Exploring Weather

Length: 3 lessons

Lesson One: Challenge and Background Reading
Lesson Two: Cloud in a Jar Investigation
Lesson Three: Collecting Weather Data

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North Carolina Standards

4th Grade:

Science:

ESS.4.3.1 Ask questions to infer whether changes in an organism's environment are beneficial or harmful.

ESS.4.3.2 Engage in argument from evidence to explain how humans can adapt their behavior to live in changing environments (e.g. recycling wastes, establishing rain gardens, planting native species to prevent flooding and erosion).

English Language Arts:

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.4.2 Determine the main idea of a text and explain how it is supported by key details; summarize the text.

RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

SL.4.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly.

SL.4.3 Identify the reasons and evidence a speaker provides to support particular points.

Math:

NC.4.MD.4 Represent and interpret data using whole numbers.

- Collect data by asking a question that yields numerical data.
- Make a representation of data and interpret data in a frequency table, scaled bar graph, and/or line plot.
- Determine whether a survey question will yield categorical or numerical data.

5th Grade:

Science:

ESS.5.1.1 Analyze and interpret data to compare daily and seasonal changes in weather conditions (including wind speed and direction, precipitation, and temperature) and patterns.

ESS.5.1.2 Analyze and interpret weather data to explain current and upcoming weather conditions (including severe weather such as hurricanes and tornadoes) in a given location.

ESS.5.1.3 Construct an explanation to summarize the ocean's influences on weather and climate in North Carolina.

ESS.5.1.4 Use models to explain how the sun's energy drives the processes of the water cycle (including evaporation, transpiration, condensation, precipitation).

English Language Arts:

RI.5.2 Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

RI.5.4 Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.

RI.5.8 Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

SL.5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts,
building on others' ideas and expressing their own clearly

SL.5.3 Summarize the points a speaker makes and explain how each claim is supported by reasons and evidence.

Math:

NC.5.MD.2 Represent and interpret data.

- Collect data by asking a question that yields data that changes over time.
- Make and interpret a representation of data using a line graph

NC.5.G.1 Graph points in the first quadrant of a coordinate plane, and identify and interpret the x and y coordinates to solve problems.

North Carolina Standards

6th Grade:

Science:

PS.6.2.1 Use models to compare the directional transfer of heat energy of matter through convection, radiation, and conduction.

PS.6.2.2 Use models to explain how the transfer of heat and resulting change of temperature impacts the behavior of matter to include expansion, and contraction.

PS.6.1.2 Use models to explain the relationship between changes in thermal energy in a substance and the motion of its particles (including phase changes).

English Language Arts:

RRI.6.1 Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

RI.6.2 Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.

RI.6.3 Analyze in detail how a key individual, event, or idea is introduced, illustrated, and elaborated in a text.

SL.6.1 Engage effectively in a range of collaborative discussions (one on one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.6.3 Delineate a speaker's argument and specific claims, distinguishing claims that are supported by reasons and evidence from claims that are not.

Math:

NC.6.SP.1 Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.

NC.6.SP.5 Summarize numerical data sets in relation to their context
- Analyze center and variability by:
  - Giving quantitative measures of center, describing variability, and any overall pattern, and noting any striking deviations.
  - Justifying the appropriate choice of measures of center using the shape of the data distribution

7th Grade

Science:

ESS.7.1.3 Analyze and interpret data to explain the relationship between the movement of air masses, high and low pressure systems, frontal boundaries and weather conditions that may result.

ESS.7.1.4 Use models to predict weather conditions based on observations (including clouds, air masses, fronts), measurements (wind speed and direction, air temperature, humidity and air pressure), weather maps, satellites and radar.

ESS.7.1.2 Use models to explain how the energy of the Sun and Earth's gravity drive the cycling of water, including changes of state, as it moves through multiple pathways in Earth's systems and relates to weather patterns on Earth.

ESS.7.1.5 Use models to explain the influence of convection, global winds, and the jet stream on weather and climatic conditions.

English Language Arts:

RI.7.2 Determine two or more central ideas in a text and analyze their development over the course of the text; provide an objective summary of the text.

RI.7.4 Determine the meaning of words and phrases as they are used in a text; analyze the impact of a specific word choice on meaning and tone.

RI.7.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims.

SL.7.1 Engage effectively in a range of collaborative discussions (one on one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.7.3 Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.

Math:

NC.7.SP.3 Recognize the role of variability when comparing two populations.
- Calculate the measure of variability of a data set and understand that it describes how the values of the data set vary with a single number.
  - Understand that the range describes the spread of the entire data set.
- Informally assess the difference between two data sets by examining the overlap and separation between the graphical representations of two data sets

Materials List:

Lesson One:

- Large glass beaker (1 per workstation)
- Small plastic cup (1 per workstation)
- Tape
- Plastic wrap
- Hot plate (1 per workstation)
- Any other various lab supplies to act as decoy**s**
- Copies of the reading
- Reading guide/reading notebooks

Lesson Two:

- Beaker
- Water
- Hot plate
- Matches (or hairspray)
- Ice
- Metal tray/bag to place on top of beaker
- Research activity lab sheet

Lesson Three:

Thermometer:

- Clear Plastic Straw
- Ruler
- Fine-tipped permanent marker
- Narrow-necked plastic bottle with lid
    - (small bottles used for food-coloring or vanilla extract work best)
- Water
- Rubbing Alcohol
- Food coloring (just a few drops)
- Modeling clay
- Pipette

Barometer:

- Small coffee can or empty food can
- Balloon
- Scissors
- Tape
- Drinking straw
- Index Card or sturdy piece of paper
- Rubber band

Anemometer:

- Scissors
- 5 cups (such as dixie or solo cups), one should be of a different color or easily discernible
- Pen
- 2 strips of stiff cardboard/wooden dowels
- Ruler
- Stapler
- Push pin
- Pencil with an eraser on the end
- Watch with a second hand or a timer.
- Calculator

Raspberry Pi:

- Raspberry pi
- Monitor, keyboard, mouse
- MPL3115A2 sensor

Lesson One: Challenge and Background Reading

Lesson Overview: Students will understand that thermal energy is the driving force behind the water cycle and that the cycling of water is connected to weather patterns.

Challenge	20 minutes	Students use the principles density to stack different object on top of one another in a beaker full of liquid.
Reading	20 minutes	Students individually read the attached artcie dicussing extreme weather
Reading guide	10 minutes	Students work in pairs or small groups to complete the attached reading guide
Lesson Wrap Up	10 minutes	After students have completed their background reading, review their answers to number six. Record the questions that students have on sticky notes, group similar questions together and display in the room. Have the students brainstorm one driving question to write at the top of the poster. If students are struggling to think of a question provide guidance along the lines of: **How does energy from the sun impact the weather we experience.**

Challenge: Density Layers

Objective: Students use the principles density to stack different object on top of one another in a beaker full of liquid.

Materials:

- Large glass beaker (1 per workstation)
- Water
- Corn Syrup
- Vegetable oil
- Tape
- plastic bottle cap
- grape
- metal nut
- piece of sponge

Challenge Set Up:

- Place an empty beaker at each table along with the nut, grape, bottle cap, and sponge.
- Place all other liquids, as well as any decoy supplies on a designated materials table

Challenge Procedure:

- State the goal of the challenge:

Fill the beaker with liquid and then place the objects in the beaker so that they float one on top of the other in a column.

- Explain any addition rules (no talking, only one person can move, ect)
- Provide ten minutes of work time
- At the end of ten minutes, have a successful group demonstrate their solution,
  - if no group is successful, demonstrate the correct solution

Challenge Solution

- Place a layer of corn syrup at the bottom of the beaker
- Pour a layer of water on top of that
- Top with a layer of vegetable oil
- Gently drop the objects into the beaker and observe which layer they stop at.
  - Nut sinks to bottom, grape rests on top of corn syrup, bottle cap on top of water and sponge on top of oil.

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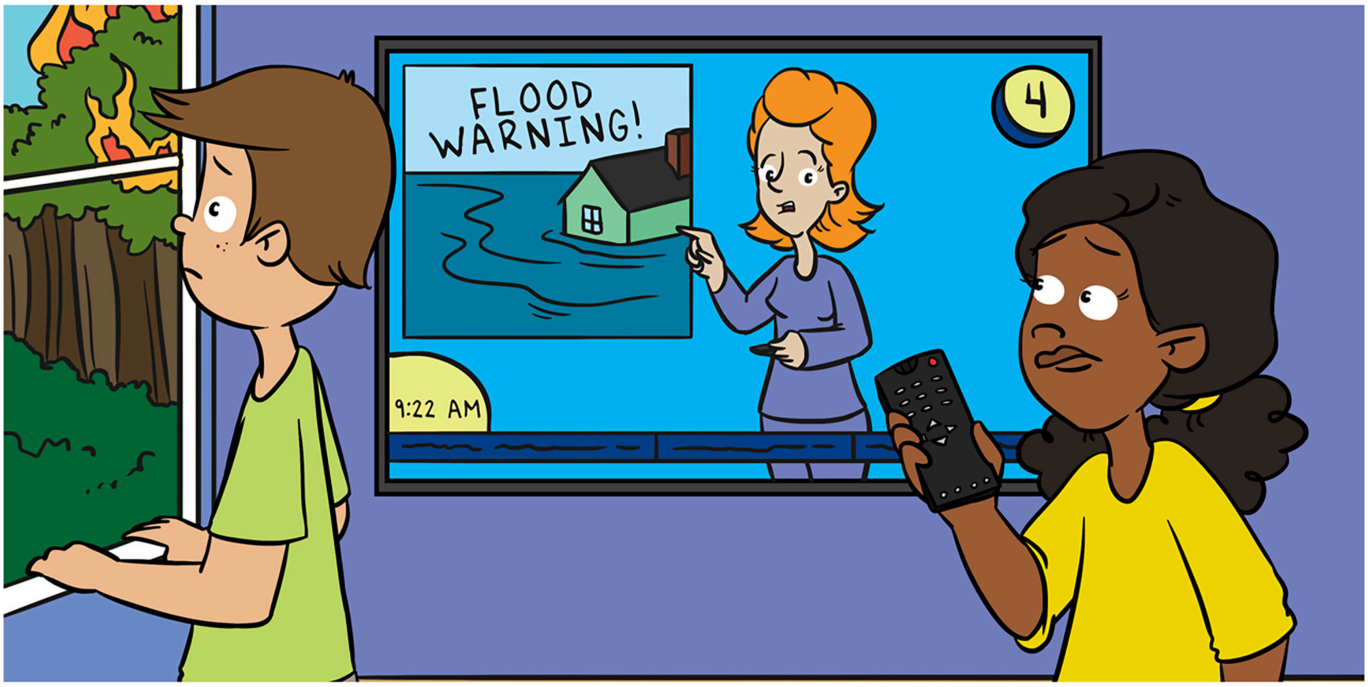

EXTREME CLIMATE AND WEATHER EVENTS IN A WARMER WORLD

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YOUNG REVIEWERS:

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AGE: 14

HAYTAM
AGE: 14

KATELYN
AGE: 13

Extreme climate and weather events are unusual and rare events that often cause a lot of damage both to nature and to people. They take place in the air (storms, tornadoes, heavy rain, atmospheric rivers), in the ocean (storm surges, marine heatwaves), and on the land (wildfires, heatwaves, floods, droughts). Many weather and climate extremes happen naturally, even without climate change. But Earth's changing climate *does* change where and how often some extreme events take place, and how strong those events are. What are extreme climate and weather events? Will new or stronger extreme events happen due to climate change? How is climate change impacting extreme events? These are the type of questions that our team of

climate and earth scientists from around the world will answer in this article.

WHAT ARE EXTREME EVENTS?

Extreme **climate** and **weather** events are defined as unusual and rare events. They are so intense or out of place that they get special mention. Heatwaves, extreme rainfalls, floods, thunderstorms, typhoons, hurricanes, tornadoes, tropical cyclones, hailstorms, storm surges, droughts, and wildfires are all **extreme events** (Figure 1).

Extreme events are important because they often cause damage, both to nature and to people. The damage caused by extreme events can cost individuals, businesses, and governments a lot of money. For example, the October–November 2019 wildfires in California (USA) caused $25 billion in damage [1]. Extreme events also cause health problems and can even cause the deaths of people and animals. However, not all extreme events bring damage, and some can bring good changes. For example, some extreme rainfall events in California bring a precious supply of water to the region. We cannot stop extreme events from happening, but we can prepare and protect ourselves from them, and learn how to better take advantage of them when possible.

Many weather and climate extremes happen naturally, but **climate change** *does* change where and how often some extreme events take place, and how strong those events are. Some extreme events are already happening more often, are more intense, and will continue to worsen.

TYPES OF CLIMATE AND WEATHER EXTREMES

Most of us have experienced at least one type of climate and weather extreme, and some of us have experienced many. Types of storms like tropical cyclones, tornadoes, hailstorms, and storm surges are well-known extreme events (Figures 1g,i,j). These storms can be very intense and often do a lot of damage. Another group of extremes is linked to floods, and includes extreme rainfall and **atmospheric rivers**, or "rivers in the sky" (Figure 1h). Extreme events also include droughts (Figure 1a), heatwaves, and coldwaves. Heatwaves are common and happen in many regions of the planet, including the oceans! Wildfires are also extreme events (Figures 1b,k). Wildfires have many names: forest fires, grass fires, peat fires, bushfires, or hill fires. While they can be very dangerous, wildfires are also a natural part of the environment and are needed to maintain healthy **ecosystems**.

MACKENZIE

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AGE: 15

CLIMATE

The pattern of weather over many years. Climate includes things such as clouds, temperature, wind, humidity, snow, and rain. Climate is like weather but over a long time.

WEATHER

A specific event, like a hot day or a storm, that happens over a few hours, days, or weeks. Weather changes daily.

EXTREME EVENTS

Unusual and rare weather and climate events that are particularly intense or happen in unexpected locations.

CLIMATE CHANGE

Over the past 150 years, gases released by human activities have trapped more heat on the Earth than in the past, resulting in increased temperatures, glacial melting, and sea-level rise.

ATMOSPHERIC RIVER

A long, narrow corridor of strong horizontal moisture flow in the air. Atmospheric rivers usually bring heavy rainfall or snowfall.

ECOSYSTEM

A biological community of living and non-living things (and their interactions) in an area.

Figure 1

Figure 1

Different types of climate and weather extremes and their impacts: **(a)** Drought conditions near Jaguari dam, Brazil (January 2014). **(b)** Smoke from the Williams Flat Fire (WA, USA, 8 August 2019). **(c)** The "Victoria's hailstone" in Villa Carlos Paz in Argentina (8 February 2018). **(d)** Paris during a heatwave (France). **(e)** New Jersey shoreline after a storm surge (USA). **(f)** Flooding following hurricane Eta (Central America, November 2020). **(g)** Four tropical cyclones across the Pacific Ocean (1 September 2015): Typhoon Kilo, Hurricane Ignacio, Hurricane Jimena, and Tropical Depression 14E. **(h)** Atmospheric river bringing moisture from the tropics to the Western U.S. (2018). **(i)** Thunderstorm off the coast of Byron Bay, Australia. **(j)** Tornado. **(k)** Wildfire and firefighters near Bilpin, Australia (19 December 2019). See the Author's Note section for photo credits.

STORMS: HOW THEY FORM AND THEIR FUTURE

Air, water, and heat are the three main ingredients that make the weather. Depending on the combinations of these ingredients, different types of weather form and some can create storms. Updrafts (warm air moving upwards in the atmosphere) create clouds, which are made of small water droplets. When clouds move higher, the droplets get colder and form ice particles. As the particles get bigger and heavier, they start to fall as snow or rain.

Thunderstorms are storms with lightning, thunder, and hail. In winter, freezing air temperatures associated with strong winds can create snowstorms (blizzards). Some really big and intense storms, called typhoons, hurricanes, or cyclones (different names in different regions), can form over the ocean. These storms can be up to 200 km wide and can cause ocean water to flood onto the land when approaching the coasts. This is called a storm surge. Tornadoes are rotating air columns about 150 m wide that link clouds to the ground, and they have winds between 100 and 500 km per hour (faster than a car)!

Some storms are quite rare and only develop under very specific conditions. However, as Earth's climate warms, storms are predicted to happen more often and they will be stronger [2]. Warming air is more unstable and has more winds and updrafts, creating more powerful thunderstorms, tornadoes, and blizzards. The ocean is also getting warmer and the extra heat can fuel big cyclones, which can create more extreme storm surges in coastal regions.

ATMOSPHERIC RIVERS AND EXTREME RAINFALL

Away from the equator and tropics, there are storms called extra-tropical cyclones. These cyclones transport heat and moisture away from the tropics. Some of these storms become extreme when they pick up a lot of moisture. All this moisture can be carried very long distances (more than 2,000 km) in narrow corridors (<500 km across), and can travel as far as the Arctic and Antarctic regions. Scientists named these long corridors of moisture atmospheric rivers because they are like rivers in the sky [3]. A typical atmospheric river can carry more than double the flow of the Amazon River!

As atmospheric rivers rise high into the air, they become colder and form clouds. This happens quickly, especially when the atmospheric rivers hit a coast or a mountain range, and the moisture transforms into intense rain or snow [3]. While rain is a key part of Earth's water cycle, extreme rain can cause too much water to fall in too short a time. We call rainfall "violent" when the ground receives more than 5 cm of water in 1 h. The most extreme rainfall in a day occurred in La Réunion, an island in the southern Indian Ocean, where 1.8 m of rain fell during the passage of Cyclone Denise over 2 days in 1966. Extreme rainfall brings severe risks to human health, the environment, and our economy. Impacts include flash flooding, landslides, damage to buildings and farmland, loss of livestock, and damage to lands and forests that increase soil erosion.

HEATWAVES AND DROUGHTS

Heatwaves are usually defined as times when temperatures are much higher than expected over a few days in a row. Heatwaves can happen everywhere—from Siberia to India. There are many reasons why heatwaves occur, including some weather patterns like anticyclones (also called "highs"), and climate patterns such as El Niño. Climate change also influences heatwaves. We know that the more the planet warms due to climate change, the more heatwaves we will experience, and these heatwaves will get longer and hotter [4]. Heatwaves like the European heatwave of July 2019 are now 100 times more likely to occur, due to climate change.

Droughts occur when there is low water availability over a period of a few months or longer. Although droughts occur on different timescales and for different reasons, droughts and heatwaves are linked. During droughts, we are more likely to experience heatwaves because dry conditions favor warmer temperatures. Also, when a heatwave occurs, the heat can increase the rate at which moisture evaporates from vegetation and the land, increasing the severity of drought.

NATURAL VARIABILITY

Changes in climate caused by non-human forces. For example, changes in the sun, volcanic eruptions, and interacting climate patterns result in natural climate variability.

Understanding how climate change impacts droughts is trickier than it is for heatwaves. Decreased rainfall can be caused by several different climate patterns. Because of the **natural variability** of these patterns, it can be difficult to detect a long-term change in rainfall. However, some weather patterns that normally bring rainfall are shifting due to climate change, which can increase the likelihood of drought over these areas.

WILDFIRES

Fire is a natural and essential part of many ecosystems around the world. Fire is needed to regenerate and maintain healthy forests and grasslands. However, wildfires can also do a lot of damage, destroying homes, killing people, causing breathing illnesses from smoke, and impacting ecosystems, particularly fire-sensitive species and communities. Climate change increases wildfire risk by making Earth hotter, which dries out the vegetation and makes it more flammable. Fire seasons are starting earlier in the year and lasting longer.

Wildfires are occurring more often and burning larger areas in many parts of the world, such as the Amazon region, Australia, Siberia, and North America, but it is not always easy to determine how much of the increased wildfire activity is due to climate change. Other factors, like deforestation, expansion of agriculture, and short-term changes in weather and climate conditions, can also have a big influence on fire activity. However, the link between climate change and the recent increase in wildfires and area burned has been proven in Australia and North America [5, 6]. The 2019/20 Black Summer wildfires in Australia were unprecedented in their size, strength, and impact. Areas that burnt included parts of rainforests that would not normally have wildfires [7].

More severe wildfires are likely to occur in a hotter and drier world, increasing the risk of wildfires in areas where fires were not previously common. Wildfires lead to more wildfires, because wildfires release large amounts of carbon into the atmosphere, further increasing global warming and amplifying climate change.

WHAT DO CLIMATE EXTREMES LOOK LIKE IN THE FUTURE?

Climate change is increasing the frequency, severity, and impacts of some extreme events. The world has already warmed an average of 1.1°C since the late 1800s. Because of Earth's changing climate, we can expect hotter heatwaves, drier droughts, stronger storms, and more extreme rainfall (Figure 2).

Figure 2

Climate change has already increased the frequency, severity, and impact of some extreme events. Wildfires are more frequent and larger, and heatwaves happen more often and are hotter. In the future, we can expect drier droughts, stronger storms, more extreme rainfall, and more intense atmospheric rivers.

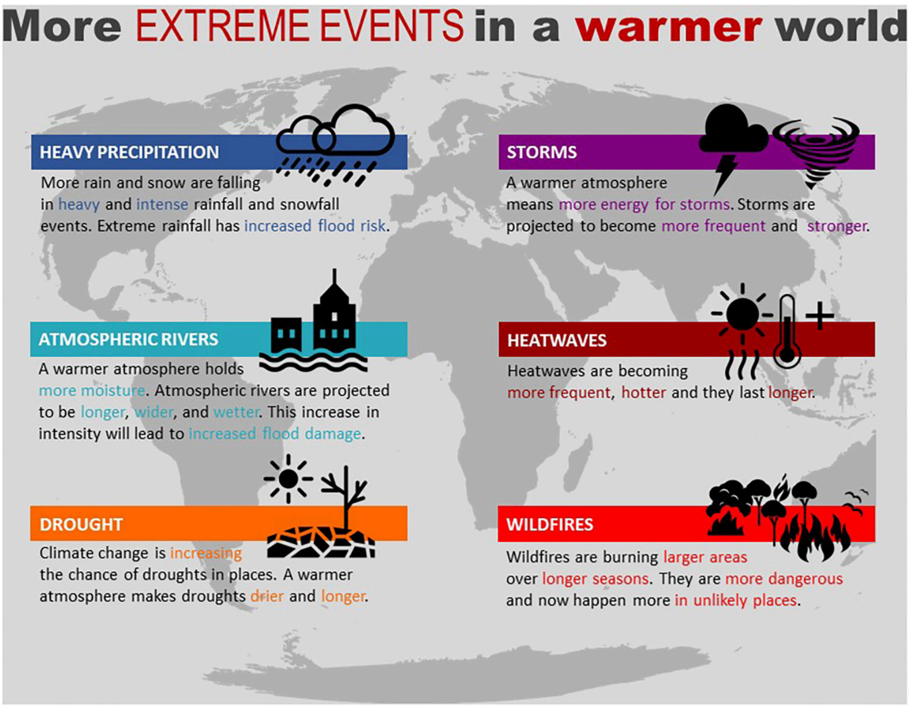

Figure 2

A warmer and wetter atmosphere can hold more water—about 7% more water for every degree of warming. The extra heat and water in the atmosphere mean that there is more energy for storms that generate intense rainfall. As a result, we expect more intense rainfall in the future, with increased floods and damage to structures like buildings and roads. Climate change also increases the risk of coastal flooding due to higher sea levels and more storms.

Some extreme events have already been affected by climate change. Wildfires are now more dangerous and fire seasons have lengthened. Climate change has also already increased how often heatwaves happen. If we want to protect ourselves and our planet from a future full of many more extreme events, governments around the world must plan to rapidly stop deforestation and the burning of coal, oil, and gas. These activities have been driving climate change over the past century and contributing to the increased risk of extreme events. The world must pull together to create a future in which extreme events, and the damage they cause, remain relatively rare.

AUTHOR'S NOTE

The credits and sources for the photos used in Figure 1 are **(a)** Nacho Doce, Reuters; **(b)** David Peterson, U.S. Naval Research Laboratory; **(c)** Victoria Druetta; **(d)** Beboy, Shutterstock; **(e)** N.C. DOT and U.S. DOT; **(f)** The Guardian; **(g)** NASA/NOAA GOES Project; **(h)** NOAA NESDIS;

Reading Guide

Article Title:____

Date Published:____

1. **What is this article about? What are the authors trying to explain to you?**

2. Why is this information important to understand?

3. What part of the article did you find most interesting and why?

4. What parts of the article were confusing? Were there words you don't know?

5. What image or figure did you like the best? Explain in your own words what the image represents and why it helped you understand the article.

6. What questions do you have?

- *What would you ask the author?*
- *What else would you like to know?*
- *What question should they research next?*

Lesson Two: Make a Cloud

Lesson Overwiew: Clouds are an important aspect of understanding weather, extreme weather and making weather predictions. In this investigation students will practice their observation skills as they learn how clouds form in the atmosphere.

Journaling	15 minutes	Bring students to an outdoor area. Complete a nature journaling exercise for the sky. Emphasize that students should observe the clouds, make note of the current weather and temperature and anything else they notice. Provide time for students to work individually, then share their observations with a partner
Investigation	35 minutes	In small groups have students work through the investigation guide the answer the question: **How do clouds form in our atmosphere?** Depending on the group you can let them work at their own pace or lead them through each step as a group.
Lesson Wrap Up	10 minutes	Review the models that each group made of the cloud making process. Students can share with a group or individuals can draw on the board. Highlight that a good model contains both the how and why of a process, have students add any missing components to their model. Review the question board, address any questions that were answered with today's activity

Make-A-Cloud Research Activity

Teacher:	Lesson Topic:
Curriculum Standard:	Fifth grade: • ESS.5.1.4 Seventh grade: • ESS.7.1.2 • ESS.7.1.4 • ESS.7.2.1 Eighth grade: • ESS.8.3.2
STEM Categories	Use Models Construct Explanations
Essential Question:	How does energy from the sun drive the water cycle and cloud formation?
'So What' Factor	Changes in temperature and increased pollution will affect how and where clouds form. Clouds are important indicators of weather so understanding how they are formed helps us better predict weather conditions.

Investigation Goals	
What do Students need to know….	**What do students need to do…**
• Heating liquid water causes a phase change to gas • Loss of heat for gaseous water causes it to condense • Changes in temperature cause changes in density. Warm air is	• Identify the process of evaporation and condensation • Compare the behavior of water as it is heated and cooled • Construct a model of the water cycle including evaporation,

less dense and rises. • Clouds need particles in the air to condense on to. • These particles can be natural (dust) or human produced (aerosols and other pollution)	condensation and precipitation. • Analyze the role pollutants play in the water cycle

Materials	• Beaker • Water • Hot plate • Matches • Ice • Metal tray/bag to place on top of beaker

Investigation Procedure/Scientific Method		
	Description/Key Points	**Points**
Observation	• Bring students to an outdoor area. • Complete a nature journaling exercise for the sky. • Emphasize that students should observe the clouds, make note of the current weather and temperature and anything else they notice.	
Idea & Questions	Inform students that today they will be making a cloud inside a beaker. **Question:** *How does energy from the sun aid in cloud formation?* • For older students, allow them to view the materials list and generate their own questions about the process of cloud formation	

Hypothesis	● Students write an answer to the question that is <u>testable</u> using the materials available in this investigation. ● "I hypothesize that……"	
Experiment/Test	● Have students read through each step of the procedure on their guide before starting. ● Instruct students to draw a model of the set up just based on the procedure. This will reinforce the directions. ○ Fill the beaker with roughly 2 inches of water and place on the hot plate. Warm slowly, you will begin to see the water vapor condensing on the sides of the beaker. ○ Fill the metal tin with ice and set on top. ○ Light a match, (or several for a larger beaker) blow it out, and quickly drop it into the beaker. ○ Immediately cover the top of the beaker with the metal tin. Watch the cloud form. ○ Remove the metal tin from on top of the beaker. Watch the cloud disappear. ● Before starting the investigation have students think through what they will be observing based on their variables, will it be qualitative or quantitative or a mix of both? ● Complete the investigation	
Results & Analysis	**Share Observations** Collect on the board. ● *Look for:* ○ *Heat source caused water to evaporate and rise*	

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Before we dropped the match, we began to see condensation on the sides of the beaker
Match produces smoke when dropped into the beaker
When we lift the ice lid off, the cloud disappears

Discussion questions:

What happens to water when it is heated?
Where did the condensation on the side of the beaker come from?
Why do you think there was ice at the top?
What change did the match introduce to the system?
What do you think smoke is made out of?

These questions are designed for students to begin breaking down the phenomena, at this point we are just gathering information, not looking for correct answers.

Create/Modify the model

Have students add in arrows and explanations of what is occuring to the drawing of the experiment set up

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<tr>
<td colspan="3">Science Communication & Assessment Options</td>
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<tr>
<td colspan="2">Make a model: Make a presentable model of the experiment to explain the role that energy from the sun has in cloud formation.</td>
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<td colspan="2">Extensions:

Design the next experiment based on the question, “how will increasing pollution affect cloud formation”

Optional Readings:
Dirty clouds change rainfall
Super-tiny pollutants may help fire up fierce storms</td>
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Cloud Observations

Head outside and find a spot where you can see the sky. In the space below record your observations of the sky. Be sure to include:

- A drawing of the clouds
- Description of clouds color and texture
- Descriptions of the current weather (temp, humidity, wind, ect)
- Any other important details you notice

Make-A-Cloud Lab Sheet

Question:____

____

Notes from Observations:____

____

____

____

Hypothesis:____

____

____

Model of the experiment:

Observations *(separate into qualitative and quantitative)*

Analysis Questions: *(answer in the space below or on a separate piece of paper)*

- What happens to water when it is heated?
- Where did the condensation on the side of the beaker come from?
- Why do you think there was ice at the top?
- What change did the match introduce to the system?
- What do you think smoke is made out of?

Lesson Three: Collecting Weather Data

Lesson Overview: Daily weather data is collected at weather stations around the world. Daily information can help meteorologists make predictions and long term trends can inform us about our climate. In this lesson students have to opportunity to explore some weather data, make their own weather measurement tools and begin collecting their own data.

Observations	10 minutes	Students begin this activity by exploring some weather data graphs. They can see the types of measurements taken, how they can be visualized, and begin to analyze the data.
Investigation	30 minutes	Students rotate through four stations to build three different weather measurement tools and see how a Raspberry Pi can be used to collect weather data. At each station, students use their tool to collect some qualitative and quantitative data.
Lesson Wrap Up	20 minutes	After the stations, create a class average and begin some class weather graphs so that students can see how tracking data daily allows us to observe trends. Read the article “What do we mean by ‘Climate’ and ‘Climate Change’” and hold a class discussion on the concluding questions. *This article and discussion can be assigned as homework if tight on time*

Collecting Weather Data Research Activity

Teacher:	**Lesson Topic:**
Curriculum Standard:	**Fifth Grade:** ● ESS.5.1.1 Analyze and interpret data to compare daily and seasonal changes in weather conditions (including wind speed and direction, precipitation, and temperature) and patterns. ● ESS.5.1.2 Analyze and interpret weather data to explain current and upcoming weather conditions (including severe weather such as hurricanes and tornadoes) in a given location. **Seventh Grade** ● ESS.7.1.3 Analyze and interpret data to explain the relationship between the movement of air masses, high and low pressure systems, frontal boundaries and weather conditions that may result. ● ESS.7.1.4 Use models to predict weather conditions based on observations (including clouds, air masses, fronts), measurements (wind speed and direction, air temperature, humidity and air pressure), weather maps, satellites and radar.
STEM Categories	Use Models Analyze and interpret data Construct Explanations
Essential Question:	What can we learn about our climate from daily weather data?
'So What' Factor	Collecting and analyzing daily weather data supports climate change monitoring by tracking long-term trends and informing policy decisions. Public health and safety also benefit from weather monitoring, particularly in air quality management and disease prevention.

Investigation Goals	
What do Students need to know….	**What do students need to do…**
• Data can be collected to analyze wind speed, precipitation, air pressure and temperature. • This data changes daily and seasonally. • Weather data can help make predictions for upcoming weather and potential storms. • Long term weather trends can inform us on changing climate.	• Analyze weather data graphs to begin drawing conclusions. • Use weather tools to collect their own weather data. • Observe digital weather data collection through raspberry pi. • Differentiate between weather and climate. • Connect long term weather data trends to ideas surrounding climate.

Materials	Thermometer: • Clear Plastic Straw • Ruler • Fine-tipped permanent marker • Narrow-necked plastic bottle with lid ○ (small bottles used for food-coloring or vanilla extract work best) • Water • Rubbing Alcohol • Food coloring (just a few drops) • Modeling clay • Pipette Barometer: • Small coffee can or empty food can • Balloon • Scissors • Tape • Drinking straw • Index Card or sturdy piece of paper • Rubber band Anemometer: • Scissors • 5 cups (such as dixie or solo cups), one should be of a

	different color or easily discernible • Pen • 2 strips of stiff cardboard/wooden dowels • Ruler • Stapler • Push pin • Pencil with an eraser on the end • Watch with a second hand or a timer. • Calculator Raspberry Pi: • Raspberry pi • Monitor, keyboard, mouse • MPL3115A2 sensor

Investigation Procedure/Scientific Method		
	Description/Key Points	**Points**

Observation	• Navigate to [this weather data website]
	• Use the search feature to locate the nearest weather station to your location.
	• Allow 3-5 minutes for students to explore the current weather and make any observations
	• Direct students to the **"Plot Recent Data"** tab.
	• Begin with temperature:
	  ○ Select **"Monthly"**
	  ○ Select **"Past 10 Years"**
	  ○ Select **"Average Air Temperature"**
	  ○ Select **"Update Plot"**
	• Provide students with two minutes to observe the graph that has been generated and record observations
	  ○ Seasons, average temperature in winter is trending warmer
	• Select **"Clear Plot"**
	• Allow students 5 minutes to create and	

<table>
<tr><td></td><td>observe graphs exploring any parameters they wish.
Inform them that they must have one observation to share out loud at the end of the time.</td><td></td></tr>
<tr><td>Idea & Questions</td><td>Inform students that today they will be making their own weather data collection tools and practice collecting weather data.

Question:

What can we learn about our climate from daily weather data?</td><td></td></tr>
<tr><td>Hypothesis</td><td>Students write an answer to the question that is <u>testable</u> using the materials available in this investigation.
“I hypothesize that……”</td><td></td></tr>
<tr><td>Experiment/Test</td><td>Weather Data Stations

Students will rotate through a series of stations where they will build their own weather data collection tools and also work with weather data technology on the Raspberry Pi.

Thermometer
The clear plastic straw will become the narrow tube of your thermometer. Use the marker to make small marks on the straw, from the top down, at half-centimeter intervals. These marks will serve as level marks on your thermometer.
Modeling clay will seal the bottle's neck and hold the straw in place. Mold the clay until it feels soft and elastic, then form a ball and push it flat. This round flat piece of clay should be bigger than the neck of your bottle.
Use your straw to punch a hole in the</td><td></td></tr>
</table>

middle of this round piece of clay, just big enough to allow the straw to go through.

4. Remove any clay clogging the straw (toothpicks work great for this). Don’t put the clay cap on the bottle until **Step 6.**
5. Fill the bottle about halfway with rubbing alcohol and a few drops of food coloring, put the lid on the bottle, and shake well.
6. Take the lid back off of the bottle and place your clay cap over the opening. The straw should be immersed in the liquid, but NOT touching the bottom of the bottle. The jar should be closed off to any outside air.
7. Use the medicine dropper to drop the colored alcohol solution into straw until the liquid reaches about halfway up the straw.
8. This is now your Room Temperature. Draw a symbol on your straw to indicate room temperature.
    a. Make note of the actual temperature using a digital thermometer.
9. Take your thermometer outside and observe the way the liquid changes. Does it raise or lower?
    a. Use a digital thermometer to make note of the temperature.

Barometer:

1. Cut the neck off the balloon and stretch it to cover the top of the can and secure it using the rubber band. The balloon should form an airtight seal over the can.
2. Place the straw horizontally on the top of the can. Make sure it is centered (looking down, the straw should split the top of the can into two half circles). Tape the straw in place.
3. Tape the index card to the can behind the straw (you may need to trim the straw for this).
4. Record the location of the straw on the index card with a pencil. Find the current

	barometric pressure for your location at https://forecast.weather.gov/MapClick.php?lat=34.2367&lon=-77.9462 and label your index card with the true pressure (ex. 996.2 mb) 5. Continue recording the location of the straw as often as you want. Does the location of the straw change? 6. For a particular straw reading, you can look up the current pressure at a nearby station and make note of it on your card. **Anemometer:** 1. Cross the cardboard strips so they make a plus sign and staple them together. 2. Using the ruler and pencil, find the center of the two pieces of cardboard by drawing lines down the center of each piece and finding where they intersect. 3. Staple 4 of the cups, including the cup with the different color, to the ends of each cardboard piece. Make sure all the cups are facing the same direction relative to the cardboard pieces. 4. Push the pin through the center of the cardboard pieces. Take the pencil and push the eraser onto the pin sticking out of the cardboard pieces. 5. Using the scissors, poke a small hole in the center of the bottom of the remaining cup. Insert the pencil into this cup. 6. Bring your anemometer outside to a windy spot. 7. Using the stopwatch, count the number of rotations in 15 seconds and multiply this number by 4 to get the number of rotations per minute (rpm). **Raspberry Pi Station:** 1. Complete all Raspberry Pi technical setup and hook up the MPL3115A2 sensor. 2. Press run on the code and observe the	

<table>
<tr><td></td><td>following data:
a. Barometric pressure
b. Temperature
c. Altitude</td><td></td></tr>
<tr><td>Results & Analysis</td><td>Create class averages:
Have each student fill in their collected data for temperature, pressure and wind speed on a master class data table
Find the average
Repeat measuring the weather data as often as possible. Use averages to update graphs posted in the classroom to visualize data.
Read the following article as a class
What Do We Mean by “Climate” and “Climate Change”?
Discussion questions:
How is weather different from climate?
How are weather and climate related?
Why do we collect daily weather data?
What can we learn from this data?</td><td></td></tr>
<tr><td colspan="3">Science Communication & Assessment Options</td></tr>
<tr><td colspan="2">Data Talk:
Revisit the weather data website. Students can pick a piece of weather data and a graph to present. In their explanation of the graph they must include:
What data we are seeing
What it tells us about our daily weather
What we can learn about our climate from studying long term trends.</td><td></td></tr>
<tr><td colspan="2">Extensions:
Use Raspberry Pi’s to set up a school weather station, continue to collect daily weather data.</td><td></td></tr>
</table>

Thermometer

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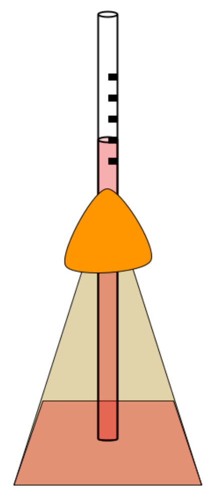

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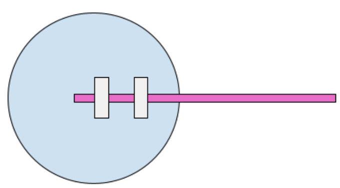
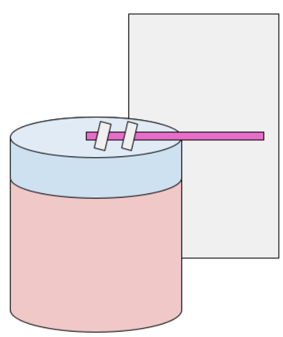


Top Down View



Side View

Anemometer

1. Cross the cardboard strips so they make a plus sign and staple them together.
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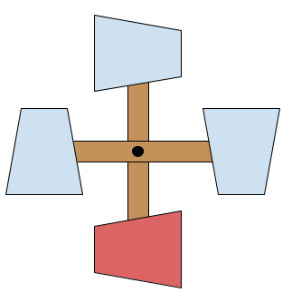
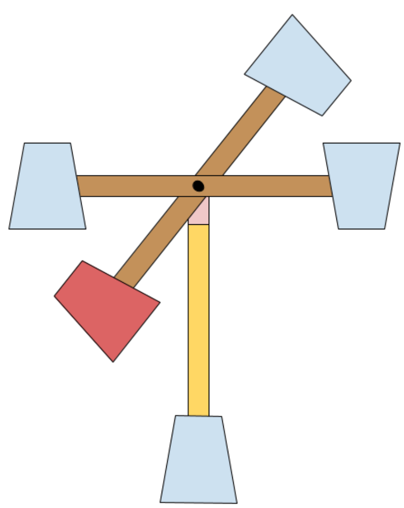


Top Down View



Side View

Weather Data Lab Sheet

Station: Thermometer

Data Collection

Quantitative Observations	Qualitative Data

Station: Barometer

Data Collection

Quantitative Observations	Qualitative Data

Station: Anemometer

Data Collection

Quantitative Observations	Qualitative Data

Station: Raspberry Pi

Data Collection

Quantitative Observations	Qualitative Data

EARTH AND ITS RESOURCES
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WHAT DO WE MEAN BY "CLIMATE" AND "CLIMATE CHANGE"?

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YOUNG REVIEWERS:

COLÉGIO MAXI – MIZZOU ACADEMY
AGE: 12

Climate change is all over the news. But what exactly do we mean by "climate" and "climate change?" The word "climate" describes the average state of the atmosphere. It is a result of the composition and interactions between the natural elements: the air, oceans, plants and animals, ice and snow, and rocks. There are several different climate zones around the world. The state of the global climate is described by the average global air temperature. This temperature depends on how much heat the Earth receives from the Sun and how much of this heat is sent back to space. If the amount of heat received through the sun's rays or the composition of one or several of the natural elements changes, the amount of heat taken up by the Earth changes. All elements are connected and constantly interacting, and this has consequences for the whole planet: climate change.

CLIMATE IS NOT WEATHER

You might have heard or read about climate change or global warming in the media. Scientists from all around the world say that the Earth is warming and Earth's climate is changing. They predict that these changes will probably continue over the coming decades to centuries. But, if scientists cannot predict the weather over more than a couple of days, how can they know what the temperature on Earth will be in several years?

WEATHER

Current state of the atmosphere (what you see when you look out of the window). If it is a rainy or sunny day, for example.

Such predictions can be made because *weather* and *climate* are different things. In scientific words, **weather** is the *current* state of the atmosphere and **climate** is the *average* state of the atmosphere. For example, the clothes you wear today or tomorrow are a response to the weather you see when you look out the window. On a rainy, cold day, you will wear something different than you would on a sunny, warm day. Climate, on the other hand, describes the typical weather conditions in a region for a very long time—30 years or more. That is how we define seasons—for example, in summer, the climate is hotter than it is in winter. So, in winter, we know that we must wear warmer clothes than we do in summer. Climate describes the average characteristics of the weather over a long time at a specific place.

CLIMATE

Average state of the atmosphere, meaning typical weather conditions a in region for a very long time.

THE CLIMATE SYSTEM

Weather, and therefore climate, is a consequence of interactions between the atmosphere and the environment around us: the oceans, lakes, and rivers (also called the hydrosphere); the vegetation and animals (biosphere); the mountains, volcanoes, and ocean floor (lithosphere); and the ice and snow surfaces (cryosphere). These components continuously exchange things like heat, water, or gases. Together, these elements form the **climate system** (Figure 1A). These elements influence the average weather and are important to understand if we want to understand what climate is and how it can change.

CLIMATE SYSTEM

Interactive system consisting of five major components: atmosphere, hydrosphere, biosphere, lithosphere, and cryosphere.

The components of the climate system are constantly interacting. Because the atmosphere covers the whole globe, it is an important means of transport for heat, water, and gases between different regions. When transported, these components affect the state of the atmosphere and influence the average weather. As an example, let us look at how water (Figure 1B) and carbon dioxide (CO_2) (Figure 1C) are exchanged within the climate system.

The oceans are the largest water reservoir on Earth. Every day, due to the heat reaching the Earth from the Sun, water from the oceans, lakes, and rivers evaporates to become water vapor in the atmosphere. The clouds and the moist air are then transported by winds to other regions of the Earth. At some point, the water vapor cools down and falls back

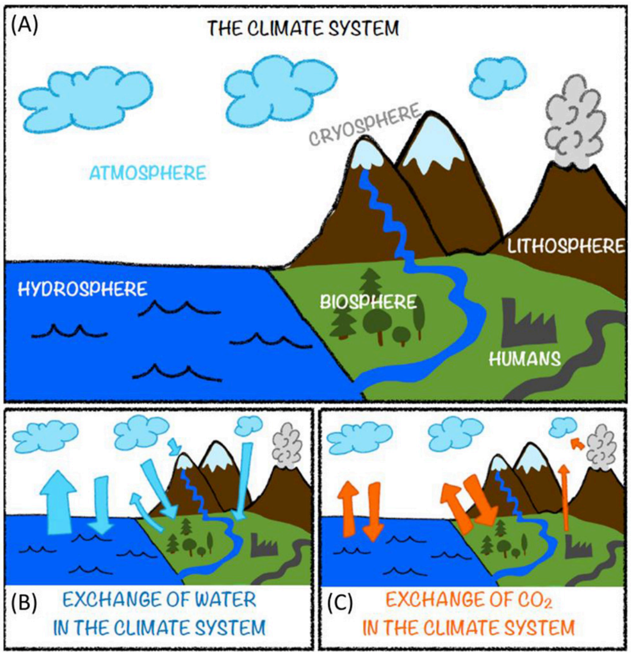

Figure 1

Figure 1

(A) The climate system includes the atmosphere, the hydrosphere (oceans, rivers, and lakes), the biosphere (vegetation and animals), the lithosphere (mountains, volcanoes, rocks, and the ocean floor), and the cryosphere (ice sheets, glaciers, and snow). **(B)** The water cycle: Water is exchanged between the five components of the climate system, mainly between the hydrosphere, the biosphere, the atmosphere, and the cryosphere. **(C)** The carbon cycle: CO_2 is exchanged between the five components of the climate system, mainly between the hydrosphere, the biosphere, the atmosphere, and the lithosphere.

to Earth. If this happens in a cold region over land, it falls as snow and accumulates either on the ground or on glaciers and larger ice sheets. If rain falls over a region covered by vegetation, the water will be taken up for plant growth. Part of the rain also falls directly into rivers and the ocean. Additionally, plants "sweat" and "breathe." Through these processes, plants release water vapor into the atmosphere. The exchange of water between the hydrosphere, atmosphere, biosphere, and cryosphere is called the **water cycle** and it is one example of the interactions between the various elements of the climate system.

The atmosphere is a thin layer of gas surrounding the Earth. It contains the oxygen we breathe and other gases, including CO_2. CO_2 is a **greenhouse gas**, which means that it helps keep the planet warm enough for us to live on. But CO_2 is not only present in the atmosphere—large amounts of carbon are stored in the oceans and in vegetation and are constantly exchanged with the atmosphere in the form of CO_2. This is called the **carbon cycle**. But human activity is throwing this balance off. Every year, as we burn fossil fuels, we release large amounts of CO_2 into the air. The large amounts of CO_2 that we continually release make it very difficult for the exchange between the atmosphere, ocean, and vegetation to readjust and find balance. The excess CO_2 accumulates in the atmosphere, which causes Earth's temperature to rise and results in climate change.

WATER CYCLE

Regular exchange of water between the hydrosphere, atmosphere, biosphere, cryosphere, and lithosphere.

GREENHOUSE GAS

Gas that traps heat and makes the planet warm enough for us to live on.

CARBON CYCLE

Regular exchange of carbon between the atmosphere, hydrosphere, biosphere, cryosphere, and lithosphere.

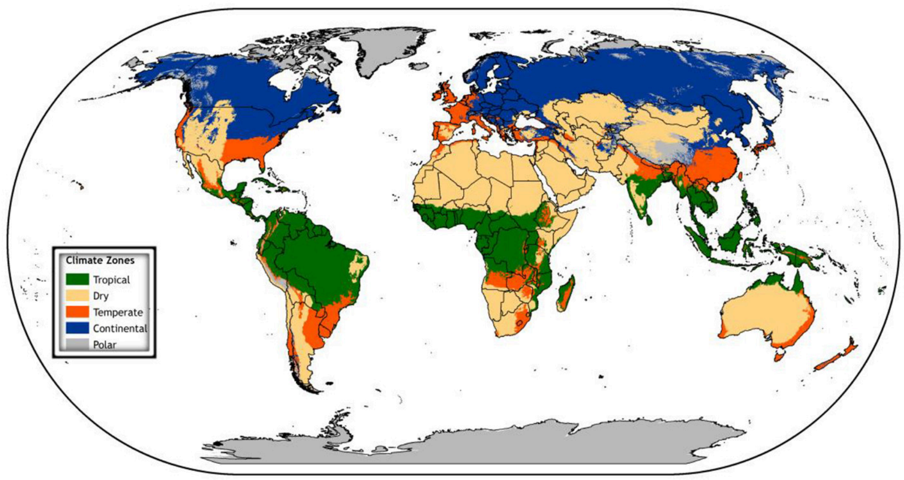

Figure 2

Figure 2

The five main climate zones around the world, as defined by Wladimir Köppen. The zones are in various colors, explained in the key on the left [1].

CLIMATE ZONES

The climate is different all around the world. Scientists have classified the regions that have similar patterns of temperature and rain into **climate zones**. The scientist Wladimir Köppen defined five main climate zones (Figure 2).

CLIMATE ZONE

Regions around the world that have similar patterns of temperature and rainfall.

The tropical climate, found around the Equator, is warm and wet year-round. The dry climate, such as that of deserts, is usually warm, with large variations of temperature between day and night, and has very low rainfall. The temperate climate, such as that of Western Europe, typically has warm summers and mild winters, without a dry season; but for some places, like the Mediterranean, the summers are dry. The continental climate, seen in Russia and Canada, has cooler summers and very cold winters, without a dry season; but in areas like northeastern China, the winters are dry. Finally, the polar climate, seen at the North and South Poles, is very cold year-round.

HOW CAN CLIMATE CHANGE?

The evolution of the global climate is usually monitored by measuring the average global air temperature. This temperature is obtained by measuring the temperatures at various locations worldwide. The average global air temperature represents the amount of heat trapped near the Earth, and it is determined by how much heat from the Sun reaches the Earth and how much heat the Earth releases back to space (Figure 3). Climate has been changing continuously since the formation of the Earth, due to changes in three factors: the position of the Earth compared to the Sun; interactions within the climate system near the Earth's surface; and the gases in Earth's atmosphere. Let us look a little closer at each of these factors.

Figure 3

Heat from the Sun reaches the Earth's surface and warms it. The Earth emits heat back into space. Some of that heat is trapped by greenhouse gases and sent back to the Earth's surface. This is the "greenhouse effect" and makes Earth warm enough to live on.

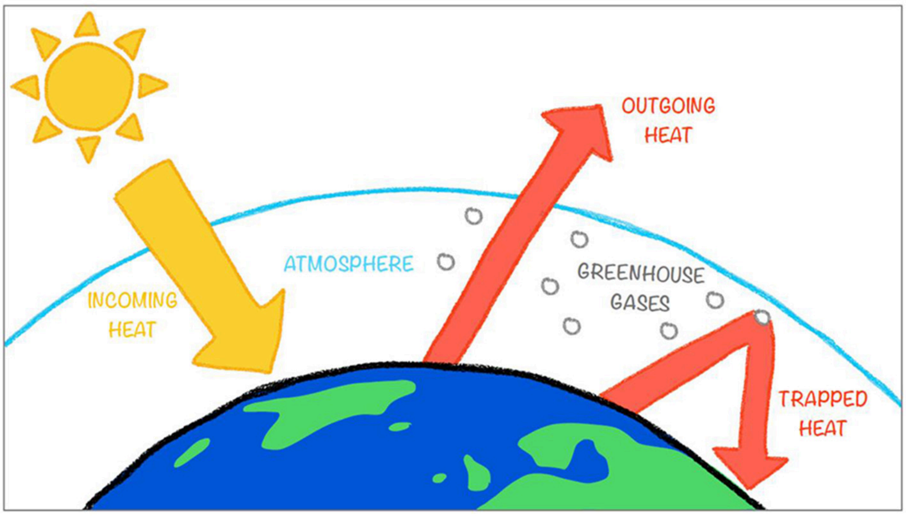

Figure 3

The Position of the Earth Compared to the Sun

Although it is about 150 million kilometers away from the Earth, the Sun provides the Earth with huge amounts of heat. Over the course of the past 4.5 million years, the Earth has sometimes moved a tiny bit closer to the sun, and sometimes a tiny bit further away from it, or has changed its angle toward the Sun very slightly. These small positional changes led to small variations in the heat that reached the Earth. These tiny heat variations were enough to cause ice ages or hot periods.

Interactions Within the Climate System Near the Earth's Surface

When reaching the Earth's surface, some of the Sun's heat is reflected and bounces back into space. But the majority of the heat is absorbed by the natural elements at the Earth's surface. This heat powers the exchange of water and gases between the components of the climate system (atmosphere, hydrosphere, biosphere, lithosphere, and cryosphere), as described earlier.

The Gases in Earth's Atmosphere

The Earth's surface also emits heat back to space. If all the heat released by the Earth's surface were lost to space, it would be too cold for us to survive on Earth! This is where the Earth's atmosphere comes into play. The greenhouse gases in the atmosphere—water vapor, CO_2, and methane—absorb some of the heat released by the Earth's surface on its way to outer space and send that heat back toward the Earth's surface. This way, the Earth stays warm enough for us to live on. The warming caused by the heat trapped by greenhouse gases is what we call the **greenhouse effect**. It is a natural phenomenon that has always happened. By emitting more CO_2 into the atmosphere, humans are currently making the greenhouse effect

GREENHOUSE EFFECT

Warming process caused by the heat trapped by the greenhouse gases. It is a natural process but can be enhanced by the increase of greenhouse gases in the atmosphere.

stronger. These processes are described in more detail in other articles in this Climate Collection.

IN SUMMARY

Climate describes the average characteristics of the weather and it can be quite different all over the planet. Although we describe weather by the current state of the atmosphere (whether it is a sunny day or it is raining, for example), weather is strongly influenced by the cryosphere, hydrosphere, biosphere, and lithosphere. There is continuous exchange of water, heat, and gases between the various components of the climate system. Changes in these processes lead to changes in the average properties of the atmosphere and therefore in weather and climate.

The average global air temperature helps us to monitor the evolution of Earth's climate over time. This temperature describes the difference between the incoming heat from the Sun and the heat released into space. Changes in the average global air temperature, like global cooling or global warming, can be due to changes in Earth's position compared to the Sun, changes in interactions between the elements of the climate system, or changes in the amounts of greenhouse gases in the atmosphere. Such changes have happened in the past and are happening right now. Because all components of Earth's climate are linked, changes in the average global air temperature affect all other parts of the climate system. This is how we define and detect climate change.

ACKNOWLEDGMENTS

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SCIENCE MENTOR: Maria Hunter

What Do We Mean by "Climate" and "Climate Change"?
DIscussion Questions

1. How is weather different from climate?

2. How are weather and climate related?

3. Why do we collect daily weather data?

4. What can we learn from this data?

Graph Data Talk Planning Guide

Title of my graph:

Sketch the general shape

Independent variable (x-axis):

Dependent variable (y-axis):

Describe your graph in two - three sentences:

Do you see any patterns on your graph?

Does anything stand out? Are there any outliers?

Any other graph observations:

Write a short paragraph to present for your data talk addressing the question:

What can we learn from this graph