays a large role in determining the air quality in a particular area. Precipitation generally means less air pollution. Particulates, or aerosols, are typically 'washed out' of the air by rain or snow. Some pollutants dissolve in rain drops. Wind has a large effect on air quality. Pollutants are frequently transported from their source to different areas downwind.

Additionally, land cover and surface conditions can also affect local air quality. For example, wind blowing over recently plowed fields can carry particulate matter to locations downwind.

The amount of aerosols in our atmosphere affects our sky conditions. Most aerosols are too small to see but we can observe their impacts by observing and categorizing sky color and visibility. When sunlight enters the atmosphere, it encounters air molecules (water vapor, oxygen, nitrogen, CO2, and other trace gases) as well as other small particles, known as aerosols. Air molecules and aerosols both scatter the light; the color blue is scattered most effectively, causing the sky's blue color. In large enough concentrations, aerosols can change the appearance of the sky, affecting color and visibility. A perfectly clear sky will be deep blue in color and very clear in visibility. When many aerosols are suspended in

Air Quality Index

AQI Category and Color	Index Value	Description of Air Quality
Good Green	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate Yellow	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.
Unhealthy for Sensitive Groups Orange	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Unhealthy Red	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy Purple	201 to 300	Health alert: The risk of health effects is increased for everyone.
Hazardous Maroon	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

the atmosphere, the color will look pale or milky and the visibility will become extremely hazy. Other atmospheric conditions can impact color and visibility. High relative humidity can also make the sky appear more milky. Visibility can also be impacted by fog. Some atmospheric conditions may even make the sky obscured, such as when there is a high level of ash from a forest fire.

Why is knowing about air quality important?
The greatest health risks from air pollution are caused by ground level ozone and particulate matter. Particulate matter, particularly PM smaller than 2.5 microns, can aggravate asthma, and, according to the EPA, can cause “decreased lung function and increased respiratory symptoms”.

How are Aerosols Studied?
Aerosols, including PM2.5, are measured in two ways: by satellites in space and by instruments on the ground (Aeronet). Many of these measurements are of Aerosol Optical Thickness (AOT), sometimes referred to as Aerosol Optical Depth (AOD), which determines how sunlight is being affected by particulate matter in the air. Measurements of AOT made from space can be compared to measurements made with ground-based instruments (including instruments used by research and community scientists). Additionally, since aerosols scatter and reflect sunlight as it travels through the atmosphere, large amounts of aerosols can sometimes be mistaken for clouds by satellites. Observations of clouds, sky color and sky clarity by observers on the ground can help to validate satellite observations.

NASA has a fleet of Earth-observing satellites whose instruments observe our planet's oceans, biosphere, and atmosphere. Several of these satellites have instruments that observe air pollutants around the world. This includes Aqua, Terra and CALIPSO. The data collected are being used by air quality managers and researchers studying the impact of air pollution on human health and agriculture and Earth’s energy budget.

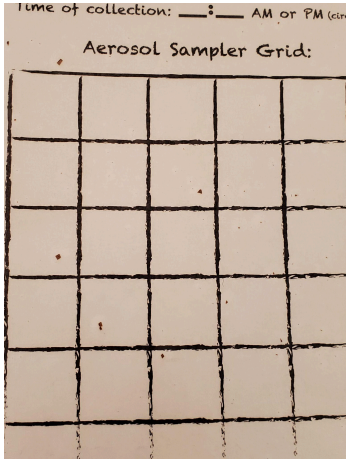
While the satellites deployed by NASA and worldwide space agencies give us a big picture of what’s happening on Earth, they struggle at times to provide a detailed analysis of what's happening in specific locations. That's why it's so crucial for researchers to have ground truth data gathered from the Earth's surface. The GLOBE Program is NASA's largest and longest lasting citizen science program about the Earth. Through the program's GLOBE Observer app, you can submit cloud and sky reports and photograph what you see. After you submit your observations, the NASA GLOBE Clouds team at NASA Langley Research Center compares your observations with satellite data and the results of the comparisons are sent to you via a NASA personalized email.

Air Quality (Aerosols) One-Week Pacing Guide

Activities		Assessment Options
Day 1: Observe Your Sky ● Watch Climate Mission Secrets of Aerosols and Clouds Animation ● Observe ***and track for the week*** using the Visibility and Sky Color Data Sheet to use on Day 5. ● Look up and record the Air Quality Index for the day in the comments column. *(This may be done by the instructor if necessary.)* *Optional:* If time permits, students may also use the GLOBE Observer App or GLOBE Clouds Data Sheet to record sky observations on any day and submit the data.. **Materials:** ● Visibility and Sky Color Data Sheet **Only make observations if you can do so safely and legally.**		● Within groups, develop consensus on observations using evidence. ● Record observations on Visibility and Sky Color Data Sheet. ***Connection to guiding question:*** *What did the sky look like when you made your observation?* ***Answer:*** *Accept reasonable responses. Answers will vary depending upon the conditions at the location.* Optional Instructional Video: How to use the GLOBE Observer Clouds Tool

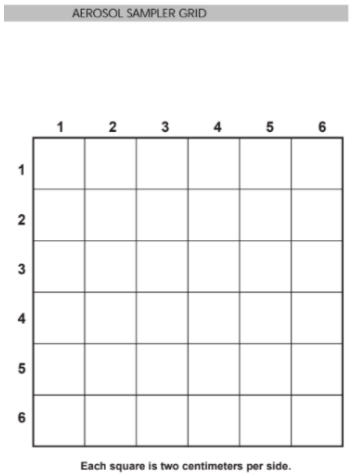
Air Quality (Aerosols) One-Week Pacing Guide

<table>
<tr><th colspan="2">Activities</th><th>Assessment Options</th></tr>
<tr><td>Day 2: Atmospheric Detectives
● Complete STEP 1 only. Students build the particle sampler and set it up to collect aerosols.
○ If weather does not permit outside placement, consider different locations in the school.
○ They should be left out for at least two hours. The instructor can collect them prior to Day 3 to save time.
● While placing the sampler outside, make the observations for the Visibility and Sky Color Data Sheet.
● Record the Air Quality Index.

Materials: Listed in the activity</td><td> 
</td><td>● Completed particulate samplers

Connection to guiding question: What do you think you might find on the aerosol sampler?
Answer: Accept reasonable responses.

Optional Instructional Video: What's Up in the Air? demonstrates how to make a similar version of an aerosol catcher and discusses some options for how to use it.</td></tr>
<tr><td>Day 3: Atmospheric Detectives
● Complete STEPS 2 and 5 of the activity. The objective is to find evidence of aerosols in the atmosphere.
● Observe sky color and visibility for the day and record it on the Visibility and Sky Color Data Sheet.
● Record the Air Quality Index.

Materials: Listed in activity</td><td> 
</td><td>● Step 5 analyzing the Data Questions 1-5 only. Graphs of different samplers are optional. Answers are provided in the master activity.

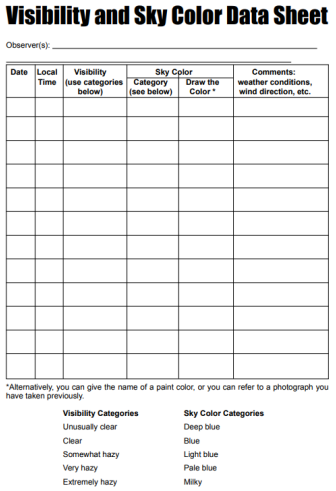
Connection to guiding question: How could the aerosols collected have arrived at your location?
Answer: They could come from local sources or be transported by wind.</td></tr>
</table>

Air Quality (Aerosols) One-Week Pacing Guide

<table>
<tr><th colspan="2">Activities</th><th>Assessment Options</th></tr>
<tr>
<td colspan="2">Day 4: Sky Color & Visibility
● Choose one of the following options:
○ Sky Color and Visibility Online
○ Sky Conditions Hands-on. This can be done with plain blue paper rather than the form provided.
● Observe sky color and visibility for the day and record it on the Visibility and Sky Color Data Sheet.
● Record the Air Quality Index.

Materials: Listed in activities.</td>
<td> 
</td>
<td>● Completed activities
○ Sky Color and Visibility answers in online teacher key
○ Sky Conditions answers provided in master activity.

Connection to guiding question: How do aerosols affect sky color and visibility?
Answer: When more aerosols are present, the sky color will be a more pale shade of blue. In addition, visibility will decrease as there are more aerosols.</td>
</tr>
<tr>
<td colspan="2">Day 5: Summarize Results and Look for Patterns
● Analyze GLOBE Sky Color and Visibility summary data for four days.
● Watch NASA Worldview visualization of smoke transport across long distances.

Materials: Listed in activities.</td>
<td> 
</td>
<td>● Summarize results, and compare with AQI that was recorded during the week.
● Answer the questions for understanding in the Sky Color and Visibility activity. Answers will vary depending on local conditions.
● After watching the visualization, answer the question: What does it mean that aerosols can be transported such long distances? Answer: Activities and events can have far reaching effects.</td>
</tr>
</table>

		Connection to guiding question: *Were there differences in your local sky during the week that may have been due to aerosols? If so, what were they? If not, what would you expect if there were high levels of aerosols in your area?* ***Answer****: Accept reasonable responses. If there were high levels of aerosols, the sky would likely be a paler shade of blue than on a very clear day when the sky can be deep blue.* ***Connection to NASA:*** *How and why does NASA study aerosols?* ***Answer:*** *NASA uses ground based instruments (Aeronet) and satellites to study aerosols. This is done to help monitor air pollution for health impacts and to study the effects of aerosols on Earth's energy budget.*

Air Quality (Aerosols) One-Week Pacing Guide

Additional Resources		
Online Activities	Audience	Description
My NASA Data Cloud Sort	Grades 3 - 8	Learn about the different cloud types and their names. Match cloud photos and names by cloud type and for all types and evaluate the types of clouds represented in various data displays.
My NASA Data Modeling Cloud Cover	Grades 3-12	This activity will help students better understand and practice estimating percent cloud cover.
Guide to Using NASA Worldview in the Classroom	Grades 6-12	NASA Worldview is a free online visualization tool that is a great launchpad for learners who are new (or veteran) users of satellite data.
AerosolWatch	All	Visualize satellite data for aerosols
Hands-On Activities	Audience	Description
Elementary GLOBE Up in the Air	Elementary	Use this activity to make an aerosol catcher and use it to collect and sample aerosols in your area of choice.
Elementary GLOBE Why (Not) So Blue?	Elementary	Help students understand that aerosols in the atmosphere have an effect on sky conditions, including sky color and visibility.
GLOBE Estimating Cloud Cover: A Simulation	All	Help students better understand percent cloud cover and take more accurate cloud cover observations.
Videos and Reading	Audience	Description
Sources of Aerosols	Ages 10-adult	Animation showing aerosol sources of cities, fires, oceans and deserts , how they mix in the atmosphere and disappear by creating sediment or raining out. Credit: NASA/Goddard Space Flight Center.
An Extra Air Pollution Burden	All	Read the NASA Earth Observatory article about how particulate matter is linked to health.

Air Quality (Aerosols) One-Week Pacing Guide

Additional Resources		
Videos and Reading	Audience	Description
Tracking Volcanic Ash with Satellites	All	Video showing a visualization of the transport of volcanic ash following the Calbuco Volcano in Southern Chile.
EO Kids Cleaning Up Our Air	Ages 9-14	NASA EO (Earth Observatory) Kids is written for audiences aged 9 to 14. In this issue, find out about air quality, how NASA studies it from space and what you can do to improve it.
Elementary GLOBE Air Quality Module	Elementary	This module includes a storybook and related activities to explore aerosols and their effect on sky color and visibility.

This work was supported by GLOBE Mission Earth, award No. NNX16AC54A, in collaboration with NASA Earth Science Education Collaborative.