SUCCESS
ACADEMY
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Earth and Space Science: Unit 3

Weather and Atmosphere: Lessons

Lesson 1: How Do Meteorologists Use Science to Predict the Weather?

Lesson Objective: Scholars know that weather can be defined by current atmospheric conditions, including temperature, precipitation, humidity, wind, and air pressure. Weather maps present information about these conditions using a common set of symbols. Materials Needed

- For each scholar: computer

Prep

- Materials Prep:
  - Visit **weather.com** and ensure you know how to access all needed information.

What are scholars doing in this lesson?

- Scholars use their prior knowledge to create weather predictions for tomorrow’s forecast. They explore a current weather map to revise their predictions and create a list of questions about weather maps they would like answered.

Do Now

- Follow the **Do Now plan**.

Launch

- Let’s try to predict tomorrow's **weather** and justify your prediction.

Activity

- Scholars record a prediction about tomorrow's weather and explain their reasoning.
- Scholars look up a real weather forecast and current weather map using the **weather.com** website.

[**Tip:** Provide scholars with a zip code, so they can easily find information.]

- Scholars study the parts of the weather report and create an updated forecast.
- Scholars make predictions about how meteorologists create a forecast. They also record questions they have about parts of the weather report or maps that they don't understand.
- As scholars are working, circulate and gauge their prior knowledge about weather reports and forecasting. Ask:
    - When have you watched a weather report before? What kind of information does it usually communicate to people?
    - What evidence might a meteorologist use when creating a weather forecast?

Discourse Debrief experiment/activity:

- Ask: How well were you able to predict the weather? Explain.
- Ask: What information would you need to make a better prediction?
- Ask: What are the parts of a weather report? What about a weather **map**? How is information communicated differently on each?
    - What terms are unfamiliar to you? How could you figure out what they mean?
    - Define **precipitation** and **temperature**.

Make connections to the Essential Question:

- Ask: How do you think meteorologists know what tomorrow's weather will be like?
- Introduce the Essential Question: What scientific understandings allow meteorologists to predict the weather?
    - In this unit, we will study the formation of weather to see whether we can figure out how meteorologists predict it. What is the science behind this ability to predict the weather?

Accountability (Lab Notebook)

1. How do you think meteorologists are able to predict the weather? Include evidence and reasoning to support your.

I think meteorologists use tools to measure the current weather and make hypotheses about what the weather will be in the near future. For example, if they measure the temperature and it is 80°F, they might predict that tomorrow will be 77°F because usually the temperature is pretty similar from one day to the next. Or if they see that there is a rainstorm nearby and the area is getting cloudy, they might predict rain.

Scoring Award points as follows:

1. Score based on the quality of the idea and the evidence for it. Use data to gauge scholar effort and assess prior knowledge.

    - How will you press high fliers to improve their ideas and evidence?
    - How will you help struggling scholars express their ideas?

Lesson 2: Weather vs. Climate

Lesson Objective: Scholars can distinguish between weather and climate and know the terms cannot be used interchangeably. (Weather describes the atmospheric conditions in the moment, and climate is defined by the typical weather patterns in an area over time. Location on Earth has an impact on climate.) Materials Needed

- For the teacher: map showing latitude and longitude
- For each group: Markers, **weather and climate maps of the US**.

[**Materials Management Tip:** Laminate the maps, so scholars can mark them with dry erase markers.]

Prep

- Materials Prep:
    - Prepare to display visuals (such as **these**) to assist in reviewing latitude/longitude.

What are scholars doing in this lesson?

- Scholars analyze sets of data about US climate and weather to understand their difference. They use these definitions to help them understand how meteorologists predict the weather each day.

Do Now

- Follow the **Do Now plan**.

Launch

- During the last investigation, no one predicted that it was going to be a hot day. Why not?
    - You've probably heard the terms <u>weather</u> and <u>climate</u> many times. But what's the difference? Which do meteorologists use when creating a weather forecast?
- Today, we will compare data from multiple maps to determine the difference between weather and climate. Before we begin, let's take a look at the maps together.
    - Elicit from scholars the right place to look for information on a map.

    - Explain that two major factors we will consider when comparing climate and weather are precipitation and temperature.

Activity

- Scholars interpret the maps to determine how weather and climate are different. They should mark the maps with evidence to support their claim.
- Scholars record noticeable patterns in their Lab Notebooks and explain the difference between weather and climate.
- As scholars are working, circulate and collect two work samples. Prepare to discuss in the wrap-up. Ask:
    - What do you notice is similar or different about these maps? How might that help you define climate or weather?
    - Based on these maps, how are weather and climate different?

Discourse Debrief experiment/activity:

- Ask: What is the difference between **climate** and weather?
- Ask: How did your maps help you understand this difference? Have scholars show evidence from their maps when answering this question.
    - Evaluate the ideas and evidence in the scholar work.

Make connections to the Essential Question:

- Ask: How might meteorologists use weather or climate data to create daily forecasts?

Make broader connections:

- Introduce and define **latitude** and **longitude**.

[**Tip:** Ensure that scholars are able to differentiate between degrees of latitude/longitude and the degrees used to measure temperature.]

- Display a **global biome map**. Point out familiar biomes such as rain forests, deserts, and tundras and ask scholars to describe the climate of each.
- Ask: Why do you think different areas have unique climates?
    - What is the connection between latitude/longitude and climate?
    - Define **atmosphere**.
    - Do you think there is a connection between altitude and climate? Explain.

Accountability (Exit Ticket) Li Wei is looking at two maps on the **weather.gov** website: one climate map and one weather map.

1. Which map will look completely different in 24 hours? Explain. [3]

The weather map will look completely different in 24 hours. Weather is just a measure of the current atmospheric conditions in a given location, whereas climate is the average weather conditions over a longer period of time.

2. How does the average annual surface temperature compare in locations with different latitudes? [1]
    1. As latitude increases, the average annual surface temperature decreases.
    2. As latitude increases, the average annual surface temperature remains the same.
    3. As latitude increases, the average annual surface temperature increases.

Scoring

1. Award points as follows:
    - One point for correctly identifying the map that will change (the weather map)
    - One point for evidence from class to support the claim (can explain why the weather map will change and/or why the climate map will not change)
    - One point for reasoning that supports the evidence
2. Award one point for answer A.

Lesson 3: How Does Air Move?

Lesson Objective: Scholars understand that the movement of air is caused by variations in temperature and pressure. As temperature increases, air molecules spread and rise, whereas decreasing temperature makes them condense and fall. Denser air tends to have higher pressure. Air molecules actively spread to fill the space around them evenly, so in areas where the air is not evenly dense (differences in air pressure), the high-pressure area will flow into the lower pressure area, creating wind. Materials Needed

- For the teacher: Clear garbage bag, hair dryer (for demonstration)
- For each group: supply of cold water, supply of warm water, “trash” cup with water (for used incense sticks), 2 soda bottles (connected by a tube), 1 incense stick, 1 long-handled lighter

Prep

- Materials Prep:
    - For each group, cut holes in two bottles and connect them with a small length of plastic tubing as shown in the investigation. “Tubing” can also be constructed from rolled cardstock.
- Intellectual Prep:
    - Review reading material and videos:
        - **The Highs and Lows of Air Pressure** by UCAR Center for Science Education
        - **Children's Misconceptions about Weather: A Review of the Literature** by Laura Enriques, California State University, Long Beach

What are scholars doing in this lesson?

- Scholars use a model to discover why air moves and how variations in temperature and pressure create specific wind patterns.

Do Now

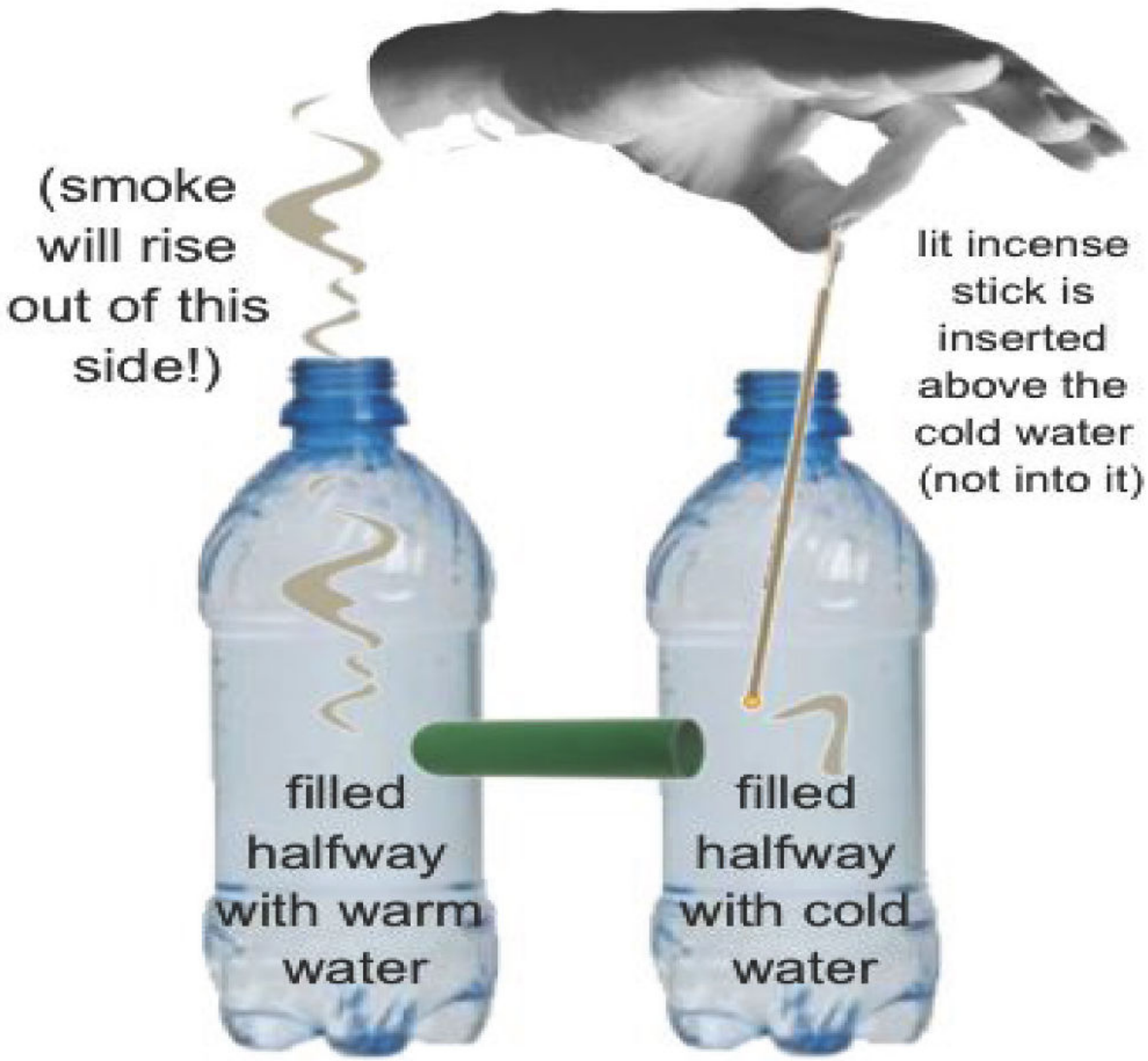
- Follow the **Do Now plan**.

Launch

- Fill a garbage bag with hot air from a hair dryer.
    - Ask: What is happening to the bag? Why do you think that is?
- Explain: Today, you will complete an experiment to learn more about the behavior of airâ€” and what makes the wind blow!
    - Define **air pressure**.

Experiment

- Scholars follow the lab procedure:
    - Pour cold water into the bottle on the left. Fill it halfway, so the water stops just below the connecting tube.
    - Pour hot water into the bottle on the right. Fill it halfway, so the water stops just below the connecting tube.
        - Discuss with your group: Do you think the air over the cold water and the air over the hot water are the same temperature? Why?
    - Light one incense stick by holding it in the flame for 5 seconds. Lift the incense stick. If there is a flame present, gently blow it out, so you can see the orange tip glow. Insert the lit incense stick into the bottle on the right, above the cold water. (Do not allow the incense stick to touch the water because it will burn out.) Instead, hold the stick still about 2 cm above the water. Observe the movement of the smoke from the incense stick.



- Scholars record their observations by writing and/or drawing in their Lab Notebooks.
- Scholars answer the following analysis question in their Lab Notebooks:

    - Where is the smoke moving? Why?

- As scholars are working, circulate and ask them to explain what is causing the smoke to move in the direction that it is. Press them to draw parallels to other similar phenomena, such as **convection** in the Earth's mantle or steam rising from a boiling pot.

    - What is different about both bottles? How might that explain the direction the smoke is moving in?
    - If you put the incense stick in the bottle with the warm water, what do you predict would happen? Why?

Discourse Debrief experiment/activity:

- Ask: What did you observe during the experiment? Why do you think this happened?

- Ask: How does this setup act as a model for what happens in our atmosphere?
- Ask: How does air pressure connect to the movement of air?
    - Explain that when air moves quickly due to differences in pressure, we call it **wind**.
- Explain:
    - Hot air rises, moving molecules upward and leaving behind areas of low pressure.
        - Ask: Why would having fewer molecules lower air pressure?
        - Air naturally moves from areas of **high pressure** to areas of **lower pressure**, just as people do in a subway car! This allows the molecules to space themselves out more evenly.

Make connections to the Essential Question:

- Ask: How might understanding the movement of air help a meteorologist create a weather forecast?

Make broader connections:

- Display a current local weather map. Ask scholars to identify areas of high and low pressure and explain how they know. What symbols are related to air movement and high-/low-pressure areas?

Accountability (Exit Ticket)

1. Air moves from areas of __________ to areas of ___________. [1]
    1. lower pressure, higher pressure
    2. higher pressure, lower pressure
    3. higher longitude, lower longitude
    4. lower longitude, higher longitude
2. A high-pressure center is generally characterized by __________. [1]
    1. warm, dry weather
    2. cool, wet weather
    3. warm, wet weather
    4. cool, dry weather

Scoring

1. Award points as follows:
    - One point for an explanation of the connection between air pressure and the movement of air
    - One point for evidence from the diagram that clearly highlights the differences in air pressure between the two areas
2. Award one point for answer D.

Lesson 4: What Goes Up Must Come Down

Lesson Objective: Scholars know that water reacts predictably to atmospheric changes and affects the weather conditions we experience. As water evaporates into the air when heated, the amount of water vapor in the air increases, causing an increase in humidity. Water also falls to the earth in various forms as precipitation. Materials Needed

- For each group: large glass flask or beaker, ice cubes, water, metal pan, hot plate, 2 sets of tongs, heat-resistant gloves

Prep

- Materials Prep:
    - Perform an experiment to determine the correct quantities of ice and water for scholars to use with the beakers/flasks you have.
    - Make or acquire ice in advance of the investigation.

What are scholars doing in this lesson?

- Scholars use a model to review the steps of the water cycle. They use the model to build understanding of how warm air may affect weather conditions and learn how the water cycle, humidity, and precipitation are connected. (Note: This lesson is intended as a "refresher" of the water cycle. If scholars do not yet know the stages of the water cycle, pause and spend a day introducing the water cycle before proceeding with this lesson.)

Do Now

- Follow the **Do Now plan**.

Launch

- We've learned a little about the movement of air in the atmosphere. Today, we will investigate the movement of water and its connection to the movement and interaction of air.
    - Ask: What do you remember about the water cycle?
    - Ask: How might a meteorologist use the water cycle to predict the weather?

[**Tip:** Scholars studied the water cycle in elementary school and should remember it well. Press them to *connect* their prior knowledge to the new information they learn to deepen their understanding.]

Experiment Adapted from **Exploring Water Cycle Demonstrations** by NASA

- Scholars create the water cycle in a beaker:
    - Scholars heat a beaker of water on a hot plate until steam begins to rise.

    - Using heat-resistant gloves and tongs, scholars hold a metal plate of ice over the rising steam and observe the results. Scholars should continue holding the plate until they see precipitation occurring.

- As scholars finish the lab, they complete the following analysis questions in their Lab Notebook:

    - Create a diagram of the water cycle and label it.
    - During which part(s) of the water cycle is the water the warmest? How do you know? Where is the heat coming from?
    - During which part(s) of the water cycle is the water the coldest? Where does the heat go?

- As scholars are working, circulate and press those who are struggling to make connections between the water cycle and the movement of air on Earth. Ask:

    - Which part of the model represents a typical weather condition you might experience? How?
    - What might happen to the model if we turned down the hot plate? What would this represent in the water cycle? How would this affect the resulting weather conditions?

Discourse Debrief experiment/activity:

- Show a work sample of a labeled water cycle.
- Review the analysis questions from the investigation.
- Scholars evaluate the work sample.

Make broader connections:

- Ask: How might warm air moving into an area affect the weather? What about very cold air? Why?

    - When scholars describe **humidity**, introduce and define the term. Explain that humidity is measured on a **scale** from 0 percent to 100 percent, with 100 percent being the maximum amount of water. When areas reach 100 percent humidity, precipitation occurs.
    - Also define **condensation** and **evaporation**.

Make connections to the Essential Question:

- Ask: If the sky was very cloudy one day, what might you predict about the next day's weather?
- Ask: the humidity is very low, is it likely to rain soon? Why or why not?
- Ask: How does understanding the water cycle help meteorologists predict the weather?

Accountability (Exit Ticket) The graph and table below provide information about the weather conditions in Orlando, Florida, over several hours one day. Florida is bordered by the Atlantic Ocean on three sides.

Weather Conditions for Orlando, FL

Time	Humidity	Precipitation
6:00 AM	21%	None
9:00 AM	43%	None
12:00 PM	65%	None
3:00 PM	88%	None

Current Temperature in Orlando, FL

Time	6:00 AM	9:00 AM	12:00 PM	3:00 PM
Temperature	78°F	85°F	93°F	94°F

1. Based on the weather data above, do you predict that the people in Orlando, Florida, should expect precipitation in the next 24 hours? Include evidence and reasoning to support your response. [3]

Orlando, Florida, should expect to receive precipitation within 24 hours. Over the course of the day, the temperature has increased from 78°F to 94°F, which would create more evaporation. The humidity, in turn, has been increasing, and when it reaches 100 percent, it will likely rain. Because the humidity is already up to 88 percent as of 3:00 PM, rain is likely to occur in the coming hours.

2. As a sample of very moist air rises from sea level to a higher altitude, the probability of condensation occurring in that air sample will ___________. [1]
   1. decrease
   2. increase
   3. remain the same

Scoring

1. Award points as follows:
   - One point for claim (can argue either way but must be supported by relevant evidence)
   - One point for evidence from one or both tables
   - One point for reasoning addressing the relationship between humidity, temperature, and precipitation
2. Award one point for answer B.

Lesson 5: How Air Creates Our Climate

Lesson Objective: Scholars can explain how solar radiation results in unequal heating of the Earth and has a significant effect on the air masses that shape the climate in an area. They also know that air masses can be categorized based on where they form, near poles or equator and over land or over water. The temperature and humidity of an air mass are predictable and help create the climate. Materials Needed

- For each group: **world climate map**, **solar radiation map**, **air mass map**
- For each scholar: computer

Prep

- Materials Prep:
  - Create a digital slide or printable reference sheet that describes the characteristics of each climate found on the **world climate map** for scholars.
  - Create a key for scholars to reference as they study the **air mass map**. (Do not give away the meanings of these wordsâ€” let scholars discuss and discover them during the investigation.) Include the following:
    - M = **Maritime**
    - C = **Continental**
    - P = **Polar**
    - T = **Tropical**
    - A = **Arctic**
    - AA = **Antarctic**
- Intellectual Prep:
  - **What's the Difference between Weather and Climate?** by NASA
  - **Air Masses and Fronts** by Science Clarified

What are scholars doing in this lesson?

- Scholars analyze different maps and explore an interactive website to make connections between solar radiation, air mass, and climate.

Do Now

- Follow the **Do Now plan**.

Launch

- Ask: Why do different parts of the world have different climates? Is it just a coincidence that the coldest air masses are found near the Earth's poles?

- Explain:
    - **Solar radiation** is the energy we get from the sun.
    - An **air mass** is a large amount of air with the same temperature and humidity throughout. Think of it as a giant, uniform air bubble. Air masses can be thousands of miles wide and 10 miles tall!
    - You will study a set of maps to uncover the major causes of global variations in climate. This will help you better understand the work of meteorologists.

Activity

- Scholars examine the climate map alongside the solar radiation map.
    - Scholars record their observations and inferences.
- Scholars examine the climate map alongside the air mass map.
    - Scholars record their observations and inferences.
- Scholars explore the **Climate Types For Kids** website.
    - Scholars begin by reading the “Home” and “5 Causes of Climate” pages, then explore specific climates of their choice to learn more about them.
- As scholars are working, circulate and use scaffolded questioning to coach the scholars who are struggling to draw connections between the maps.
    - What does the solar radiation map tell you about the polar regions of Earth? What kind of climate do you find there? How might solar radiation connect to the climate of the poles?

Discourse Debrief experiment/activity:

- Ask: What patterns exist in global climates?
- Ask: Why do climates differ? What’s your evidence?
- Ask: How does the location where an air mass forms affect its properties?

Make broader connections:

- Explain:
    - Different parts of the world receive different amounts of solar radiation. The number of hours of sunlight as well as the angle at which the sun hits the Earth’s surface contribute to the total amount of solar radiation in an area.
    - Show this **diagram** to support scholar understanding of the different angles at which we receive sunlight.
        - Ask: How do you think the amount of solar radiation affects the average air temperature in an area?

- Ask: At what time of the year do you think we receive the most solar radiation? What about the least? Why?

- Being **landlocked** or **coastal** can affect the climate in an area.
- Air masses vary in temperature and humidity depending on where they form.

Make connections to the Essential Question:

- Ask: Does understanding the factors that affect climate help meteorologists predict the weather?

Accountability (Exit Ticket) [**Note:** Print this Exit Ticket on two pieces of paper and in color, so scholars can reference the maps while they answer the questions.]

Use the maps below to help you answer the questions on the next page. The first map shows the average temperature on Earth's continents throughout the year.

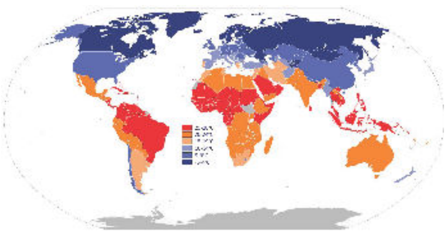


Image Credit: **OchToms, Wikipedia**

The second map shows the average temperature on the surface of the Earth's oceans throughout the year.

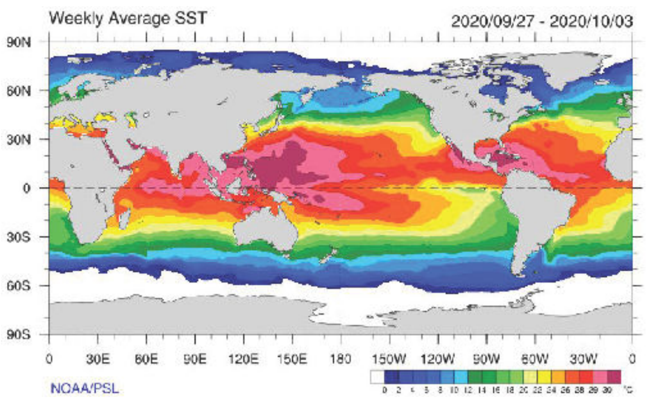


Image credit: [NOAA Physical Sciences Laboratory]

Two scientists were discussing trends they noticed in the two maps:

Dr. Raynor Schein: "*Air and ocean temperatures are warmer near the equator and colder near the poles due to differences in solar radiation.*"

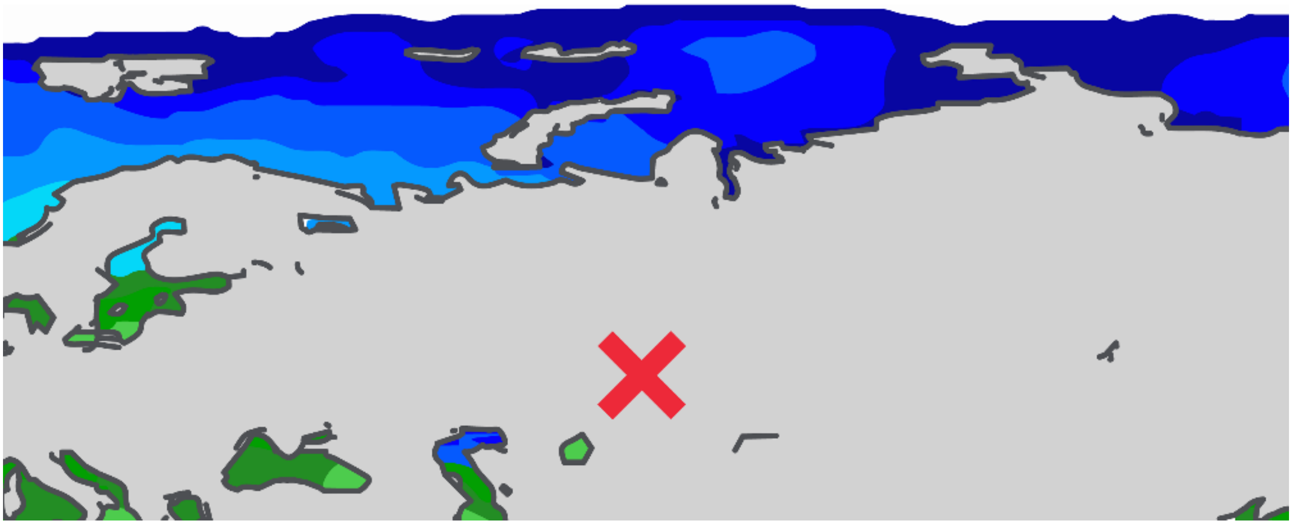
Dr. Augusta Wynd: “*Air and ocean temperatures are colder near the equator and warmer near the poles because the poles have ice and the equator doesn’t.*”

1. Which scientist do you agree with? Include evidence and reasoning to support your response. [3]

I agree with Dr. Raynor Schein because solar radiation causes different areas of Earth to be warmer than others due to the amount of sunlight they receive. Areas closer to the equator tend to be hotter, whereas areas near the poles tend to be colder, and this trend holds true for both land and water. On the first map, the land nearest the equator had the highest average temperatures (around 30°C) and areas near the poles had the lowest (around −30°C). Similarly, on the second map, areas near the equator had the highest ocean surface temperatures (around 30°C), whereas areas near the poles had the lowest temperatures (slightly below 0°C).

2. On the second map, draw an **X** in one location where you might expect to find a cold, dry air mass. [1]

Exemplar:



3. A student observed the following weather conditions in Albany, New York, for two days: <u>The first day was warm and humid with southerly winds. The second day, the temperature was 15 degrees cooler, the relative humidity had decreased, and the wind direction was northwest.</u> Which type of air mass most likely had moved into the area on the second day? [1]
    1. maritime polar
    2. continental polar
    3. continental tropical
    4. maritime tropical

Scoring

1. Award points as follows:
    - One point for indicating agreement with Dr. Raynor Schein
    - One point for evidence from map 1 and map 2
    - One point for reasoning of why solar radiation causes differences in temperature on both land and water
2. Award one point for X marked near the Earth’s poles and over the land (not the water).

[**Note:** It is not always the case that landlocked areas have dry climates, but scholars only have a base-level understanding of climate trends and should not be penalized if they choose a location that has high humidity in reality.]

3. Award one point for answer B.

Lesson 6: Fronts (Two Days)

Lesson Objective: Scholars understand that the movement of air masses creates frontal boundaries that result in changes to weather conditions. When warm air and cold air meet, the warmer air loses heat and some of its water vapor condenses. This forms clouds along the frontal boundary, which will bring precipitation. Commonly seen fronts include cold, warm, stationary, and occluded. Fronts are represented with standardized symbols on a weather map. Materials Needed

- Day One:
    - For the teacher: electric water boiler/other method to heat water
    - For each group: tank, apothecary bottle, warm/hot water (to fill the bottles), cold water (to fill the tank), red and blue food coloring, bucket or drain (for clean up), heat-resistant gloves, tongs
- Day Two:
    - For each scholar: **National Weather Service's Air Masses**, **There Are Four Basic Types of Fronts - Can You Name Them?** by DTN, computer

Prep

- Materials Prep Day One:
    - Preview the current forecast at **weather.com** to prepare for the discussion.
    - Fill the tanks with water the night before. The temperature of the water in the tanks being room temperature from overnight will work for the experiment. (See this **photo** of this experiment for reference.)
    - Ensure you have a small glass apothecary bottle to go with each tank. Having a small electric water boiler to fill the bottles with hot water right before the lab is ideal for this experiment.

[**Materials Management Tip:** Consider how scholars will clean up the tanks after this activity if you have back-to-back classes.]

- Intellectual Prep:
    - **Weather Fronts** by Oklahoma Climatological Survey
    - **What Are Weather Fronts? Video** by Met Office - Weather (5 minutes, 28 seconds)

What are scholars doing in this lesson?

- During day one, scholars explore what happens when two air masses meet using a model. On day two, they deepen their understanding of frontal movement by connecting resulting weather conditions to prior knowledge of the water cycle.

Day One

Do Now

- Follow the **Do Now plan**.

Launch

- Explain: Air pressure varies based on temperature, and air moves from areas of higher pressure to areas of lower pressure. What exactly happens when two of these gigantic air masses meet?
- Explain:
    - There is a finite amount of space in Earth’s atmosphere, so when air masses move around, collisions are common!
    - The boundary between two masses of air is referred to as a front. Many are categorized as a **cold front** or a **warm front**, depending on the movement and relative temperature of the air masses.
    - Today, you will conduct an experiment to see what happens when one of the “collisions” mentioned above occurs.

Experiment

- Scholars have their tank at their group stations and put drops of blue food coloring in. This represents cold air.
- Scholars fill their apothecary bottle with hot water and put drops of red food coloring in. This represents warm air.
- Scholars gently place the apothecary bottle at the bottom of the tank (do not drop it in!).
- Scholars discuss their observations and record drawings in their Lab Notebooks.
- As scholars are working, circulate and press them to answer the following questions:
    - Why do you think the water from the bottle is rising to the top of the tank? What is different about the types of water that would cause such a phenomenon?
    - If we repeat this experiment again, would the same temperature water move to the same place? Why?

Discourse Debrief experiment/activity:

- Ask: What happened when the warm and cold water met? Why?

- Ask: How does this relate to the movement of air?
    - How does **density** affect the movement of air?
- Ask: What would happen if warm air pushed into a cold air mass? What about if cold air pushed into a warm air mass?
    - Read the information on warm and cold fronts on the **Fronts** by CK-12 as a class.
- Explain: Warm air always rises above cold air because of their discrepancy in densities. The bigger the difference in temperature, the more dramatic the rise. When warm and cold air meet, condensation and precipitation occur.

Make connections to the Essential Question:

- Ask: How does understanding what happens when air masses meet help meteorologists predict the weather?

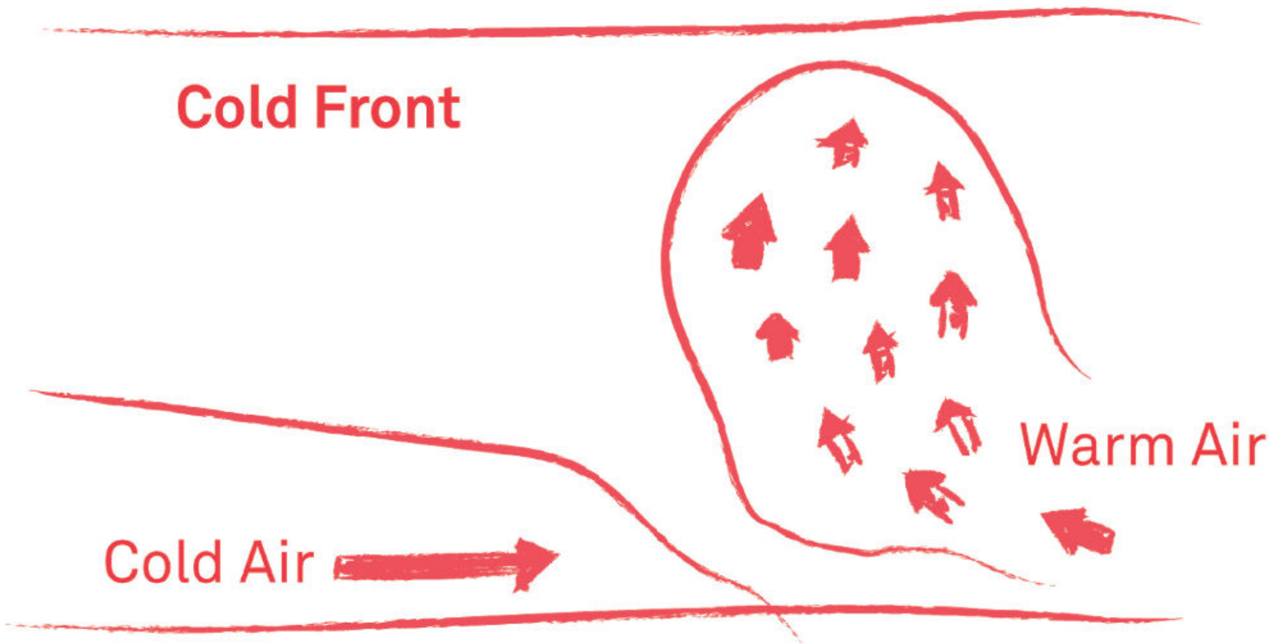
Make broader connections:

- Ask: If hot air rises, why is it colder at the top of a mountain?
- Review **If Heat Rises, Why Does Temperature Decrease at Higher Elevations?** by Scientific American as a class if needed to support understanding.

Accountability (Exit Ticket)

1. Which statement best describes how an air front is formed? [1]
    1. Cold air and warm air swirl together.
    2. Two air masses with the same temperature meet.
    3. Two air masses with different temperatures meet.
    4. Clouds form within an air mass.
2. Draw a diagram to demonstrate what happens during a cold front. Ensure you include the following:
    - Arrows to indicate the direction of air movement [2]
    - Labels to indicate the relative temperature of each mass of air [2]
    - A descriptive title [1]

Exemplar:



3. Why do clouds usually form at the leading edge of a cold air mass? [1]
    1. Cold air contains more dust than warm air does.
    2. Cold air flows over warm air, causing the warm air to descend and cool.
    3. Cold air contains more water vapor than warm air does.
    4. Cold air flows under warm air, causing the warm air to rise and cool.

Scoring

1. Award one point for answer C.
2. Award points as follows:
    - One point for arrows indicating that the cold air is moving in (toward warm air) and sinking
    - One point for arrows indicating that the warm air is rising above the cold air
    - One point for clear labeling of the hotter air mass
    - One point for clear labeling of the colder air mass
3. Award one point for answer D.

Day Two

Do Now

- Follow the **Do Now plan**.

Launch

- After yesterday's experiment, you began to develop an understanding of the way warm and cold air behave when they meet. But how does this affect the weather?
- Today, we will deepen our understanding to bring us closer to answering our Essential Question.

Activity

- Scholars work independently (or in pairs) to read the **air mass reading**.
    - Scholars fill out the graphic organizer in their Lab Notebooks.
- Scholars view **There Are Four Basic Types of Frontsâ€" Can You Name Them?** by DTN and take notes in their Lab Notebooks.
- As scholars are working, press them to apply their understanding to the Essential Question and explain the connection between fronts and weather forecasting.
    - Ask: How is the water cycle involved in the weather conditions caused by frontal movement?

Discourse Debrief experiment/activity:

- Ask: What type of weather does a cold front cause? What about a warm front? Why?
- Ask: What other types of fronts are there?
    - Define **occluded** and **stationary fronts**.

Make connections to the Essential Question:

- Ask: How can we use fronts to predict the weather?
- Ask: How does tracking fronts help meteorologists to predict the weather?

Make broader connections:

- Display a weather map. Ask:
    - Where are the fronts on this map?
    - Point to a specific front. Ask: What is the temperature like on each side of the front (relative to the other side)?
    - Explain the weather associated with that front.
    - Define **weather conditions**.

Accountability (Exit Ticket) The map below shows a recent weather report for the Midwestern United States. Use the map to answer the questions that follow.

1. In the coming hours, is Billings or St. Louis more likely to experience stormy weather? [1]

Billings

2. Was the weather likely warmer in Casper or Omaha at the time of this forecast? Read all statements and place a checkmark () next to the correct statement. [1]

☐ The weather is warmer in Omaha because a warm front just passed through, but the warm front has not yet reached Casper.

✓ The weather is warmer in Casper because a warm front just passed through, but the warm front has not yet reached Omaha.

☐ The weather is warmer in Casper because a cold front just passed through, but the cold front has not yet reached Omaha.

☐ The weather is warmer in Omaha because a cold front is heading towards Casper.

Scoring

1. Award one point for correctly identifying Billings.

2. Award one point for selecting the second statement.

Lesson 7: Our Swirling Atmosphere

Lesson Objective: Scholars can explain how the Earth's rotation causes unique swirling patterns in weather that affect the movement of water and air in the atmosphere. Different parts of the Earth rotate at different speeds, so rather than moving in a straight line, moving air/weather follows a curved course across Earth's surface. The Coriolis effect causes most weather and fronts in the United States to move counterclockwise from west to east. Materials Needed

- For the teacher: globe, 2 push pins or stickers
- For each group: globe, dry erase marker, eraser

Prep

- Materials Prep:
    - Practice the investigation with another adult to get a feel for the correct speed and pressure to use with the marker and globe. Consider how you will model this for scholars.

What are scholars doing in this lesson?

- Scholars explore how Earth's rotation affects air and weather movement using a model and watching a video on the Coriolis effect.

Do Now

- Follow the **Do Now plan**.

Launch

- Display the image at the top of **Coriolis Effect: Air Circulation in the Atmosphere** by EarthHow showing the large wind currents on Earth.
    - Ask: What might create these wind patterns?
    - Explain to scholars that today, they will learn about another phenomenon that affects the weather conditions we experience on Earth: the **Coriolis effect**. (Define this term but do not give away information about its effects on the movement of weather.)

Experiment Adapted from **Coriolis Effect Activity** by Teach Earth Science, (CC BY-NC-SA 4.0)

- Follow the procedure below:
    - Working with a partner, place a globe on a steady, flat surface. Locate the equator, the north pole, and the south pole on the globe.
    - Have your partner rotate the globe in a counterclockwise direction at a slow, steady speed. As the globe rotates, use a marker to gently draw a line from the north pole to

the equator. Sketch the line in circle A in your Lab Notebook. Mark the four compass directions and the equator in your diagram. When you are done, erase the line on the globe.

    - Next, rotate the globe counterclockwise while another group member uses the marker to draw a line from the equator to the north pole. Sketch this line in circle B in your Lab Notebook. Then, add compass directions and the equator. When you are done, erase the line on the globe.
    - Next, rotate the globe counterclockwise while another group member uses the marker to draw a line from the south pole to the equator. Sketch this line in circle C in your Lab Notebook. Then, add compass directions and the equator. When you are done, erase the line on the globe.
    - Next, rotate the globe counterclockwise while another group member uses the marker to draw a line from the equator to the south pole. Sketch this line in circle D in your Lab Notebook. Then, add compass directions and the equator. When you are done, erase the line on the globe.

- Scholars discuss:
    - What happened when you tried to draw a straight line on the globe as it rotated?
    - What patterns do you notice in the appearance of the lines?
- Scholars watch the **Coriolis Effect Video** by National Geographic (2 minutes, 57 seconds) and discuss the guiding questions:
    - How was the ball toss different when the platform was moving? Why?
    - Was the ball actually curving in midair? Explain.
    - How might this connect to the movement of weather on Earth?
- As scholars are working, circulate and press them to explain how the Coriolis effect contributes to weather patterns on Earth.
    - Ask: How might Earth's rotations affect the weather we experience?

Discourse Debrief experiment/activity:

- Ask: What is the Coriolis effect? How does it affect weather on Earth?
- Ask: Why did you have to rotate the globe counterclockwise each time while modeling?
- Explain that different parts of the Earth rotate at different speeds and that this further complicates the weather patterns we experience.
- Demonstrate unequal rotation on Earth by putting push pins or stickers on two spots on a globe with the same longitude (one near the equator, one near the poles). Show scholars how the pin closer to the equator is traveling much farther in the same amount of time.

Make connections to the Essential Question:

- Ask:How do you think the Coriolis effect affects meteorologists' ability to forecast the weather?

Make broader connections:

- Ask: How do you think the Coriolis effect changes the movement of ocean water on Earth?
    - Show **this** diagram of the ocean's surface currents.
    - Revisit the wind pattern **diagram** from the beginning of the investigation. Ask scholars to apply their new understanding to explain the diagram.

Lesson 8: Storm Warning!

Lesson Objective: Scholars understand that especially unstable atmospheric conditions, such as large changes to air pressure, can lead to extreme weather events, and some places are more prone to these conditions than others. Materials Needed

- For each scholar: computer

What are scholars doing in this lesson?

- Scholars study videos on severe weather events and storm formation to deepen their understanding of how the water cycle and atmospheric conditions contribute to weather events.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain: We have a basic understanding of how the movement of Earth's water and air create variations in temperature, humidity, air pressure, and precipitation. But what about extreme weather phenomena, like hurricanes or thunderstorms?
- Ask: How do you think these storms form? And why do you think they're so much more rare than a rainstorm or a snowstorm?

Activity

- Scholars study the videos below and record information about severe weather events and storm formation.
    - **How Do Tornadoes Form? - James Spann Video** by TED-Ed (4 minutes, 11 seconds)
    - **Hurricanes 101 Video** by National Geographic (2 minutes, 51 seconds)
    - **The Coriolis Effect Video** by NOVA PBS Official (3 minutes, 5 seconds)
    - **What Causes Thunder and Lightning? Video** by SciShow Kids (3 minutes, 37 seconds)
- As scholars are working, coach those who struggle to apply their understanding of air circulation from previous investigations to develop new understanding. Press them to determine

the root cause of this issue and provide concrete feedback that will encourage improvement of this important skill. Ask:

  - What causes air to move in a certain way? How does this connect to the formation of storms?
  - Why might we have different types of severe weather? What is different about hurricanes and tornadoes? What might cause severe weather to be different?

Discourse Debrief experiment/activity:

- Ask: What did you learn about how storms form?
- Ask: What do different severe weather events have in common?
- Ask: What might cause severe weather to be different?

Make connections to the Essential Question:

- Ask: How do you think meteorologists predict these storms?

Make broader connections:

- Ask: Why are storms uncommon weather events?

Accountability (Exit Ticket)

- This lesson has no formal Exit Ticket. Informally assess scholar understanding using the notes in their Lab Notebooks.

Lesson 9: You've Got Mail

Lesson Objective: Scholars can explain how climates are created by the patterns in the circulation of air and water that result from unequal heating and rotation of the Earth. Materials Needed

- For the teacher: **Copy of letter**
- For each scholar: **Copy of letter**, lined paper, blank stationery paper (optional), envelope (optional)

What are scholars doing in this lesson?

- Scholars synthesize their knowledge about weather and climate gained throughout the unit as they respond to a letter from a curious second-grade scholar.

Do Now

- Follow the **Do Now plan**.

Launch

- Display Charlie's letter. Explain:
    - You have received a letter from a second-grade scholar. It reads:

Dear SA Scholars,

I am a second grader. I live in New York, and I have a cousin who lives in Nevada. Every time I visit my cousin, it's really hot and dry there. I mean really, really hot! I feel like the whole time I'm there, my throat is parched and I just want water! I know we both live in the same country, so I am really confused about how the climate can be so different there. Please help!

Sincerely,

Charlie

- Explain: You will respond to this letter to explain to Charlie why the climate in Nevada is different than in New York.

Activity

- Scholars plan and write a letter in response to the second-grade scholar.

[**Engagement Tip:** Provide themed stationery paper and an envelope for each scholar to write their finalized "return letter" on.]

- As scholars are working, circulate and press them to synthesize their understanding from throughout the unit to compose a thorough, clear response. Coach scholars who are struggling to convey their understanding in writing. Ask:
    - What might be different about New York and Nevada to cause the climate to be different?
    - Is it possible to live in the same country and have different climates? How?

Discourse Debrief experiment/activity:

- Have scholars peer review.
- Scholars work in pairs to exchange and review their partner's letter.
- Partners summarize and discuss their review.
- Share two letters and review as a class.

Make connections to the Essential Question:

- Ask: How might understanding climate help Charlie predict the weather in New York or Nevada?

Accountability (Lab Notebook) Allow scholars 5–10 minutes to revise their letter based on the conversation the class had during Discourse.

Dear Charlie,

What a great question! The reason you and your cousin experience different weather is because you have a different climate.

Nevada is closer to the equator, surrounded by land, and receives a lot of direct sunlight. This makes Nevada hot and dry. New York is farther from the equator, near an ocean, and receives less energy from the sun. This makes it cooler and wetter than Nevada.

If you look at Map 1, which I included, you can see that Nevada receives close to twice the amount of solar energy that New York gets (2,500 kWh/m^2 vs. 1,200 kWh/m^2) annually! Because their climates are so different, it is more common to experience hot and dry weather in Nevada than in New York.

Sincerely,

SA Scholar

Scoring Award points as follows:

1. Score based on the inclusion of an accurate claim, supporting evidence drawn from knowledge gained throughout the unit and reasoning that helps the letter flow to a logical conclusion. Use scholar letters to assess mastery.

Lesson 10: Lights, Camera, Action!

Lesson Objective: Scholars can explain how our daily weather is affected by the cycling of water through Earth's systems and by the movement and interactions of air masses. Materials Needed

- For each scholar: Current weather map for their date and location

Prep

- Materials Prep:
  - Print a current weather map for your specific region the morning of this lesson.

What are scholars doing in this lesson?

- Scholars use their knowledge to study a weather map and create a forecast of their own.

Do Now

- Follow the **Do Now plan**.

Launch

- Explain: We've reached the end of the unit, and you now know many of the scientific principles behind meteorology. To put you to the test, today, you will take on your final challenge: to study a weather map and create a forecast of your own!
- Show two sample weather forecasts (such as these: **1**, **2**) and allow scholars to take notes on the parts of each forecast.

Activity

- Scholars study the weather map and script out a weather forecast.
- As scholars are working and practicing, circulate and assess their mastery of the unit's goals. Record qualitative data and make a plan to follow up with scholars who need additional support.

Discourse Debrief experiment/activity:

- Select scholars to "perform" their weather forecast for the group. Have the class evaluate the content of each forecast and the supporting evidence.

[**Engagement Tip:** Enlarge the picture that scholars created their forecasts from and display it on a large screen if possible so they can stand in front of it like a real forecaster!]

[**Parent Investment Tip:** Videotape some of the forecasts and send them to families!]

Accountability (Exit Ticket)

1. What scientific understandings allow scientists to predict the weather? Include three pieces of evidence and support your reasoning. [5]

Consider addressing the following in your response:

- the water cycle
- air temperature, pressure, and movement
- solar radiation and latitude
- Earth's rotation

Meteorologists apply their knowledge of weather and climate to analyze current conditions and make short-term predictions about the future. Meteorologists must understand the factors that contribute to weather and the creation of climate to understand the behavior of the air and water on Earth.

Meteorologists must understand the water cycle. This helps a meteorologist predict whether precipitation might be coming to an area soon. Knowing that precipitation follows condensation (cloud formation) is a helpful clue because if they see the skies getting cloudier in an area, they know it is likely that precipitation will follow. They can also apply their understanding of evaporation to predict the humidity in an area.

Meteorologists must also understand how temperature relates to air pressure and movement. Hotter air is less dense and tends to rise, whereas colder air is more dense and sinks. Areas more tightly packed with gas molecules have higher pressure, and this air tends to flow into areas of lower pressure. This can change the temperature, create wind, and bring stormy weather. Earth's rotation causes the Coriolis effect, which allows meteorologists to predict how air will move in specific patterns as it spins.

Understanding these concepts prepares meteorologists to make good predictions about what the weather will be. By applying their understanding of the behavior of water and air in our atmosphere, good meteorologists can judge the likelihood of a number of weather conditions with surprising accuracy. Once you understand the science behind the weather, you too can think like a meteorologist!

Scoring

1. Award points as follows:

    - One point for claim that meteorologists predict the future using their understanding of the large-scale processes behind the movement of Earth’s water and air (or similar)
    - One point for each piece of accurate, relevant evidence that supports the claim and explains how meteorologists make predictions (up to three points)

[**Note:** Scholars do not need to address all points in their response to receive full credit but must include three separate pieces of evidence to support their claim.]

- One point for a concluding sentence or paragraph that summarizes their argument

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Unit Vocabulary

Vocabulary List

- **weather**
- **map**
- **precipitation**
- **temperature**
- **latitude**
- **longitude**
- **climate**
- **atmosphere**
- **air pressure**
- **convection**
- **wind**
- **high-pressure system**
- **low-pressure system**
- **scale**
- **air mass**
- **density**
- **humidity**
- **condensation**
- **evaporation**
- **maritime**
- **continental**
- **polar**
- **tropical**
- **arctic**

- **antarctic**
- **solar radiation**
- **landlocked**
- **coastal**
- **cold front**
- **warm front**
- **occluded front**
- **stationary front**
- **weather conditions**
- **Coriolis effect**