Burning Questions: Fire and Weather Relationships

Unit Overview

This 8th grade and Algebra unit uses weather and wildland fire concepts as the context for graph reading, data analysis, linear and exponential functions, and problem solving. Students will conduct several investigations into concepts about weather (air pressure, relative humidity, and wind), read and present information about fire concepts, and collect and analyze data related to weather events. Technological tools will be used to collect and analyze weather data. The recommended time frame for the complete unit is 15-18 days. This unit could easily be shortened by choosing specific lessons and/or limiting the scope of the various projects/investigations.

Essential Questions	**Major Concepts**
How does weather influence fire? How are wildfires caused and spread?	<u>Science</u> Weather, Human Impact on Natural Resources <u>Technology</u> Sharing information, using graphing tools/calculators (optional) <u>Engineering</u> Designing a process <u>Math</u> Data collection and analysis Linear function relationships Exponential function relationships Writing Graphs Graph Interpretation

Suggested Lesson Sequence

<u>Prerequisites</u>

The lessons in this unit presume that students are familiar with basic data displays such as bar graphs and line graphs, as well as the features of data collection and representation (titles, axis labels, units, etc.). If your students are not proficient with these terms and/or concepts, a lesson teaching these is encouraged before beginning this unit.

This lesson is not intended to be a comprehensive study of weather or wildfire. Instead, basic concepts of weather and wildfire are used to investigate data literacy, linear and exponential functions, and graph interpretation.

Lesson 1 Establishing Context--Weather (one 50-minute lesson)
Lesson Overview: Students will watch a video and teacher demonstrations to understand the basics causes of weather.

Lesson 2, Establishing Context--Fire (one 50-minute lesson)
Lesson Overview: Students will watch a video and teacher demonstrations to understand the fire

triangle and how to reduce/eliminate fire risk.

Lesson 2, Part 2--Weather Data Collection (5-10 minutes per lesson for 2-3 students)
Lesson Overview: A small group of students will collect accurate, local weather data to use in Lesson 9.

Lesson 3 Weather Concept Stations (two 50-minute lessons)
Lesson Overview: Students will complete station activities/investigations to understand relative humidity, air pressure, and wind.

Lesson 4 Fire and Air Quality (two to four 50-minute lessons)
Lesson Overview: Students will learn how air quality is affected by weather and other factors.

Lesson 5 Fire and Lightning (one 50-minute lesson)
Lesson Overview: Students will understand the causes and effects of lightning.

Lesson 6 The Spread of Fire (three 50-minute lessons)
Lesson Overview: Students will understand, graph, and interpret two contributing factors to fire spread.

Lesson 7 Fire Danger Rating Indices (two 50-minute lessons)
Lesson Overview: Students will understand two fire danger rating indices and use them to assess fire danger based on current weather conditions.

Lesson 8 Weather Forecasting (three 50-minute lessons)
Lesson Overview: Students will use collected weather data to create a brief for the Incident Commander of a local wildfire.

Materials, Tools, & Technology

- ☐ computer/tablet/projector
- ☐ 100-watt light bulb
- ☐ six-inch paper circular disk
- ☐ small amount of talcum powder (about 1/2 teaspoon)
- ☐ burner or hot plate
- ☐ pie pan
- ☐ sponge
- ☐ water
- ☐ clock
- ☐ ice cubes
- ☐ clear glass, large-mouth gallon jar
- ☐ glass jar with metal lid
- ☐ modeling clay
- ☐ paper and wood matches

Vocabulary

atmosphere
atmospheric pressure
air currents
evaporation
clouds
water vapor
condense/condensation
fire
fuel
fire triangle
weather
air pressure
relative humidity
wind
moisture

☐ small candle ☐ 5 metal buckets/pans ☐ different-sized fuels (see procedures for details) ☐ sturdy paper cup ☐ index card ☐ straight pin/partially straightened paper clip ☐ sink/bucket/catch basin ☐ crayons/colored pencils/markers ☐ data logger or software ☐ compass ☐ graphing calculator ☐ thermometer ☐ relative humidity sensor ☐ anemometer ☐ barometer	ethical susceptible ozone pollution particle pollution precursor react elevate episode lightning thunder flash-to-bang method precautions fuel topography chain rate unit rate relative humidity temperature constant variable meteorology barometric pressure forecast predict

STEM Professional Involvement Ideas

One or more of these STEM Professionals could be invited as a guest speaker at any appropriate point in the lesson sequence:

- NOAA/NWS Representative
  - NOAA stations employ community relations employees who are trained to give presentations to the public, schools, classes, etc. A NOAA employee could speak to students about weather, forecasting, technology, radar, and other weather-related concepts. Many NOAA stations also give tours and may be able to accommodate a field trip. To find a local NOAA station and contact information, visit the "NOAA In Your State/Territory" page at http://www.legislative.noaa.gov/NIYS/.
- Wildland Firefighter/Incident Commander
  - A firefighter and/or incident commander can speak to students about fire prevention, firefighting, costs of wildfires, the behavior of wildfires, and how weather reports are used in their jobs. To find a local firefighter/incident commander, you can contact your local BLM office, National Forest Service office, and/or rural fire district.

Standards

Science

- **MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.**
- **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.**

Technology

- **Locate, organize and use information ethically from a variety of sources and media.**
- **Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.**
- **Analyze, evaluate, and summarize information or data and report results.**

Engineering

- **MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
- **MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
- **MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

Mathematics

- **Math Practices 1, 2, 3, 4, and 6**
- **S.ID.A Summarize, represent, and interpret data on a single count or measurement variable.**
- **S.ID.B Summarize, represent, and interpret data on two categorical and quantitative variables.**
- **S.ID.7 Interpret the slope and the intercept of a linear model in the context of the data.**
- **F.IF.7E Graph exponential functions, showing intercepts and end behavior.**
- **F.LE.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.**

Notes

For math, this unit focuses on the application of data collection, representation, and analysis for 8th grade and high school data standards. If students are not familiar with basic types of graphs, coordinate graphing, and linear functions, some pre-teaching may be necessary to complete all of the lessons.

For a complete and comprehensive knowledge of the science standards, additional lessons may be necessary.

Appendix List

Appendix A: Student handouts

Establishing Context: What Causes Weather? – Lesson 1

Grade Level: Middle School/ Algebra I	**Time Needed:** (1) 45-50 minute class period	**Subjects:** Science

Objective/ Learning Target: The students will understand that weather is caused by the sun heating the earth and its atmosphere.

Standards:
MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

Background Information:
Weather is the state of the atmosphere (hot, cold, wet, dry, cloudy, sunny, etc.) that we experience each day. The average weather conditions over an extended period of time makes up the climate of a region.

But what causes weather? Why does it rain? What causes the wind? An exploration of the answers to these questions is a good context to explore data collection, representation, and analysis.

Materials:
- ☐ computer/tablet/projector for video
- ☐ 100-watt light bulb
- ☐ six-inch paper circular disk
- ☐ small amount of talcum powder (about 1/2 teaspoon)
- ☐ burner or hot plate
- ☐ pie pan
- ☐ sponge
- ☐ water
- ☐ clock
- ☐ ice cubes
- ☐ clear glass large-mouth gallon jar
- ☐ copies of What Is Weather Exit Ticket

Vocabulary:
atmosphere
air currents
evaporation
clouds
water vapor
condense/condensation

Resources:
See Appendix A for What Is Weather? Exit Ticket

Procedures:
1. <u>Warm-up:</u>
   a. Pose the question “What is weather?” to students.
   b. The students will have private think time for one minute before sharing with an elbow partner or small group.
   c. The group should come up with an answer to write on the board or a large piece of paper.

2. <u>Introductory Video(s):</u>
   a. The students will watch one or more videos/video clips as an introduction to the concept of weather. The following videos are suggestions:
      i. Earth: Climate and Weather – National Geographic – 24hToday https://www.youtube.com/watch?v=zz_CRzcIT-Q
      ii. What is Weather?

https://www.youtube.com/watch?v=G2e273LAcnE

iii. Our World: What is Weather?
https://www.youtube.com/watch?v=UtgFHHhm1xU

3. Teacher Demonstrations:
   a. Visible Air Currents
      i. Turn on the light bulb and allow it to get hot.
      ii. Allow students to feel the *air around the light bulb* but not the bulb itself.
      iii. Sprinkle very small amounts of talcum powder over the bulb and several feet away from the bulb.
      iv. The students will watch the movement of the talcum powder swirling over the light bulb and the movement of the talcum powder farther away from the bulb.
      v. Cut the paper circle along the lines and attach a short length of string to the center.
      vi. Hold the paper swirl over the light bulb.
      vii. The students will observe the motion of the paper swirl over the light bulb.
      viii. Lead the students in a discussion about the demonstrations:
         - Is the bulb hot?
         - Is the air around the bulb hot?
         - What makes the talcum powder swirl in the air?
         - Why didn't the talcum powder farther away from the light bulb swirl in the air?
         - What causes the paper swirl to move?

   b. Rain in the Classroom
      i. Place a pot of water on a burner or hot plate to boil.
      ii. Hold a pie pan with a wet sponge in it above the boiling water.
      iii. The students will watch the bottom of the pie pan to see where and when condensation forms.
      iv. The students will time and record how long it takes for the first raindrop to fall from the pan.
      v. Repeat the experiment with ice in the pan.
      vi. Lead the students in a brief discussion about the demonstration:
         - Compare the times it took for the first raindrop to fall.
         - What reasons can you think of for the difference in times?
         - What was different about the contents of the pan?
         - Why did the pan with the ice create raindrops more quickly?

   c. Clouds in the Classroom
      i. Place a pot of water on a burner or hot plate to boil.
      ii. Hold an inverted large-mouth glass jar over the pot of water to collect hot air as it rises.
      iii. Cover several ice cubes with a wet paper towel and place them on top of the jar.
      iv. When the hot air reaches the cold at the top of the jar, clouds will begin to form.
      v. If the temperature difference is significant enough, raindrops may begin to fall.
      vi. Lead the students in a brief discussion about the demonstration:
         - What forms of water did you see in this demonstration?
         - How did these changes happen?
         - What can you tell about how clouds and rain form?

4. Exit Ticket
   a. The students will complete a brief exit ticket as a reflection of the demonstrations they viewed during the lesson.

Differentiation:

Supports

Students with limited writing skills can be asked to write one answer to each question on the exit ticket.

Assessment Opportunities:

This lesson is designed to provide an introduction to the concept of weather and what causes it. No assessment opportunities were designed in this lesson.

Citations:

Teacher demonstrations adapted from the Southwest Educational Development Laboratory (SEDL): http://www.sedl.org/scimath/pasopartners/pdfs/weather.pdf

The suggested videos were found on YouTube

Establishing Context: What Causes Fire? – Lesson 2

Grade Level: Middle School/ Algebra I	**Time Needed:** (1) 45-50 minute class period	**Subjects:** Science

Objective/ Learning Target: The students will understand the three elements of the fire triangle and explain how eliminating one or more can help prevent or control a fire.

Standards:

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

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.

Background Information:

Fire is a natural event in most forest ecosystems. In fact, some forests depend on fire to recycle nutrients back into the soil and some tree species need high heat to open their cones and release seeds. Fire also opens up the canopy of the forest and provide light to low-lying shrubs and plants.

From an ecological standpoint, fire is neither "good" nor "bad." Fire occurs naturally through lightning strikes. Fires also occur when humans start them either intentionally or accidently.

Fires need heat, fuel, and oxygen to burn—a trio known as the "fire triangle." If you remove any one of the elements of the fire triangle, the fire will not burn.

Weather conditions have a great influence on when fires occur and how they spread. Hot temperatures and dry winds can dry out trees and grasses, making them available as fuel for fires. Wildfires do not usually occur in the winter months when the fuels (trees, shrubs, and grasses) are wet and cold.

Materials:

- ☐ copies of What Causes Fire? Student Handout
- ☐ glass jar with metal lid
- ☐ modeling clay
- ☐ paper and wooden matches
- ☐ small candle
- ☐ 5 metal buckets/pans
- ☐ different-sized fuels (see Procedures for details)

Vocabulary:

fire
fuel
fire triangle

Resources:

See Appendix A for What Causes Fire? Student Handout and map of the Eagle Complex Fire and Weather Data Table

Procedures:

1. <u>Warm-up:</u>
   a. Pose the questions "What things do you think a fire needs to burn?" and "What do you think happens if one of these things is missing?" to students.

b. The students will have private think time for one minute before sharing with an elbow partner or small group.
c. The group should come up with an answer to write on the board or a large piece of paper.

2. Teacher Demonstrations:
   a. Three Elements of Fire: Use a small birthday candle to demonstrate the effects of each of the three elements of the fire triangle.

      Heat

      ix. Mount the birthday candle inside the jar lid using a small piece of modeling clay.
      x. Place the jar lid and candle onto a tabletop. Point out that without heat, there can be no fire.
      xi. Use a match to light the candle.

      Oxygen

      i. Screw the jar onto the lid to cover the lit candle.
      ii. As the flame consumes the oxygen in the jar, the flame will go out. Explain that cutting off a fire's oxygen supply is one way to manage a fire.
      iii. Open the jar, relight the candle, and put the lid back on the jar.
      iv. When the candle starts to go out, reopen the lid to let more oxygen into the jar. The candle will reignite.
      v. Explain that opening the jar lid to let in more oxygen demonstrates what happens when the wind picks up during a fire—it may reignite or burn out of control.

      Fuel

      i. Take the lid completely off and allow the candle to burn until all the fuel (paraffin) is consumed and the fire extinguishes itself. Let students see how long it takes. Point out that without fuel, a fire cannot burn.

   b. Types of Fuel:

      Prior to the lesson, set up five metal buckets/pans filled about halfway with the following fuels:
      #1 – an assortment of different-sized branches, leaves, and needles (all green)
      #2 – an assortment of different-sized dead and dry branches, leaves, and needles
      #3 – an assortment of different-sized dead and dry branches, leaves, and needles that have been lightly sprayed with water before being put into the bucket/pan
      #4 – an assortment of fuels (branches, pieces of wood) all of large diameter (small surface area to volume ratio, so no kindling)
      #5 – an assortment of fuels, all partially burned (from a fireplace or campfire), but not completely consumed.

      vii. Explain to students that as city populations get larger, the boundaries of the city are moved out into wildland areas. Pose these questions to the students:
         - What are the risks in living next to or in wildland areas?
         - How could people reduce the risk of fires in these areas?
         - How could the type of fuel around the homes affect the risk of fire?
      viii. Take students outside and show them the five buckets/pans you prepared earlier.
      ix. Describe what is in each bucket/pan. Tell them that you will try to start a fire in each one.
      x. Have students predict which bucket will be easiest to start, and which will be the most difficult.
      xi. Use matches to try to light a fire in each bucket/pan, one at a time.
      xii. Discuss the results:
         - How did the different fuels affect whether a fire burned?
         - Why do you think the different fuels burned differently?
         - What types of plant material do you think would be best to have around a house that was in a wildland area?

3. Introduce the Project:
   b. Display the map of the Eagle Complex Fire.
   c. Explain that you will be beginning a project in which your family owns a cabin near Hawkins Pass in the Eagle Cap Wilderness. You currently have guests staying with you in the cabin. With no wind, the fire has been spreading 198 feet per hour. You will be providing a weather report to firefighters fighting the fire, and predicting the amount of time you and your guests have until you will need to evacuate the cabin.
   d. If time allows, show students the video about Incident Meteorologists found in the OregonLive article at http://www.oregonlive.com/pacific-northwest-news/index.ssf/2015/09/incident_meteorologist_portlan.html

Differentiation:

Supports

Extensions

Students can research the causes of forest and/or range fires in their state. Students can use this information to create tables or pie charts showing numbers and percentages of fires from different causes.

Have students compare the number, cost, and sizes of prescribed fires in the United States over the past several years. These statistics are available from the National Interagency Fire Center at www.Nifc.gov. Students can make pie charts and graphs of the data to help in their analysis.

Assessment Opportunities:

This lesson is designed to provide an introduction to the concept of fire and what causes it. No assessment opportunities were designed in this lesson.

Citations:

Teacher demonstrations adapted from the "Living with Fire" lesson from *Project Learning Tree: Pre K – 8 Environmental Education Activity Guide*.

Establishing Context, Data Collection – Lesson 2, Part 2

Grade Level: Middle School/ Algebra I	**Time Needed:** 5-10 minutes per day for 2-3 students	**Subjects:** Science, Math

Objective/ Learning Target: The students will understand how to accurately collect and record data about current, local weather.

Standards:

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

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.

Background Information:

Materials:

- ☐ copies of Weather Data Table
- ☐ GPS device/thermometer/anemometer/ barometric reading device

--OR—

- ☐ Vernier LabQuests and assorted probes to measure location, altitude, temperature, wind speed, humidity, and barometric pressure

Vocabulary:

accurate
analysis
data

Resources:

- See Appendix A for Weather Data Table Student Handout

Procedures:

Starting today, send a small group of students (2-3 people) outside to collect weather data each class period. They should collect the weather data in an area away from buildings and wind obstacles. A good location would be the center, or outer edge, of the school's parking lot. The weather data should be recorded in the Weather Data Table (see appendix A) and will be used in Lesson 9 to create the weather report for the Incident Meteorologist of the Eagle Complex Fire.

Differentiation:

<u>Supports</u> <u>Extensions</u>

Assessment Opportunities:

This lesson is designed to collect accurate, local weather data for future use. No assessment opportunities were designed in this lesson.

Citations:

Weather Concept Stations – Lesson 3

Grade Level: Middle School/ Algebra I	**Time Needed:** (2) 45-50 minutes class periods	**Subjects:** Science

Objective/ Learning Target: The students will understand three components of weather: relative humidity, air pressure, and wind.

Standards:

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

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.

Background Information:

We have to have air around us, or we wouldn't be able to breathe. Even though we do not usually feel the air, there are times when the force of the air around us is evident. Examples include the wind that tornados and hurricanes produce. Short of those extremes, though, air pressure can also be felt by holding a hand out of the window of a moving car.

The force of air has to do with differences in air pressure. Some people are more sensitive than others to those differences, resulting in ears popping during elevation changes and aching in joints. Differences in air pressure also influence wind, cloud formation, and help meteorologists predict weather patterns.

Relative humidity is a comparison of the amount of water molecules contained in the air around us to the amount of water that can still be absorbed by the air around us. For example, if the air was completely saturated and could not absorb any further moisture, the relative humidity would be 100%. On the other hand, if there was absolutely no moisture in the air, the relative humidity would be 0%. These two states rarely happen naturally. Instead, the relative humidity exists somewhere in the spectrum between those two extremes on a daily basis.

A simple definition of wind is air moving from areas of high pressure to areas of low pressure in an effort to find balance (or equilibrium), causing an air movement that we can feel. Wind is affected by the Earth's rotation, the temperature, and land masses.

Materials:

- ☐ copies of Air Pressure Investigation Recording Sheet (see Appendix A)

For each group:

- ☐ sturdy paper cup
- ☐ index card
- ☐ straight pin/partially straightened paper clip

Vocabulary:

weather
air pressure
relative humidity
wind
pressure
moisture

- ☐ water
- ☐ sink/bucket/catch basin
- ☐ copies of Relative Humidity Video Response Sheet (see Appendix A)
- ☐ computer/tablet/laptop to view video

Resources:

See Appendix A for Air Pressure Investigation Recording Sheet, Relative Humidity Video Response Sheet

Procedures:

1. Divide the class into small groups of 2-3 students.

2. Divide the groups evenly among the three stations. Each station will take approximately 20-25 minutes but students can be given additional time for discussion and recording on their activity sheets if needed.

3. <u>Station Activities:</u>
   <u>Station A: Air Pressure Investigation</u>
   a. Test #1
      xii. Working over a sink or catch basin, fill a cup with water until it is at the point of overflowing. It is important for the cup to be filled to overflowing so that there is no air in the cup. Place an index card over the top of the cup. Make sure the card is touching the entire rim of the cup.
      xiii. On your recording sheet, in the box labeled "Test #1 Prediction," write what you think will happen when you turn the cup upside down and let go of the index card. Explain *why* you think that will happen.
      xiv. While holding the index card securely to the top of the cup, turn the cup over carefully. Hold the index card firmly to the cup so that no space is between the index card and the cup, but no so tightly that the cup bends. Remove the hand that is holding the index card. Record your observations of what happens in the box labeled "Test #1 Observation."

   b. Test #2
      xiii. Repeat the Test #1 procedure, but only turn the cup sideways (not all the way upside down), holding the card to keep it in place.
      xiv. Remove the hand holding the index card.
      xv. Record your observations of what happens in the box labeled "Test #2 Observation."

   c. Test #3
      vii. Repeat the Test #1 procedure. This time, after turning the cup upside down, carefully use the straight pin or paper clip to make a small hold in the bottom of the cup.
      viii. Remove the pin.
      ix. Record your observations of what happens in the box labeled "Test #3 Observation."

   d. Test #4
      i. Repeat the Test #1 procedure. This time, hold a finger securely over the hole in the bottom of the cup when you turn it over.
      ii. Record your observation of what happens in the box labeled "Test #4 Observation."

   e. Conclusions and Questions:
      i. On the back of the recording sheet, students answer the questions and then write a brief summary paragraph describing what they learned from the investigation they just completed.

Station B: Relative Humidity Video

a. Watch the video: Relative Humidity Demo.
   i. Video link: https://www.youtube.com/watch?v=CL5cgXwKUXc
   ii. Alternate video link: http://ed.ted.com/on/kaBGX46C
b. Complete the Relative Humidity Response Sheet

Station C: Wind Investigation

a. Use the lesson provided by WindWiseEducation and KidWind to set up an investigation about wind. There are several ideas included in the lesson and the teacher should choose an activity/investigation that best fits the needs and dynamics of their students.

Each station will take approximately 20-25 minutes, possibly more if students need extended time to discuss and record answers on their activity sheets. The stations should be started during one class period, put on hold overnight, and then completed the next day.

Differentiation:

Supports

Some students may have trouble holding the upside down cup and may get overly frustrated if the water does not stay in the cup as intended. For these students, an activity with a syringe may be an acceptable substitute.

- Use a small plastic syringe and feel how much pressure it takes to depress the plunger.
- Hold a finger over the opening and try to depress the plunger.
- Hold a finger partially over the opening and try to depress the plunger.

The air inside the syringe will make it difficult to depress the plunger when the opening is covered.

Fewer questions can be assigned to students with below grade-level reading and/or writing ability.

Extensions

Challenge students who finish the activity early to determine a limit for the size of cup for which the phenomenon of unequal air pressure will still allow this investigation to work.

Assessment Opportunities:

The activity/recording sheets can be used as an informal assessment of what students understand about the weather concepts of air pressure, relative humidity, and wind.

Citations:

The air pressure station in this lesson was adapted from "The Pressure's On" lesson in *Project Earth Science: Meteorology* from NSTA

The relative humidity video and response sheet were adapted from a Ted-Ed lesson at http://ed.ted.com/on/kaBGX46C and http://marielombardo.weebly.com/uploads/1/4/0/7/14072560/making_sense_of_relative_humidity.pdf

Fire and Air Quality – Lesson 4

Grade Level: Middle School/ Algebra I	**Time Needed:** (2-4) 45-50 minute class periods	**Subjects:** Science, Math

Objective/ Learning Target:
The students will identify health symptoms associated with specific air pollutants.
The students will understand which segments of the population are most at risk for air pollution.
The students will observe air quality changes and the impact of weather on air quality.
The students will gather and analyze data.

Standards:

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

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.

Background Information:

Breathing clean air is important to maintain our health. Millions of Americans live in areas where the air is sometimes considered unhealthy to breathe because it is polluted. Ground-level ozone is one common type of pollution. The effects of ground-level ozone pollution are different than the effects of the ozone layer high up in the atmosphere, which helps protect us from receiving too much of the sun's ultraviolet radiation. At ground level, ozone can cause breathing difficulties, aggravate lung diseases such as asthma, or cause permanent lung damage. A mnemonic device to help remember the different types of ozone is: "Good up high, bad nearby." Ground-level ozone pollution is formed when pollutants, known as precursors, are released from vehicles, industries, and power plants, and in the presence of sunlight and heat react together to form ozone.

Another common air pollutant is particle pollution, which can cause breathing difficulties, aggravate heart disease as well as lung disease, and may cause chronic bronchitis or reduced lung function in children. Particle pollution consists of tiny particles of dust, dirt, smoke, and liquid droplets that contain chemicals.

Materials:

- ☐ copies of handouts/activity sheets as specified in the lesson at http://www3.epa.gov/airnow/teachers/toolkit/teachers-toolkit-6-8-508.pdf#_ga=1.212119700.143895523.1443581632
- ☐ Internet access via a computer/tablet/laptop
- ☐ crayons/colored pencil/markers

Vocabulary:

ethical
susceptible
ozone pollution
particle pollution
precursor
react
elevate

	episode forecast

Resources:

See http://www3.epa.gov/airnow/teachers/toolkit/teachers-toolkit-6-8-508.pdf#_ga=1.212119700.143895523.1443581632 for all teacher and student resources

Procedures:

Airnow.gov has a comprehensive, dynamic series of lesson plans available to teachers free of charge to teach students about air quality. The lessons are available in grade bands of 3-5 and 6-8. The lessons available in the 6-8 materials are suitable for high school students as well. There is also a teacher resource download available. There are too many lessons to include in this unit, so teachers can peruse the offerings and choose the lessons that best fit the needs and dynamics of their students.

Suggested lesson sequence (from the 6-8 grade band):

- Symptoms Scenario (1-2 class periods)
- Tracking Air Quality (1-2 class periods)

All lessons incorporate science concepts, math skills, and the math practices.

Differentiation:

Supports and Extensions

See http://www3.epa.gov/airnow/teachers/toolkit/teachers-toolkit-6-8-508.pdf#_ga=1.212119700.143895523.1443581632 for a varied list of supports and extensions.

Assessment Opportunities:

The activities in the lessons will serve as an informal assessment of students' understanding of air quality concepts.

Citations:

http://www3.epa.gov/airnow/teachers/toolkit/teachers-toolkit-6-8-508.pdf#_ga=1.212119700.143895523.1443581632

Fire and Lightning – Lesson 5

Grade Level: Middle School/ Algebra I	**Time Needed:** (1) 45-50 minute class period	**Subjects:** Science, Math

Objective/ Learning Target:
The students will understand the weather conditions that cause lightning.
The students will analyze data related to lightning and make inferences.
The students will understand precautionary measures to avoid the danger of lightning and calculate the approximate distance of lightning strikes.

Standards:

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

S.ID.A Summarize, represent, and interpret data on a single count or measurement variable.

S.ID.B Summarize, represent, and interpret data on two categorical and quantitative variables.

S.ID.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

S.IC.6 Evaluate reports based on data.

Background Information:

Lightning is caused when positive and negative charges collect on opposite sides of clouds. When static electricity arcs between the charges, lightning results. The vast majority (90%) of lightning strikes occur within clouds, only 1 in 10 lightning strikes arcing to the ground.

While lightning is spectacular when viewed from a distance, it is also dangerous. It is one of the leading causes of weather-related deaths in the United States each year, as well as property damage. Being familiar with the properties of lightning, and its relationship to thunder, can guide the precautions necessary to minimize the risk of lightning strikes.

Materials:

- ☐ copies of the reading "Inner Workings of Severe Weather" from *Project Earth Science: Meteorology*
- ☐ copies of "Flash! Bang!" Reading Handouts A-C

Vocabulary:

lightning
thunder
thunderstorm
flash-to-bang method
precautions

Resources:

See Appendix A for Flash! Bang! Handouts A-C

Procedures:

1. Introductory Video(s):
   a. The students will watch one or more videos/video clips as an introduction to lightning. The following videos are suggestions:
      i. How lightning forms (a clip of a Discovery Channel documentary) https://www.youtube.com/watch?v=jM8h60S1GsM
      ii. Weather and Meteorology: What Causes Lightning? https://www.youtube.com/watch?v=BPDHCBqtPuo
      iii. What Causes Thunder and Lightning? By 60 Second Science https://www.youtube.com/watch?v=0n6lwlTtz-4
      iv. EXTREME Close Lightning in HD Compilation (video of real thunder/lightning) https://www.youtube.com/watch?v=Sp9bKDHRfsM

2. Flash to Bang Reading:
    a. The reading is divided into three sections. If there are more than three groups of students, assign the same section to multiple groups.
        i. Section A: Introduction, Deaths from Severe Weather, Lightning, Thunder, and Some Precautions
        ii. Section B: Lightning and People, Lightning and Property, and Some Precautions
        iii. Section C: The Lightning Flash, The Thunderstorm, and Some Precautions
    b. Distribute copies of the reading, Flash to Bang, from *Project Earth Science: Meteorology* and the Flash! Bang! Reading Handouts.
    c. The students, in their groups, will complete the reading, highlighting important information and taking notes as they read.
    d. The students, in their groups, will write complete the questions on the handout.

3. Jigsaw Presentations:
    a. Divide the students into groups that contain one student assigned to each of the three readings.
    b. Each group member will share their presentation and answer clarifying questions from other students.

Differentiation:

Supports

Students with low reading skills may be paired with students of higher reading ability. Alternatively, students with lower reading ability may be paired together and assigned an abbreviated section of the reading, the questions, and the presentation.

Assessment Opportunities:

The questions on the handouts and the jigsaw presentation will informally assess the student's understanding of the concepts addressed in this lesson.

Citations:

The reading "Flash to Bang" can be found in *Project Earth Science: Meteorology* from the NSTA.

The Spread of Fire – Lesson 6

Grade Level:	Middle School/ Algebra I	**Time Needed:**	(2-3) 45-50 minute class periods	**Subjects:**	Science, Technology, Math

Objective: Students will use mathematical models to understand how the weather factors of wind speed and direction influence fire behavior.

Standards:

Science

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

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.

Math

Math Practices 1, 2, 3, 4, and 6

S.ID.A Summarize, represent, and interpret data on a single count or measurement variable.

S.ID.7 Interpret the slope and the intercept of a linear model in the context of the data.

Background Information:

Fire Behavior is defined as the manner in which fuel ignites, flame develops, and fire spreads as determined by the interaction of fuel, weather, and topography.

Weather conditions such as wind, temperature, and humidity contribute to fire behavior. Wind is one of the most important factors because it can bring a fresh supply of oxygen to the fire as well as push the fire toward a new fuel source.

Temperature of fuels is determined by the ambient temperature since fuels attain their heat by absorbing surrounding solar radiation. The temperature of a fuel influences its susceptibility to ignition. In general, fuels will ignite more readily at high temperatures than at low temperatures.

Humidity, the amount of water vapor in the air, affects the moisture level of a fuel. At low humidity levels, fuels become dry and, therefore, catch fire more easily and burn more quickly than when humidity levels are high.

Rate of Spread is an index that measures how quickly a fire will grow. It is the relative activity of a fire in extending its horizontal dimensions. It is expressed as rate of increase of the total perimeter of the fire, as rate of forward spread of the fire front, or as rate of increase in area, depending on the intended use of the information. Usually it is expressed in chains or acres per hour for a specific period in the fire's history.

Chain: Unit of measure in land survey, equal to 66 feet (20 M) (80 chains equal 1 mile). Commonly used to report fire perimeters and other fire-line distances, this unit is popular in fire management because of its convenience in calculating acreage (e.g., 10 square chains equal one acre).

	The general rule is that rate of spread will double with each increase of 4 meters per second of wind speed. Rate of spread is an important fire behavior characteristic for two reasons. First, it contributes to how large the wildfire can become during a specified period of time, and that in turn influences the likelihood that a wildfire will reach certain places of concern on a landscape. Second, rate of spread is a significant factor affecting fire-line intensity and flame size, which are important for determining fire effects.
Materials: ☐ data logger or software ☐ anemometer ☐ compass ☐ graphing calculator ☐ tablet or computer ☐ spreadsheet application	**Vocabulary:** fuel topography chain rate unit rate

Resources:

See Appendix A for student resources and reproducibles:

Weather Data Table — How Does Wind Speed Impact Fire Behavior in Meters per Second

How Does Wind Speed Impact Fire Behavior in Miles per Hour — Eagle Complex Task

Procedures:

Day One:

1. Divide class into small groups of 2-3 students.

2. Distribute copies of the Wind Speed Handout to each group. Two version of the handout are available: one using metric units that includes conversion questions, and one using English units that does not include conversion questions.

3. Circulate while students work, answering questions and prompting rich discussion about math concepts as related to the spread of fire.

4. Facilitate a class discussion about the spread of fire related to wind speed.

Day Two:

1. Distribute copies of the Eagle Complex Task.

2. Students can work individually or in their small groups, as desired by the teacher.

Day Three (optional):

1. Distribute copies of the Illuminations lesson about Slope of Terrain found at https://illuminations.nctm.org/uploadedFiles/Content/Lessons/Resources/9-12/SmokeyBear-AS-

Rules.pdf

Differentiation:

Suggested Supports	Extension Suggestions
Lower grade students can draw a grade-appropriate polygon around the fire perimeter before and after spread and calculate area of original and new polygons and then the increase in number of acres burned.	Students can do more research using the unit of chain and use this unit to calculate the increase in number of acres burned. Students can calculate wind direction into degrees.
Upper middle school students can work within the context of ratio and rate and rate conversion.	Wind speed can be converted into knots or can be estimated using Beaufort scale.
Jr. high students can work with equations, functions, bi-variate data, and trendlines High school students can work with functions, bivariate data, and trendlines.	
Technology applications/extensions include using Data loggers and probes, use of cloud-based spreadsheet applications, and use of function & charting applications available in spreadsheets.	
Online calculators can be used to convert between units.	

Assessment Opportunities:

Student Resource 3B can be used as a Performance Task opportunity

Citations:

http://illuminations.nctm.org/Lesson.aspx?id=1428

https://illuminations.nctm.org/uploadedFiles/Content/Lessons/Resources/9-12/SmokeyBear-AS-Rules.pdf

Fire Danger Rating Systems – Lesson 7

Grade Level: Middle School/ Algebra I	**Time Needed:** (1-2) 45-50 minute class periods	**Subjects:** Science, Technology, Math

Objective: Students will understand two fire danger rating systems.
Students will be able to assess fire danger based on current weather conditions.

Standards:

Science

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

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.

Math

Math Practices 1, 2, 3, 4, and 6

S.ID.A Summarize, represent, and interpret data on a single count or measurement variable.

S.ID.7 Interpret the slope and the intercept of a linear model in the context of the data.

Background Information:

Wildfire is the term applied any unwanted and unplanned fire burning in the forest, shrub, or grasslands.

Fire danger is the combination of both constant and variable factors that affect the initiation, spread, and difficulty of controlling a wildfire in an area. There are many system and schemes that attempt to provide accurate and reliable predictions of fire danger.

Fire behavior is defined as the manner in which fuel ignites, flame develops, and fire spreads as determined by the interaction of fuel, weather, and topography.

Relative humidity is a measure of how much water vapor is in the air. Relative humidity is the percent of water vapor in the air compared to what would be present if the air were saturated. Fully saturated air is fog. Relative humidity is always expressed as a percentage. Fires start more easily in conditions of low humidity. High humidity works against a fire. Generally, as temperature goes up, relative humidity goes down and vice versa.

Materials:

- ☐ data logger or software
- ☐ thermometer
- ☐ relative humidity sensor
- ☐ graphing calculator
- ☐ tablet or computer
- ☐ spreadsheet application

Vocabulary:

relative humidity
temperature
constant
variable

Resources:

See Appendix A for the The Angstrom Index (High and Low)
See the National Park Service's *Fire and Aviation Management* webpage for teacher resources including more detailed content information

http://www.nps.gov/fire/wildland-fire/learning-center/fire-in-depth/understanding-fire-danger.cfm

Procedures:

Day One:

1. Read Understanding Fire Danger (Teacher Resources).

2. Distribute copies of the Angstrom Index handout. Two versions of this handout are available.

3. Analyze weather data and calculate/estimate fire danger using weather data and Angstrom Index (detailed instructions on the Angstrom Index handout).

Day Two (optional):

1. Distribute copies of the Nesterov Index handout from Illuminations found at https://illuminations.nctm.org/uploadedFiles/Content/Lessons/Resources/9-12/SmokeyBear-AS-NesterovIndex.pdf.

2. Analyze weather data and calculate/estimate fire danger using weather data and the Nesterov Index (detailed instructions on Nesterov Index handout)

Differentiation:

Supports

Lower grade level students can practice working with decimals and order of operations to calculate the Angstrom Index for various temperature and RH measures.

Upper middle school students can work within the context of ratio and rate.

Jr. high students can work with equations, functions, bi-variate data, and trendlines

High school students can work with functions and inequalities

Technology applications/extensions include using data loggers and probes, use of cloud-based spreadsheet applications and use of function & charting applications available in spreadsheets.

Extensions

Nesterov Index - Research weather data archives and use information to determine fire danger.

Research and report out on the history of Fire Danger Rating Systems.

Research and explain other indices – Haines Index or Hauling Chart.

Citations:

http://www.nps.gov/fire/wildland-fire/learning-center/fire-in-depth/understanding-fire-danger.cfm

http://ocw.usu.edu/Forest__Range__and_Wildlife_Sciences/Wildland_Fire_Management_and_Planning/Unit_4__Temperature-Moisture_Relationship_4.html

http://illuminations.nctm.org/Lesson.aspx?id=1428

Weather Forecasting – Lesson 8

Grade Level:	Middle School/ Algebra I	**Time Needed:**	(3) 45-50 minute class periods	**Subjects:**	Science, Technology, Math

Objective: Students will understand the elements of a weather forecast as given by an Incident Meteorologist assigned to a wildfire.
Students will be able to collect weather data and create a brief for an incident commander.

Standards:

Science

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.

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.

Math

Math Practices 1, 2, 3, 4, and 6

S.ID.A Summarize, represent, and interpret data on a single count or measurement variable.

S.ID.7 Interpret the slope and the intercept of a linear model in the context of the data.

Background Information:

In general, weather forecasts begin with observations of what the weather is doing all over the world. These observations are then fed into super computers that use mathematical models of the atmosphere to make predictions.

In meteorology, one of the important implications is that small differences in the initial conditions of the atmosphere can lead to big differences in the weather that results only a few days later.

Atmospheric pressure is the pressure above any area in the Earth's atmosphere caused by the weight of air. Barometric pressure is also known as air pressure or atmospheric pressure and derives its name from the instrument used to measure it called a barometer.

Two things affect the barometer's reading: the high or low air pressure caused by weather, and the air pressure caused by the station's elevation (how high it is above sea level).

Atmospheric pressure is measured with several different units. The National Weather Service reports surface air pressure in the unit of inches of mercury, (inHg and Hg).

The standard value for atmospheric pressure at sea level (atm) is equal to:
1 atm = 29.92 in Hg (inches of mercury)
1 atm = 760 mm Hg (millimeters of mercury)
1 atm = 1013.20 millibars
1 atm = 14.7 psi (pounds force per square inch)
1 atm = 1013.20 hPa (hectopascals)

When using a weather barometer (usually with a scale range between 28 and 31 inches Hg) at a location

	above sea level, the reading must be corrected back to sea level. This is automatically accomplished when you initially match your barometer's reading to that reported by local TV or radio weather forecasts. These reported readings have already been "corrected" to sea level, thus eliminating any pressure differences due to elevation.
Materials: ☐ data logger or software ☐ anemometer ☐ barometer ☐ compass ☐ tablet or computer ☐ spreadsheet application	**Vocabulary:** meteorology barometric pressure atmospheric pressure forecast predict

Resources:

See Appendix A for Predict the Weather handout

See National Park Service's *Fire and Aviation Management* webpage for teacher resources including more detailed content information

http://www.nps.gov/fire/wildland-fire/learning-center/fire-in-depth/understanding-fire-danger.cfm

Procedures:

Day One:

1. Warm-up:
   a. Read "Incident meteorologist: Portland forecaster brings predicting skills to Canyon Creek fire." http://www.oregonlive.com/pacific-northwest-news/index.ssf/2015/09/incident_meteorologist_portlan.html and/or watch video embedded in article.
   b. Have a brief class discussion about weather forecasting related to wildland fires:
      i. Why is it important to have a weather forecast when fighting a wildland fire?
      ii. What ideas do you have about why wildland firefighters don't just use local weather forecasts from the news or another local source?

2. Review Weather Data:
   a. What patterns do students see?
   b. Does the data collected make sense for the season, locale, etc.?
   c. What are the extremes of the data?
   d. What are the averages of the data?

3. Weather Brief for Incident Commander:
   a. Distribute copies of the Predict the Weather Handout
   b. Have class work in small groups of 2-3 students to complete their data analysis and weather report.

Day Two:

1. Accuracy Analysis

a. The students will analyze the accuracy of their weather report over the past 24 hours.
b. The students will write a 3-4 paragraph summary of their forecasting experience.
    i. How did they decide on their forecast?
    ii. How accurate was their forecast?
    iii. What factors could account for the differences/similarities between their forecast and the actual weather of the past 24 hours?
    iv. What information would they need in order to complete a more accurate forecast for the next 24 hours?

Differentiation:

Supports

Technology applications/extensions include using Data loggers and probes, use of cloud-based spreadsheet applications and use of function & charting applications available in spreadsheets.

Allow students to create a poster, video or podcast of their forecast.

Sample script for creating a weather forecast: http://msfaucettsmeteorologistwebquest.weebly.com/uploads/1/3/0/5/13053155/weather_forecast_script_template.pdf

Extensions

Mathematically convert among different atm units.

Research and explain other indices – Haines Index or Hauling Chart.

Citations:

http://usatoday30.usatoday.com/weather/wforcst0.htm

http://usatoday30.usatoday.com/weather/wfbarrow.htm