LESSON 7

ARCTIC MELTDOWN

GRADE LEVEL 6-8

***ARCTIC:** Our Frozen Planet*

ARCTIC: Our Frozen Planet

LESSON 7

ARCTIC MELTDOWN

GRADE LEVEL 6-8

30 minute discussion

60 minute activity

STANDARDS (NGSS):

MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

FROM THE FILM:

In ***ARCTIC: Our Frozen Planet,*** we see how ice at the poles is dramatically decreasing, putting sea life and indigenous populations at risk of losing their habitat and livelihood. In this activity, students will explore the science and reasoning behind depleting ice at the poles and work through the engineering design process to search for solutions that might help slow down the progression of melting ice and save our Arctic ecosystem.

LESSON OVERVIEW:

Students explore the ice-albedo feedback, the impact decreased albedo has on Arctic ecosystems, and how human activities and natural processes increase the rate at which our polar ice melts. An icy planet can reflect sunlight and heat back into outer space, but as the Arctic begins melting, that heat gets absorbed into our oceans, increasing temperatures globally. Students will engage in discussion on human impact on our earth's temperatures, build something to keep their ice from melting, and be challenged to see whose ice can last the longest.

MATERIALS LIST:

- ***Arctic Meltdown*** *activity sheet*
- *Ice cubes*
- *Basic building materials:*
  - *Cardboard*
  - *Paper bowls*
  - *Foam sponges*
  - *Construction paper*
  - *Aluminum foil*
  - *Craft sticks*
  - *Pipe cleaners*
  - *Mylar thermal sheets (optional)*
  - *Fabric/stuffing (optional)*
- *Scissors*
- *Tape*
- *Desk lamp*
- *2 thermometers*
- *1 piece of black construction paper*
- *1 piece of white construction paper*
- *Chart paper or SMART Board*
- *Optional additions:*
  - *Additional thermometer*
  - *Charcoal*
  - *Soot and microplastics spread on a piece of white paper*

LESSON 7

ARCTIC MELTDOWN

EDUCATOR PREP:

Freeze ice cubes for students in advance. If you are bringing ice cubes into the classroom and do not have a freezer that you can store them in, you can wrap the ice in tin foil and hold them in a cooler to keep them solid longer.

Prep any building materials by cutting cardboard into smaller pieces. Cut fabric mylar thermal sheets into small squares if using in this activity.

Plan how you want to distribute materials. For example, will you prefer students to pick out their own materials, or will each student get a standard amount of each?

Narwhals have only one tooth which protrudes far out from their snout.

LESSON GUIDES:

1. Students should write their own personal reflection of ***ARCTIC: Our Frozen Planet,*** under section 1 of the Activity Sheet.

What did we learn about the Arctic?

Student responses will vary depending on what resonated for each of them from the film, but will most likely reflect the themes of the film, including the richness of life in the Arctic, the impact of climate change, and the relationship between the organisms who live there, including humans, and the changing landscape.

What is happening at the poles?

As the earth warms due to climate change, ice in the form of glaciers and sea ice is melting, changing from solid to liquid water. This reduces the amount of solid surface in the Arctic and causes the sea levels to rise.

How does melting ice affect the wildlife in the Arctic?

Those animals that rely on a solid surface, like polar bears and humans, are forced to move to look for other places to live. Organisms which live or rely heavily on the water have to adapt to warmer temperatures and reduced salinity if they are to survive in the new environment.

2. Students will follow along answering questions under Section 2 of the Activity Sheet.

What is the ice-albedo feedback?

The ice-albedo feedback is a climate process where ice reflects some of the solar energy back into space.

How does the ice-albedo feedback relate to the Arctic?

The more ice, the more reflective the surface. Surfaces that are highly reflective are considered high albedo surfaces. The ice and snow of the Arctic creates a high albedo environment.

What impact does melting ice at the poles have on the Arctic's albedo?

As ice in the Arctic begins melting, albedo decreases. Less solar energy is reflected out into space, and instead gets absorbed into our oceans. When more solar energy gets absorbed into our oceans, global temperatures increase, which in turn melts even more ice. This creates a positive feedback loop where our problem will continue to get worse unless preventative measures are taken.

3. Introduce the concept of thermal emissivity to your students.

What is thermal emissivity?

Thermal emissivity is the rate at which a specific material or surface emits thermal radiation. Thermal emissivity can be used for heating and cooling surfaces, as well as for reflecting thermal energy away from a surface.

How do we measure an object's thermal emissivity?

Thermal emissivity can be measured from zero to one. A material with zero thermal emissivity emits no thermal radiation and can reflect thermal radiation away from it. A material with Thermal emissivity of one can completely absorb the thermal radiation that touches it.

How does thermal emissivity impact the Earth?

Warm surfaces can cool themselves by emitting thermal radiation. In the past, planet Earth has maintained a balanced rate of cooling and heating on a large scale. Human activity has altered the planet's ability to cool itself naturally, and the consequence is a continued increase in global temperatures.

EDUCATOR NOTES:

4. APPLYING CONCEPTS

Let's take a look at the thermal emissivity table under Section 3 of our Activity Sheet. Students can practice looking at the table, searching for familiar materials, and learning about their thermal emissivity.

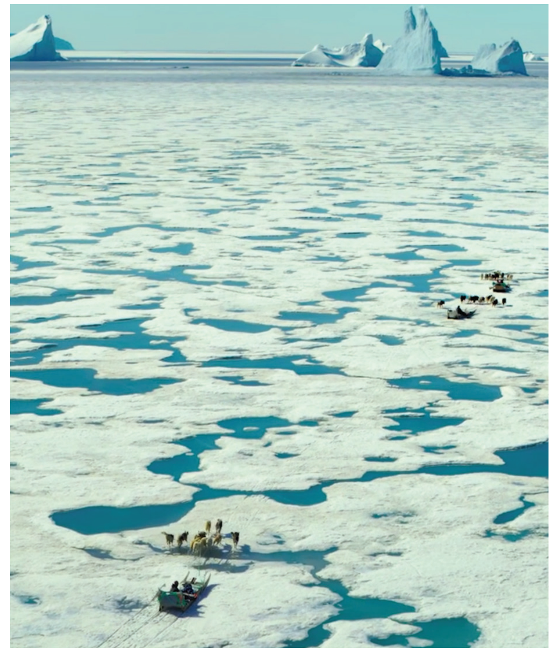
What are some materials with high thermal emissivity? What are some materials with low thermal emissivity?

Materials with high thermal emissivity include carbon (graphite), concrete, and soil.

Materials with low thermal emissivity include polished aluminum, brass, and copper.

What materials would be good to use if you wanted to design the roof of your home to be more energy efficient in the summertime? Why?

Materials that would make the roof of your home more efficient would be polished aluminum, brass, or copper. Selecting materials with low thermal emissivity helps reflect heat and sunlight away from your home, thus reducing the need for air conditioning in the summer time.



Inuit hunters sledding on the sea ice.

Black and White Surfaces

Place a piece of white paper and a piece of black paper under a desk lamp. ***Optional addition:*** add a third piece of paper covered in charcoal/soot and microplastics to discuss the impact of carbon and microplastics on ice at our poles.

Set a thermometer on each piece of paper. Have students develop a hypothesis describing what will happen to the thermometers based on their understanding of albedo and thermal emissivity. Students should write down their hypotheses under section 4 of the Activity Sheet.

Leave the thermometers on the paper for the remainder of the lesson. We will come back to this at the end of the lesson.

5. Instruct your students you will be discussing greenhouse gases and have them follow along under section 5 of the Activity Sheet.

What are greenhouse gases?

Greenhouse gases are gases released into our atmosphere that emit thermal energy. Examples of greenhouse gases in our atmosphere include carbon dioxide, methane, water vapor, nitrous oxide, fluorinated gases, and ozone.

How are greenhouse gases formed?

Natural greenhouse gases occur from volcanic activity and other geologic processes, the respiration and decomposition of plants, and from gases released by the ocean. Greenhouse gases that occur from human activity are generated from the burning of fossil fuels, burning waste, agriculture, and deforestation.

What are the consequences of increased greenhouse gases?

Greenhouse gases that build up in the atmosphere to unsustainable levels can raise global temperatures, melt ice at the poles, and disrupt the natural pH balance in the oceans.

6. Have students explore different ways to alleviate the climate crisis by asking:

What are some ways that individuals can make changes in their everyday life to help solve the climate crisis?

Here are some potential responses:

One can reduce the amount of greenhouse gases they produce by switching to renewable energy sources, reducing food and water waste, reducing their consumption of meat and dairy, recycling, avoiding single-use plastics, using mass transit or carpooling more, and using electric or hybrid vehicles with more efficient gas milage.

Other ways to make a positive impact include improving your home's efficiency with better insulation and smart heating and cooling systems, buying locally produced goods, getting involved in community cleanup events, protecting and restoring ecosystems, supporting regenerative farming practices, and planting flowers and trees that attract pollinators.

We can support politicians who advocate for climate smart policies, we can write to our government officials, and donate to organizations invested in finding climate solutions.

There are many ways that we can make a positive impact and leave the world in better shape than we found it in. Have students respond to questions under section 6 of their Activity Sheet.

EDUCATOR NOTES:

7. Tell students you are now going to start to make connections with the ideas you have been discussing.

What are some reasons for increasing global temperatures?

Decreased albedo at the poles. High levels of greenhouse gases.

Ask students if they can think of anything else?

Deforestation decreases the earth's ability to process greenhouse gases. Pollution affects ocean acidity which can increase the rate of melting ice at the poles and throw off the albedo balance. (There are many possible answers to this question.)

8. Challenge the students to build something that can keep ice from melting. Using their understanding of thermal emissivity, students must select materials to build with that they think will help keep their ice cold for as long as possible.

Allow students to take their time selecting materials and building.

Hint: reflective materials such as aluminum foil and mylar thermal sheets are best for keeping ice cold. Students should also consider insulating their creation with other materials such as cotton, foam, or fabric.

Encourage students to get creative and think outside the box with their designs. When students are all finished building, pass out one ice cube to each student/pair. Students can be challenged to see whose ice stays frozen the longest.

Instruct students to place their creations somewhere where they can be left undisturbed. Evaluate their designs.

Most students' ice will stay cool for a few hours. Teachers may want to have students check on their ice periodically throughout the day to see which students/teams are still standing.

If leaving ice overnight (or for long periods of time), students may return to find that their ice has melted. A thermometer can be used to test the temperature of the water to see if some are still cold.

Students can be evaluated by the appearance of their design. Encourage students to share their experiences with the rest of the class.

Close-up of the frozen bumblebee queen.

Ask students what materials they used? Is their creation designed to reflect solar and thermal energy away from it? Does their creation have any insulation?

Answers may vary depending on class experience.

What materials were used and why? Was your design successful? Why or why not?

Answers may vary depending on class experience.

9. After students are finished building their ice-saver, check the thermometers from earlier.

Which thermometer has the highest temperature? The one on white paper or the one on black paper?

The black paper should have had the higher temperature.

If a third paper with carbon/soot and microplastics was added, how does this compare to the white and black papers tested?

Students' answers may vary depending on class experience. The paper with microplastics and carbon/soot will likely be around the same temperature as the black paper or hotter.

What does that say about carbon and microplastics and their effect on ice in the Arctic? Why is it important to reduce our carbon and plastic consumption?

Students' answers may vary depending on class experience. Carbon and microplastics tend to generate more heat under the sun. When they end up on icy areas in the Arctic, the result leads to faster melting ice. Cutting back out carbon and plastic consumption can help prevent the problem from worsening.

Were the students' hypotheses correct? Why or why not?

Students' answers will vary.

Ask if anyone explain why it is not a good idea to wear a black shirt on a hot summer day?

Students' answers may vary depending on class experience. A black shirt will absorb heat at a faster rate than a white shirt and the threat of overheating will be increased.

EDUCATOR NOTES:

10. Ask students to reflect on the challenges they faced when designing something that would offset the effects of climate change using a 3-2-1 summary in their notebooks. Ask them to write:

What three things did they learn from this experience?

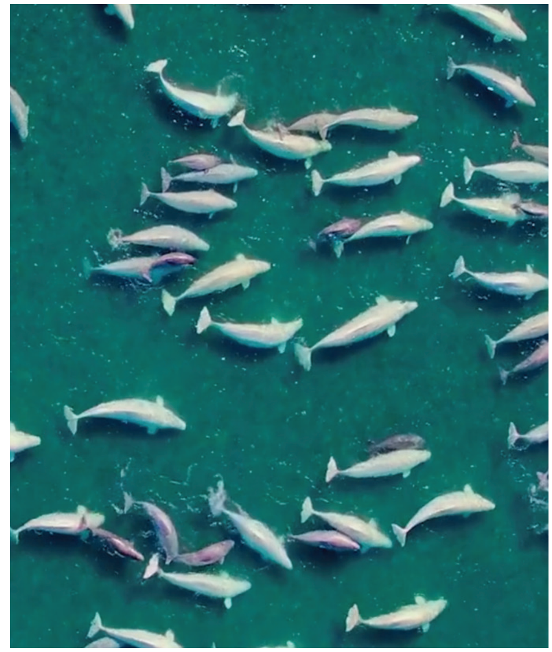
Students' answers will vary.

What two questions do they have after finishing the design and experiment?

Students' answers will vary.

What is one thing that they would change in their design if they did it again?

Students' answers will vary.



Beluga whales are very social animals, often hunting or traveling in groups.

Arctic Meltdown
Activity Sheet

Name: ______________________

Date: ______________________

1. Reflecting on The Arctic

What are some key takeaway points from ***ARCTIC: Our Frozen Planet*** about the changing environment taking place at the poles?

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____

____

2. Ice-Albedo Feedback

What is the ice-albedo feedback?

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Does the Arctic have high or low albedo?

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____

Arctic Meltdown

Activity Sheet

Is the albedo in the Arctic currently increasing or decreasing?

How does a changing albedo at the poles affect the rest of the Earth?

Arctic Meltdown

Activity Sheet

3. Thermal emissivity

Thermal emissivity is the rate at which a specific material or surface emits thermal radiation and is measured from 0 to 1. Thermal emissivity can be used for heating and cooling spaces, as well as for reflecting thermal energy away from a surface.

A material with zero thermal emissivity emits no thermal radiation and can reflect thermal radiation away from it. A material with thermal emissivity of 1 can completely absorb the thermal radiation that touches it.

MATERIAL	EMMISSIVITY VALUE (0-1)
Aluminum: Polished	**0.05**
Brass: Polished	**0.03**
Carbon: Graphite	**0.98**
Concrete	**0.92**
Copper: Polished	**0.05**
Copper: Oxidized	**0.65**
Gravel	**0.28**
Paper: Black	**0.9**
Paper: Yellow	**0.72**
Paper: White	**0.68**
Sand	**0.9**
Soil	**0.92**
Stainless Steel	**0.52**
Wood	**0.87**

Arctic Meltdown
Activity Sheet

From the Thermal Emissivity Table, what material absorbs the most thermal radiation?

What material emits the least amount of thermal radiation?

What materials would be good to use if you wanted to design the roof of your home to be more energy efficient in the summertime? Why?

4. Black & White Surfaces

In this activity, we will place a piece of black paper and a piece of white paper underneath a desk lamp and place a thermometer on top of each. (Optional: add a third piece of paper with carbon and microplastics on it.) Over a period of time, we will record the temperatures of each to find out which piece of paper is more efficient at keeping cool.

Develop a hypothesis: What do you think will happen to the temperature of each piece of paper when held under a desk lamp?

Arctic Meltdown
Activity Sheet

Observation	Time	Black Paper (temperature)	Black Paper (temperature)	Carbon/Microplastics (temperature)
Observation 1:				
Observation 2:				
Observation 3:				

Make observations: Record the temperature of each piece of paper periodically and share your observations.

Conclusion: What happened to the pieces of paper when held underneath the desk lamp for a period of time? Was your hypothesis correct? Why or why not?

5. Greenhouse gases

What are greenhouse gases?

How are greenhouse gases formed?

What are the consequences of increased greenhouse gases?

Arctic Meltdown

Activity Sheet

6. Climate Solutions

What is the climate crisis?

Take a moment to list ways that **YOU** can make changes in your everyday life to help solve the climate crisis:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Arctic Meltdown

Activity Sheet

EDUCATOR KEY

Name:

Date:

1. Reflecting on The Arctic

What are some key takeaway points from ***ARCTIC: Our Frozen Planet*** about the changing environment taking place at the poles?

(Answers will vary depending on the student's perception of the movie) Example: the ice in the Arctic is melting at an alarming rate, which affects habitats of animals and humans living there. Animals and indigenous populations are becoming displaced and global temperatures will continue to rise unless something changes.

2. Ice-Albedo Feedback

What is the ice-albedo feedback?

The ice-albedo feedback is a climate process where ice reflects some of the solar radiation back into space.

Does the Arctic have high or low albedo?

The Arctic has a high albedo.

Arctic Meltdown

Activity Sheet / **EDUCATOR KEY**

Is the albedo in the Arctic currently increasing or decreasing?

The albedo in the Arctic is currently decreasing because melted ice means less solar radiation is being reflected back into space.

How does a changing albedo at the poles affect the rest of the Earth?

As the albedo at the poles decreases, more solar radiation is absorbed into our oceans which simultaneously warms the planet more and makes the problem of ice melting at the poles even worse.

Arctic Meltdown
Activity Sheet

3. Thermal emissivity

Thermal emissivity is the rate at which a specific material or surface emits thermal radiation and is measured from 0 to 1. Thermal emissivity can be used for heating and cooling spaces, as well as for reflecting thermal energy away from a surface.

A material with zero thermal emissivity emits no thermal radiation and can reflect thermal radiation away from it. A material with thermal emissivity of 1 can completely absorb the thermal radiation that touches it.

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Wood	**0.87**

Arctic Meltdown

Activity Sheet / **EDUCATOR KEY**

From the Thermal Emissivity Table, what material absorbs the most thermal radiation?

Carbon: Graphite

What material emits the least amount of thermal radiation?

Brass: Polished

What materials would be good to use if you wanted to design the roof of your home to be more energy efficient in the summertime? Why?

Brass: Polished; (2) Aluminum: Polished; (3) Copper: Polished

These materials emit the least amount of thermal radiation and are all reflective surfaces which can also reflect thermal and solar radiation away from them. During the summertime, a house with a roof made from these materials would require less air conditioning to remain cool and would therefore be more energy efficient.

4. Black & White Surfaces

In this activity, we will place a piece of black paper and a piece of white paper underneath a desk lamp and place a thermometer on top of each. (Optional: add a third piece of paper with carbon and microplastics on it.) Over a period of time, we will record the temperatures of each to find out which piece of paper is more efficient at keeping cool.

Develop a hypothesis: What do you think will happen to the temperature of each piece of paper when held under a desk lamp?

Answers may vary.

Example: I think the black paper will increase in temperature faster than the white paper because the black paper has higher thermal emissivity and will absorb more thermal radiation. I think the paper with carbon and microplastics on it will be closer in temperature to the black piece of paper because the materials absorb heat instead of reflecting it.

Arctic Meltdown

Activity Sheet / EDUCATOR KEY

Observation	Time	Black Paper (temperature)	Black Paper (temperature)	Carbon/Microplastics (temperature)
Observation 1:	3:15	70°	70°	70°
Observation 2:	3:45	74°	72°	74°
Observation 3:	4:15	76°	72°	77°

Make observations: Record the temperature of each piece of paper periodically and share your observations. Observations may vary.

Conclusion: What happened to the pieces of paper when held underneath the desk lamp for a period of time? Was your hypothesis correct? Why or why not?

The black construction paper increased in temperature faster than the white paper. The carbon/microplastic paper was around the same temperature as the black paper (if not hotter). My hypothesis was correct because I applied my understanding of thermal emissivity before testing.

5. Greenhouse gases

What are greenhouse gases?

Greenhouse gases are gases released into our atmosphere that emit thermal energy. (Bonus if they can list examples: carbon dioxide, methane, water vapor, nitrous oxide, fluorinated gases, and ozone.)

How are greenhouse gases formed?

Greenhouse gases are formed naturally through geologic processes, decomposition of plants, and gases released by the ocean. Manmade greenhouse gases occur through deforestation, the burning of fossil fuels and waste, and through agriculture practices.

What are the consequences of increased greenhouse gases?

Increased greenhouse gases to unsustainable levels are the cause for increased global temperatures, melting of the ice at the poles, and changes in pH levels in the ocean (which can have devastating effects on plants and animals living in them).

Arctic Meltdown

Activity Sheet / **EDUCATOR KEY**

6. Climate Solutions

What is the climate crisis?

The climate crisis is what our world is facing today with increased greenhouse gases, pollution, melting ice at the poles, and an increase of global temperatures. If nothing is done to alleviate the climate crisis, our Earth will suffer and become uninhabitable. The Earth cannot absorb the level of greenhouse gases that we are releasing into the atmosphere on its own, humans need to decrease their carbon consumption, seek alternative energy sources, and nurture the Earth's ecosystems.

Take a moment to list ways that **YOU** can make changes in your everyday life to help solve the climate crisis:

Answers may vary.

Carpooling, using mass transit, or walking/riding bikes more frequently

Buy groceries from locally owned and ethically sourced businesses

Avoiding single-use plastics

Growing my own vegetables and fruits

Avoiding imported goods and goods that must travel long distances to reach me

Reducing meat and dairy consumption

Investing in renewable energy sources

Turning off lights when not using them

Not wasting water (taking shorter showers, turning water off when brushing teeth, etc.)

Using less AC in the summer and less heat in the winter (making my home more energy-efficient)

Supporting/voting for politicians who support climate smart policies

Supporting regenerative farming practices

Planting flowers and trees that attract pollinators

Making updates to my home that improve its energy efficiency

LESSON 8

LIFE ON TOP

GRADE LEVEL 6-8

ARCTIC: *Our Frozen Planet*

LESSON 8

LIFE ON TOP

GRADE LEVEL 6-8

Two / 30 minute lessons
Additional time required outside of class

STANDARDS (NGSS):

MS-LS2-1 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

FROM THE FILM:

The film *ARCTIC: Our Frozen Planet* introduces students to some of the unique species that live in the Arctic and the threats to their habitat and ways of life.

LESSON OVERVIEW:

Each student will assume the role of one of the animals highlighted in the film *ARCTIC: Our Frozen Planet*. Students will research the lifestyle and survival techniques unique to their species as well as the challenges facing them in the changing climate of the Arctic. Using this knowledge, students will write an autobiography as their animal, highlighting their survival techniques and adaptations as they live and die on the ice.

MATERIALS LIST:

- ***Life on Top*** *activity sheet*
- *Research materials (library, computers with internet access)*
- *Paper*
- *Writing utensils (pens or pencils)*

LESSON 8

LIFE ON TOP

EDUCATOR PREP:

Reserve research materials or space as applicable

LESSON GUIDES:

1. Welcome students to the beginning of their Arctic exploration! As a class, discuss what ideas students already have about the Arctic.

Ask students what they know about the Arctic?

Answers will vary depending on if students have already watched *ARCTIC: Our Frozen Planet* or if this content had previously been covered in class. If students have already viewed the film encourage them to think about what they saw or learned from the film. Possible answers could include:

-The Arctic is the northern most region of Earth.

-It is almost entirely covered by water, which is mostly frozen

-Only ¼ quarter of the Arctic is land

-The Arctic includes eight countries and covers parts of Scandinavia, Russia, Greenland, Canada, and the United States of America (Alaska)

-There are multiple types of habitats found within the Arctic including aquatic and terrestrial habitats

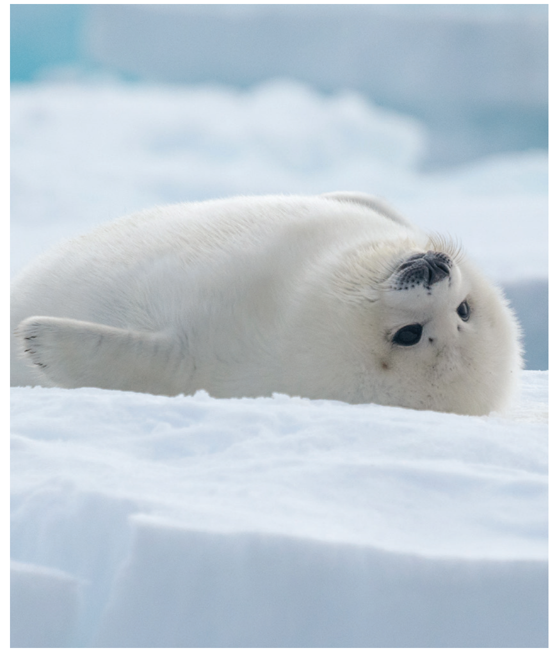
-It is home to 4 million people as well as different species of plants and animals

-There is an annual cycle of freezing and thawing

-Arctic ice is a unique habitat to the animals that live in the Arctic, many like polar bears rely heavily on the sea ice for hunting and survival.

-Arctic ice is an important part of the life and culture of the 4 million people who live in the Arctic.

-Arctic ice reflects heat and sunlight back into space.



A baby seal suns himself on the ice.

-Arctic ice helps regulate the circulation of water and nutrients in the ocean.

-Arctic ice has a major impact on stabilizing ocean and air temperatures

-Many global conditions are tied to the Arctic ice and its ability to regulate conditions worldwide.

It is important to point out that the organisms (plants, animals, people) that live in the Arctic are specially adapted to live there. These adaptations could be physical or behavioral.

We know that the Arctic is important the species that live there, but what impact does the Arctic have on us where we live?

Answers will vary depending on location, but the Arctic affects the weather everywhere as well as anything that depends on ocean currents and affected by ocean levels.

2. Divide the class into pairs or small groups and give them time to discuss their ideas about how the Arctic is impactful to their daily lives and where they live.

Float among the groups offering guidance and direction as needed. Offer these questions to guide students in their discussions:

Do you live in a coastal area that will be affected by rising sea level?

What extreme climate can we expect where we live?

How could large storms affect us and the region where we live?

3. Bring students back together to share their ideas.

What do we notice about our ideas? Are they all the same?

Student answers will vary but look for patterns or recurring issues. Supplement students' answers as needs, especially highlighting impacts to your area such as:

-Rising global temperatures
-More extreme weather events such as hurricanes, drought, blizzards
-Sea level rise
-Shifting climates affecting food supply and crop growth

EDUCATOR NOTES:

How can we adapt to these changes? What might we have to do to be able to live here once the changes take place?

Give students time to think about these questions. Student answers will vary depending on the changes they predicted for the local area, but could include:

-Needing to use more air conditioning (or putting in air conditioning) to deal with rising temperatures

-Having to move further inland to account for rising sea levels in coastal communities

-Emergency procedures to deal with weather events like hurricanes or drought

-Build a new school to better stand up to the changing conditions

What would happen if we couldn't do those things?

Allow students to reflect on this questions, but a formal answer is not needed at this time. Use this to transition into the activity.

4. Students will select an animal featured in ***ARCTIC: Our Frozen Planet*** (Arctic wolf, polar bear, caribou, narwal, walrus). Explain that students will be researching the animal's physical adaptations, behavioral adaptations, survival strategies, habitat, threats to their habitat, etc.

Provide students with access to the library or the internet and time to complete their research.

Possible resources for student research:

- *https://adfg.alaska.gov/*
- *https://www.pc.gc.ca/en/pn-np/nt/woodbuffalo*
- *https://www.fws.gov/refuge/arctic*
- *https://www.nationalparksofsweden.se/choose-park---list/abisko-national-park/*
- *https://national-parks.org/*

5. Have students use the **Life on Top** activity sheet to organize their research.

6. Now that students understand their animal better, they will write their animal's autobiography.

What is an autobiography?

An account of a person's life written by that person.

Arctic shoreline.

7. Provide students with the requirements for their autobiography. Each autobiography will include the life history of the species (habitat, diet, role in ecosystem, adaptations, survival strategies), how they are handling the current changes occurring in the habitat, and their plan if the trend in ecosystem continues.

8. Teachers will determine the appropriate length of the autobiography and how much time students will have to complete the assignment.

9. Once the students have completed their autobiographies, students will share excerpts from their autobiography focusing on the future of their species.

Discuss the similarities and differences between the predictions made by students who were embodying the same species.

10. In small groups discuss their thoughts and feelings after hearing these predictions of the fates of the different species. Ask students:

> How do you feel about the consequences of the changing ecosystem in the Arctic?

11. In conclusion, as a class, brainstorm ways that their actions can have a more positive impact on the environment. Think locally and focus on things students can do such as:

- Writing a letter to the local government about their wishes for a more sustainable climate future.
- Planting a school garden.
- Carpooling to school, etc.

EDUCATOR NOTES:

Life On Top

Activity Sheet

Choose one of the animals from the film, ***ARCTIC: Our Frozen Planet*** that you want to know more about:

Atlantic walrus *Odobenus rosmarus*	Beluga *Delphinapterus leucas*	Wolf *Canis lupus*
Polar bear *Ursus maritimus*	Bowhead *Balaena mysticetus*	Hooded seal *Cystophora cristata*
Pacific walrus *Obobenus rosmarus*	Lapland bumble bee *Bombus lapponicus*	Sea angel *Clione limacina*
Guillemots *Uria aalge*	Harp seal *Pagophilus groenlandicus*	Caribou *Rangifer tarandus granti*
Narwhal *Monodon monoceros*	American bison *Bison Bison*	Crested auklet *Aethia cristatella*

Use a primary resource to learn more about the animal. Be sure to answer these questions in your research:

Animal name:

Habitat: | Life span:

Omnivore, Carnivore, or Herbivore:

Vertebrate Class: | Live birth or Lay eggs:

Prey: | Predator(s):

Life On Top
Activity Sheet

How is this animal affected by the events in the Arctic due to climate change?

Using what you've learned about your animal, write its autobiography telling its own story as if it was reflecting on life in the Arctic:

Life On Top
Activity Sheet / EDUCATOR KEY

How is this animal affected by the events in the Arctic due to climate change?

Answers will vary. The students' answers should reflect what they have learned about the animal that they chose and the impacts of climate change.

Using what you've learned about your animal, write its autobiography telling its own story as if it was reflecting on life in the Arctic:

Answers will vary. The students' autobiographies should reflect what they have learned about the animal that they chose.

LESSON 9

BECOME A CLIMATE SCIENTIST

GRADE LEVEL 6-8

***ARCTIC:** Our Frozen Planet*

LESSON 9

BECOME A CLIMATE SCIENTIST

GRADE LEVEL 6-8

60 minute lesson

STANDARDS (NGSS):

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

MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

FROM THE FILM:

ARCTIC: Our Frozen Planet, highlights the work of global climate scientists, in partnership with the Inuit, as they try to understand how the global climate is changing and how that will affect every single one of us. Climate scientists and meteorologists conduct observations, collect data, and perform experiments to isolate the causes and effects of the changing planet.

LESSON OVERVIEW:

Climate change is warming the Arctic three times as fast as the rest of the globe, and melting ice at record rates. Scientists are confident that there is a strong connection between changes in the Arctic and the weather patterns across the rest of the planet, as our climate continues to warm.

EDUCATOR PREP:

Educator will need to print out **NOAA sea ice extent data**, or let students access the Excel sheet or PDF online.

Educator will need to print out **Arctic Visualization activity sheet** for students.

MATERIALS LIST:

- ***Become a Climate Scientist** activity sheet*
- *Laptops for students*
- *Access to Google Sheets or Excel Docs*
- *NOAA Arctic Sea Ice Extent Data*
  Educator can hand out printouts or give them access to Excel sheet or PDF online
- *Pens/ pencils*

LESSON 9

BECOME A CLIMATE SCIENTIST

LESSON GUIDES:

1. Begin by tapping into students' background knowledge around what they already know about what climate scientists do and how they try to understand how the world around us works, using the following questions:

What do scientists do?

Answers should reflect students' background knowledge about science, the scientific method, and different types of science-related careers. Students should be able to describe how the scientific method helps scientists go from a research question to experimentation to results. They may also be able to hint at the idea that results need to be repeated, verified, and shared with others in the field through a peer-review process. Scientists also need to communicate their findings to peers, and in climate change – the public.

What is the difference between weather and climate? How is the climate changing?

Student responses should reflect their understanding in the difference between weather and climate.

Weather is the day-to-day changes in the atmosphere and how they impact temperatures, precipitation, and other weather phenomena. Meteorologists study the weather – you see them most often on TV, but work in all sectors of business and government.

Climate is the average weather over a long period of time. Climate scientists examine trends over years and decades. Let students explain the difference in overall weather between Canada and Mexico – one is very cold and snowy, the other is very hot and humid – that is climate!

Climate overall is warming across the globe as we add more greenhouse gases that trap heat. Canada is maybe not as cold anymore, and Mexico is even hotter.

Narwhals are one of the best diving mammals, spending a lot of their time under 800 meters (2,625 feet).

Why is the work of climate scientists so important?

Answers should reflect some of the points learned in the film. The climate is changing, rapidly, and is impacting everything from Inuit people to polar bears. Scientists need to examine these trickle-down changes, like melting sea ice, to help us predict the future changes of climate so we can better come up with solutions.

2. Students will now become climate scientists themselves. They will use real data that climate scientists have gathered in the Arctic, as we saw in the film. This data will help students examine trends of sea ice loss in the Arctic.

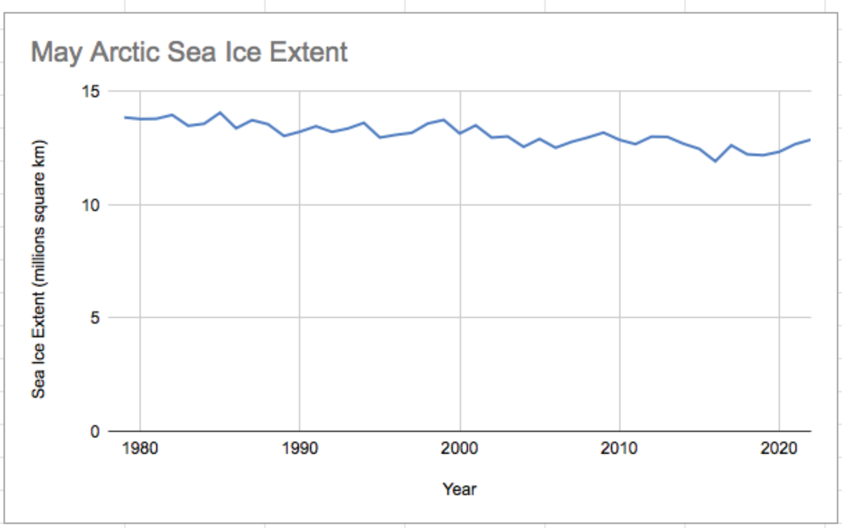
Make sure students have access to the charts with data from NOAA, either printed or digitally. To begin, instruct the students to pick the month of their birthday.

3. Open up a **Google Sheets** or **Excel document.** Paste or type in the data into columns for the month of your birthday. One column should be year; this will be your X-axis. The next column will be sea ice extent; this will be your Y-axis.

Create a line graph from the data. Check students progress to make sure they properly label and title their graph.

Below is an example for the month of May:

YEAR	MAY
1978	
1979	13.86
1980	13.79
1981	13.8
1982	13.97
1983	13.49
1984	13.58
1985	14.07
1986	13.38
1987	13.74
1988	13.56
1989	13.04
1990	13.23
1991	13.47
1992	13.22
1993	13.37
1994	[illegible]



EDUCATOR NOTES:

To make a line graph using Google Sheets:
Insert the data for year/ sea ice extent in two columns. Highlight the columns. At the top tab click "Insert," "Chart." The chart will populate. You can edit chart titles, type, and style on the toggle menu that pops up. This will be needed for later activities in this lesson.

To make a line graph using Excel:
Insert the data for year/ sea ice extent in two columns. Highlight the columns. At the top tab click, "Chart," "Line." The chart will populate. You can edit chart titles, type, and style in the "Chart" and "Chart Layout" tabs. This will be needed for later activities in this lesson.

Hills and Valleys vs. Trends

As students examine their line graphs, make sure they understand the difference between year-to-year variation and overall trend. The little hills and valleys you see are the year-to-year ups and downs, or the weather. But if you look at the line overall…where is it headed? Is it a straight line? Is it slanted headed up or headed down? The overall trend is the climate.

Helpful analogy: When you walk your dog, your dog may swerve right and left to pick up a stick or sniff some flowers. Your dog is curving up and down like the hills and valleys. Both of you are headed in the same direction even though there is some deviation to your path.

You are walking straight ahead in one direction; you are the climate trend; while the dog is curving here and there a bit, so he is the year-to-year variation.

Let's make a prediction:

How will your birthday month sea ice continue to trend in the future?

4. Let students examine their trends and compare with each other. Discuss in small groups. Most of them will be declining trends, but some will have larger, steeper trends than others.

A "super pack" of wolves has adapted by increasing their numbers to survive in the Arctic.

Develop a Hypothesis:

Why are some trends more extreme than others?

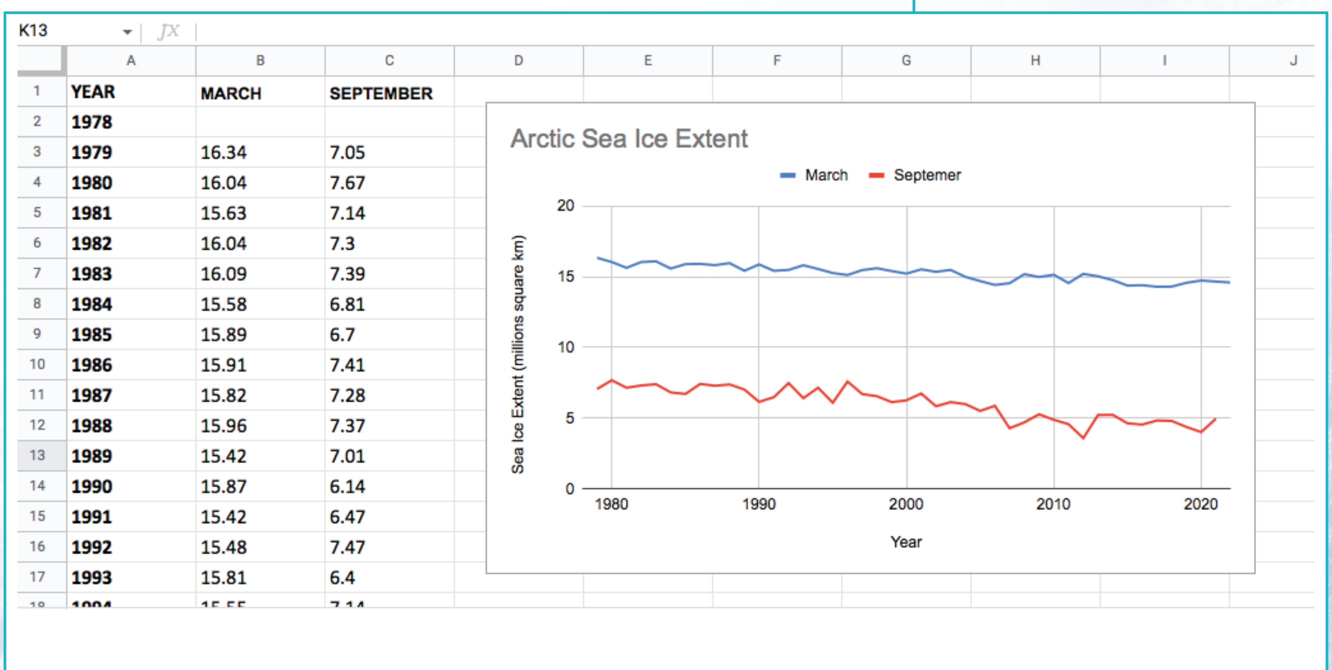
This is because of the seasonality of Arctic sea ice. Even without climate change, Arctic sea ice has a season of growth in colder winter months, and a season of melt in warmer summer months. As our climate warms, winter growth is slowing to a halt, and summer melt is increasing at record rates. Students should see these different trends in the data.

Anyone with a winter birthday will have a slower decline. Anyone with a summer birthday will have a steeper, more extreme decline.

5. Let's examine this concept of seasonality more directly. Go back to your NOAA data. On your Google or Excel sheet, type in or paste the data for March and September. Make sure to include the years. Years will be your X-axis again; the sea ice extent data should be your Y-axis again.

Create a line graph, labeling titles, axis, and legend. Students should put both trend lines on one chart with a color-coded legend. See example results below.

EDUCATOR NOTES:



	A	B	C
1	YEAR	MARCH	SEPTEMBER
2	1978		
3	1979	16.34	7.05
4	1980	16.04	7.67
5	1981	15.63	7.14
6	1982	16.04	7.3
7	1983	16.09	7.39
8	1984	15.58	6.81
9	1985	15.89	6.7
10	1986	15.91	7.41
11	1987	15.82	7.28
12	1988	15.96	7.37
13	1989	15.42	7.01
14	1990	15.87	6.14
15	1991	15.42	6.47
16	1992	15.48	7.47
17	1993	15.81	6.4

6. Point out that results show that September has a much steeper rate of sea ice loss than March. Ask students:

Why does September show a much steeper rate of sea ice loss than March?

September shows an even steeper trend. Why? September wraps up summer. The warmest months in the Arctic are June, July, and August. This was always slated as the natural season of melt, but what's happening over the last few decades? Arctic sea ice is melting even more than what's considered "normal," because of the warming climate.

Examination: Seasonality of Arctic Sea Ice

March wraps up the winter season of growth. The coldest months in the Arctic are December, January, and February. So, this is typically the season of sea ice growth. March should show your biggest volumes of sea ice for the year, after growing all winter. But, what is happening in March over the last few decades? Note the small decline in extent.

Make a prediction:

How will the sea ice continue to trend in the future? How will this trend vary by season?

Student answers will vary.

7. Now let's explain our findings to the public. Remember, we mentioned climate scientists are important because a lot of these changes are happening rapidly. In the Arctic, this means changes impacting the Inuit people and polar bears.

For the globe, climate change impacts all of us every day, from extreme weather to health, agriculture and ocean ecosystems.

How do we get this data and its message across in a clear, catchy way? Use the visualization activity sheet to analyze some examples from actual climate scientists doing this work today.

A seal swims just below a hole in the ice.

Color, Line and Shape:

Ask students to consider the use of colors, lines, and shapes.

Do these tools make it easier to understand the sea ice decline or temperature warming trend data? Can you spot the rapid changes more easily?

Student answers will vary.

Will someone without a science background understand these graphics? Why or why not?

Jot down notes on your activity sheet and discuss in small groups.

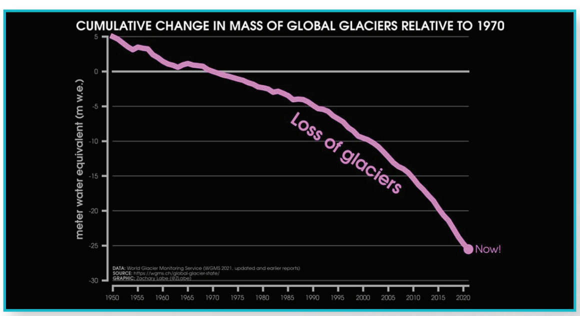
8. Ask students to look at our trend comparison for March and September again. Try different chart style and colors.

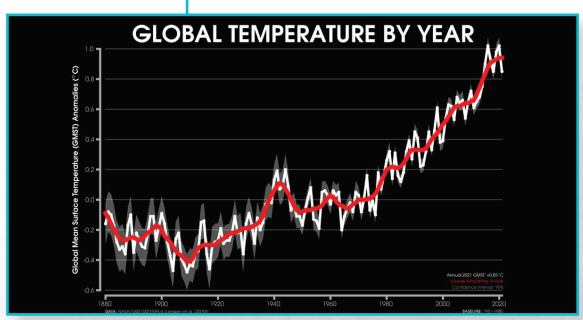
What are some other ways you can visualize this data to show the extreme melt in sea ice?

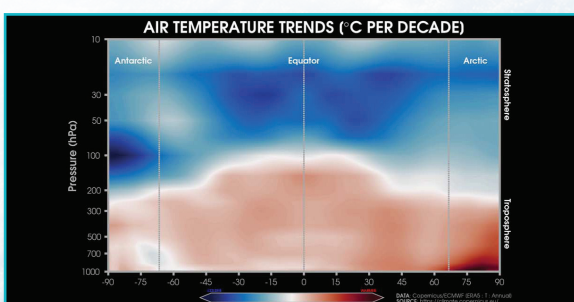
Make sure all graphs are labeled with chart and axis titles and legends.

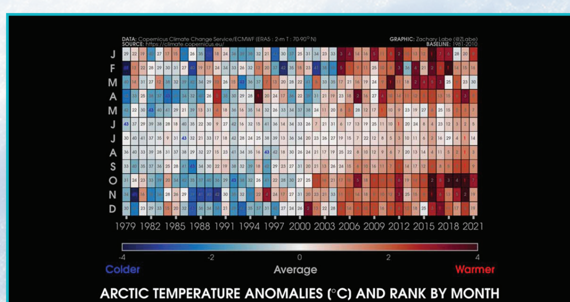
EDUCATOR NOTES:

Data visualization examples:









DATA VISUALIZATION COURTESY OF ZACHARY M. LABE, PH.D.

9. Ask the students to share and present your charts with other classmates. Have them explain the reasons as to why they chose the style, and how they think it communicates your data efficiently.

Reflection on the Process:

Is it easy to clearly convey the message of this data?

This is a challenging task. Remember, not everyone has an understanding of climate science, or climate science in the Arctic, as you do now.

What are some challenges you come across in trying to present your data?

Student answers may vary.

Caribou are highly migratory, moving seasonally from place to place, and affecting the ecology of the areas they traverse.

NOAA Arctic Sea Ice Extent Data - measured in millions square km

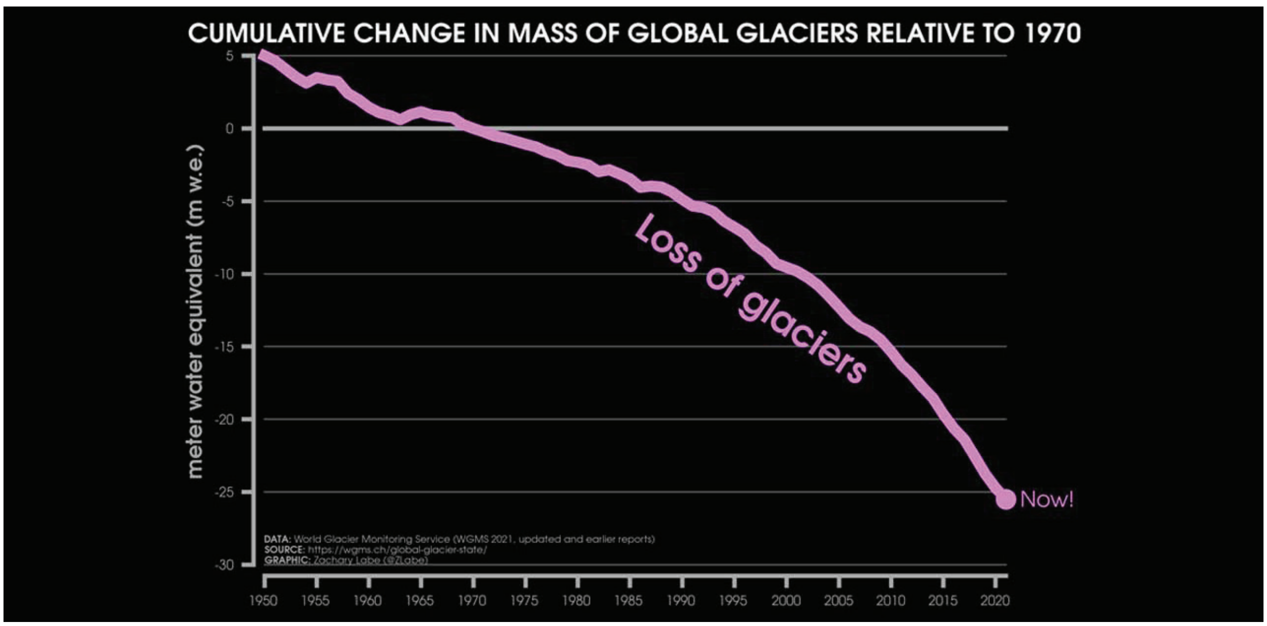
YEAR	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1978	–	–	–	–	–	–	–	–	–	–	11.65	13.67
1979	15.41	16.18	16.34	15.45	13.86	12.53	10.31	8.04	7.05	8.75	10.94	13.34
1980	14.86	15.96	16.04	15.43	13.79	12.2	10.1	7.98	7.67	9.18	11.38	13.59
1981	14.91	15.6	15.63	15.01	13.8	12.43	10.27	7.84	7.14	8.86	10.93	13.34
1982	15.18	15.97	16.04	15.47	13.97	12.48	10.37	8.14	7.3	9.42	11.63	13.64
1983	14.94	16.01	16.09	15.17	13.49	12.3	10.57	8.19	7.39	9.33	11.46	13.3
1984	14.47	15.3	15.58	15.01	13.58	12.15	9.98	7.77	6.81	8.56	10.84	12.99
1985	14.72	15.47	15.89	15.36	14.07	12.22	9.74	7.4	6.7	8.55	11.02	13.05
1986	14.89	15.78	15.91	15.06	13.38	11.98	10.15	7.98	7.41	9.48	11.45	13.22
1987	14.97	16.05	15.82	15.21	13.74	12.49	10.33	7.63	7.28	9.05	11.22	–
1988	–	15.58	15.96	15.12	13.56	11.94	9.81	7.89	7.37	9.13	11.33	13.63
1989	14.95	15.5	15.42	14.33	13.04	12.24	10.13	7.88	7.01	8.83	11.12	13.39
1990	14.78	15.58	15.87	14.65	13.23	11.64	9.25	6.8	6.14	8.48	11.08	13.11
1991	14.36	15.25	15.42	14.86	13.47	12.11	9.51	7.42	6.47	8.54	10.88	12.95
1992	14.64	15.46	15.48	14.68	13.22	12.15	10.32	7.93	7.47	9.32	11.38	13.41
1993	14.9	15.69	15.81	15.08	13.37	11.87	9.48	7.33	6.4	8.79	11.32	13.32
1994	14.73	15.56	15.55	14.89	13.62	12.02	9.93	7.64	7.14	8.92	11.12	13.27
1995	14.59	15.23	15.26	14.45	12.97	11.44	8.99	6.74	6.08	7.83	10.76	12.92
1996	14.18	15.15	15.12	14.22	13.09	12.08	10.16	8.18	7.58	9.16	10.4	12.86
1997	14.42	15.44	15.47	14.56	13.18	11.74	9.41	7.29	6.69	8.34	10.68	13.08
1998	14.72	15.75	15.6	14.89	13.59	11.71	9.42	7.51	6.54	8.45	10.44	12.76
1999	14.36	15.31	15.4	15.08	13.75	11.78	9.49	7.23	6.12	8.6	10.8	12.64
2000	14.22	15.14	15.22	14.56	13.15	11.67	9.51	7.17	6.25	8.38	10.32	12.64
2001	14.2	15.21	15.52	14.86	13.51	11.46	9.07	7.46	6.73	8.3	10.66	12.49
2002	14.27	15.34	15.35	14.3	12.97	11.58	9.27	6.6	5.83	8.16	10.34	12.61
2003	14.39	15.19	15.48	14.51	13.02	11.6	9.21	6.94	6.12	7.85	10.13	12.59
2004	14.03	14.91	14.99	13.99	12.56	11.45	9.43	6.85	5.98	7.93	10.34	12.55
2005	13.66	14.37	14.69	14.09	12.91	11.16	8.65	6.3	5.5	7.35	10.22	12.23
2006	13.47	14.32	14.42	13.91	12.52	10.92	8.46	6.5	5.86	7.54	9.66	11.95
2007	13.7	14.51	14.54	13.85	12.78	11.22	7.94	5.34	4.27	6.04	9.76	12.03
2008	13.89	14.95	15.18	14.35	12.97	11.21	8.68	5.91	4.69	7.35	10.34	12.36
2009	13.91	14.81	14.98	14.5	13.19	11.32	8.47	6.14	5.26	6.92	9.77	12.2
2010	13.74	14.58	15.14	14.66	12.87	10.59	8.07	5.87	4.87	6.98	9.61	11.83
2011	13.46	14.36	14.55	14.11	12.68	10.75	7.72	5.5	4.56	6.46	9.77	12.15
2012	13.73	14.55	15.2	14.63	13.01	10.67	7.67	4.72	3.57	5.89	9.39	12.01
2013	13.7	14.72	15.03	14.3	13	11.36	8.13	6.01	5.21	7.45	9.94	12.18
2014	13.65	14.42	14.76	14.09	12.7	11.03	8.11	6.08	5.22	7.23	10.11	12.35
2015	13.6	14.4	14.37	13.89	12.47	10.88	8.38	5.6	4.62	6.97	9.85	12.04
2016	13.46	14.2	14.4	13.68	11.92	10.41	7.94	5.37	4.53	6.08	8.66	11.46
2017	13.19	14.12	14.29	13.75	12.63	10.76	7.94	5.48	4.82	6.77	9.49	11.74
2018	13.08	13.97	14.3	13.7	12.23	10.78	8.27	5.61	4.79	6.13	9.82	11.86
2019	13.57	14.39	14.57	13.43	12.19	10.59	7.59	5.03	4.36	5.73	9.35	11.9
2020	13.64	14.64	14.73	13.62	12.34	10.59	7.29	5.07	4	5.33	8.99	11.73
2021	13.5	14.39	14.66	13.79	12.68	10.77	7.65	5.71	4.95	6.82	9.83	12.15
2022	13.88	14.61	14.59	14.04	12.88	–	–	–	–	–	–	–

Become A Climate Scientist

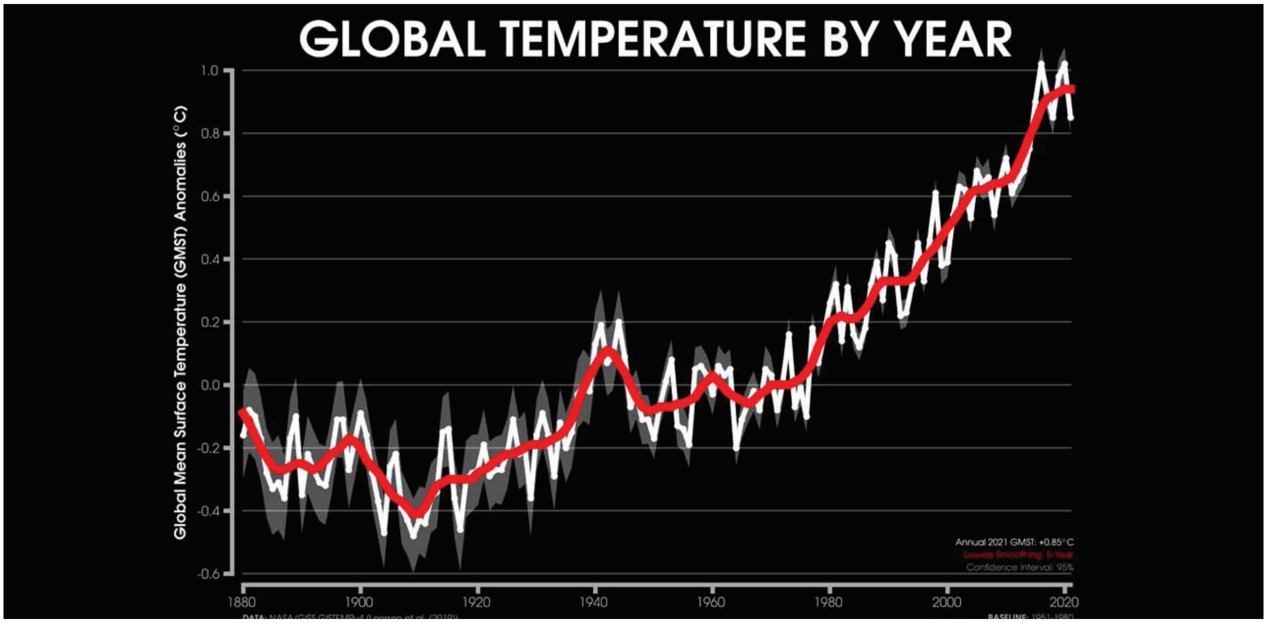
Arctic Visualization Activity Sheet

For each graph, first determine what is the variable and how is it trending.

Is the trend extreme or slow and steady? Then, study the use of lines, colors, and shapes. How does this help make the trend clearer to the public? Record your notes in the space provided, and discuss in small groups.



Data Visualization Courtesy of Zachary M. Labe, Ph.d.



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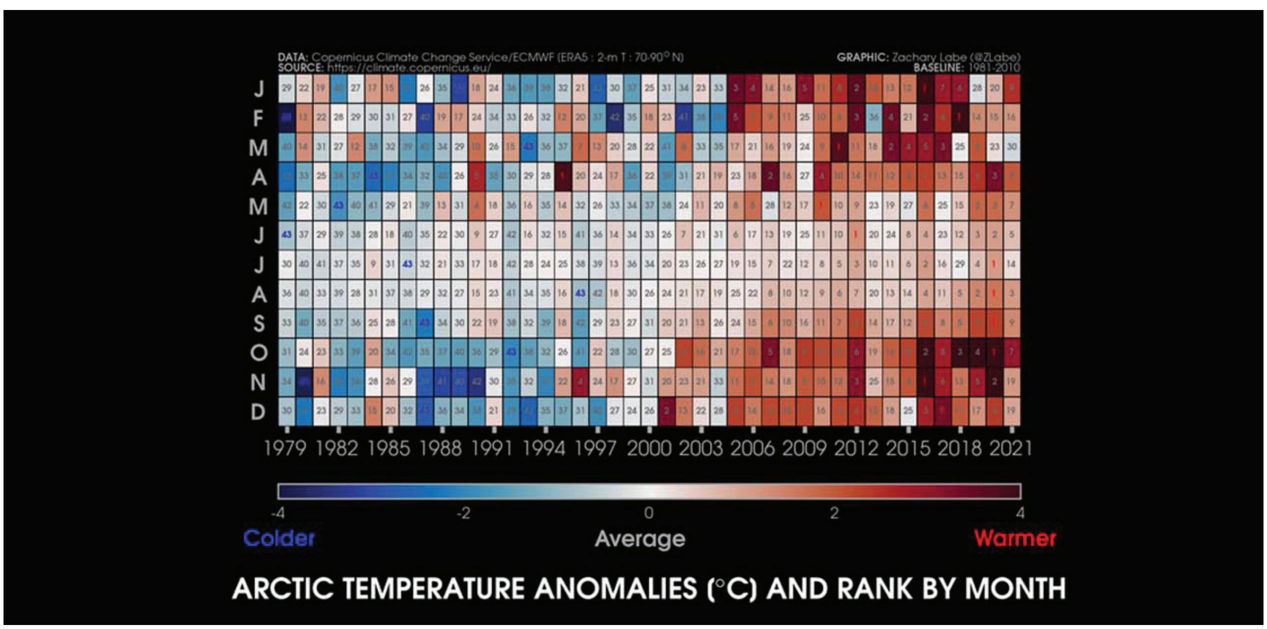
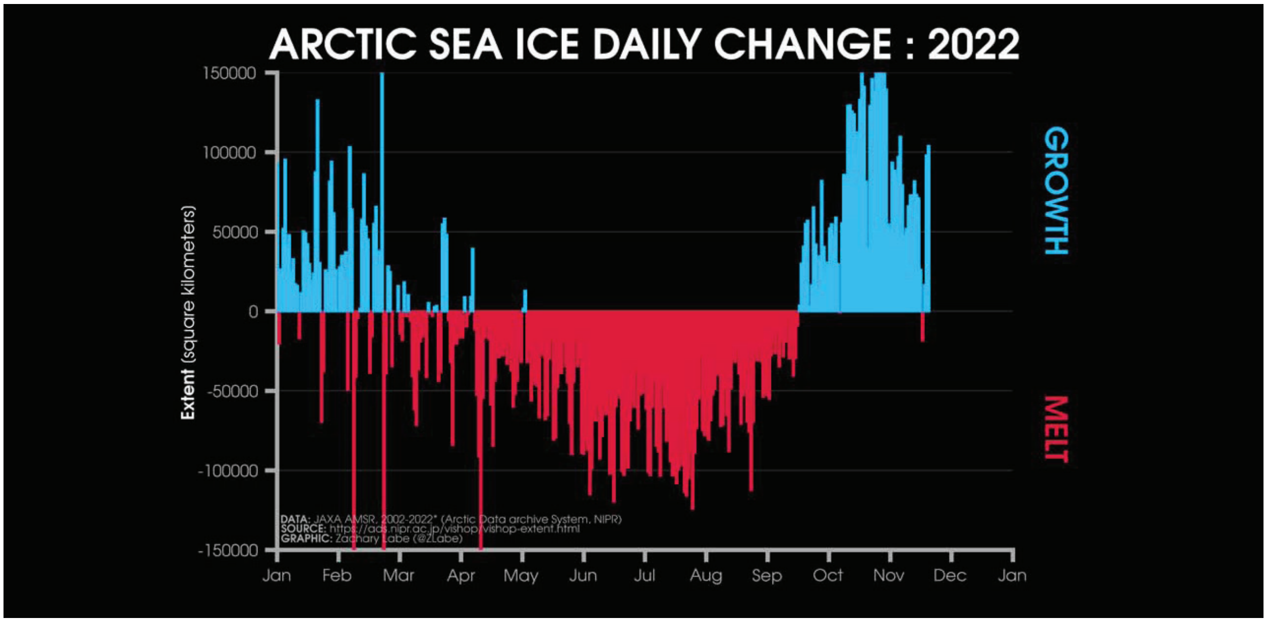


Data Visualization Courtesy of Zachary M. Labe, Ph.d.



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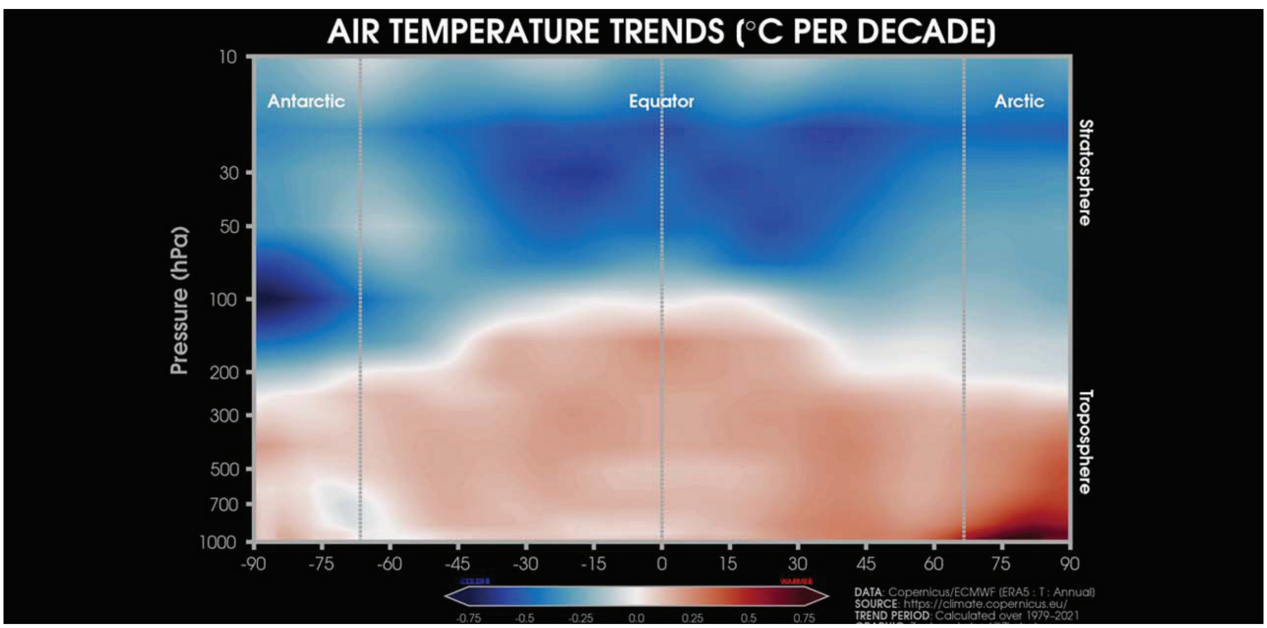

Data Visualization Courtesy of Zachary M. Labe, Ph.d.

Become A Climate Scientist

Arctic Visualization Activity Sheet / **EDUCATOR KEY**

For each graph, first determine what is the variable and how is it trending.

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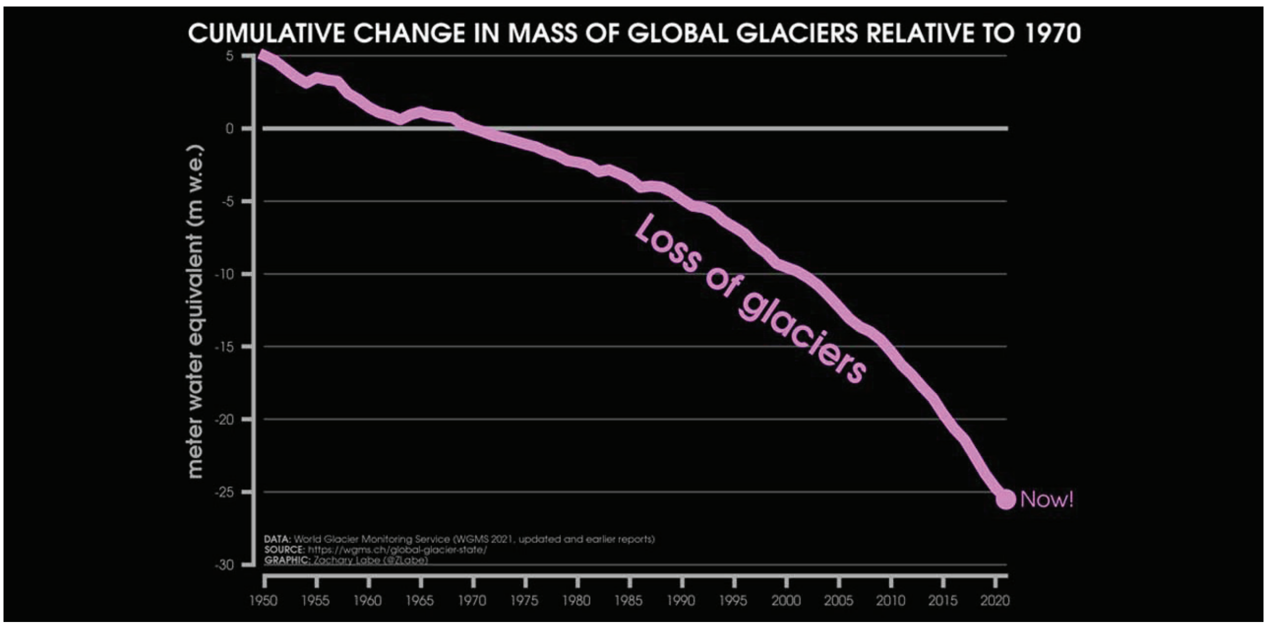
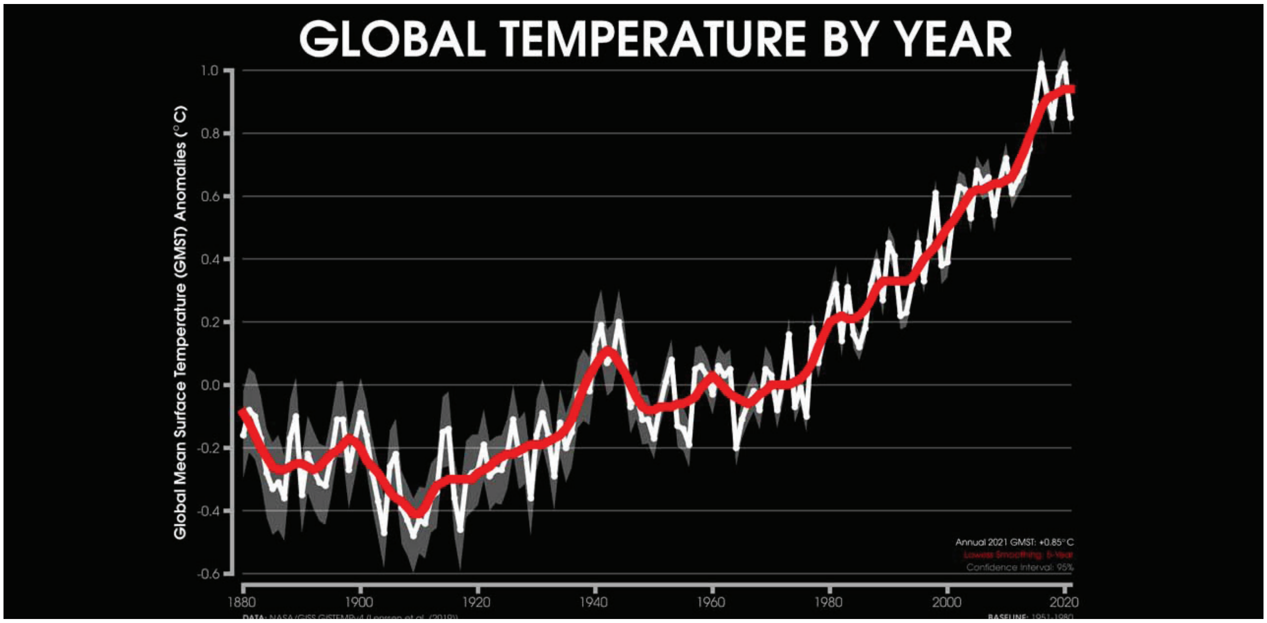


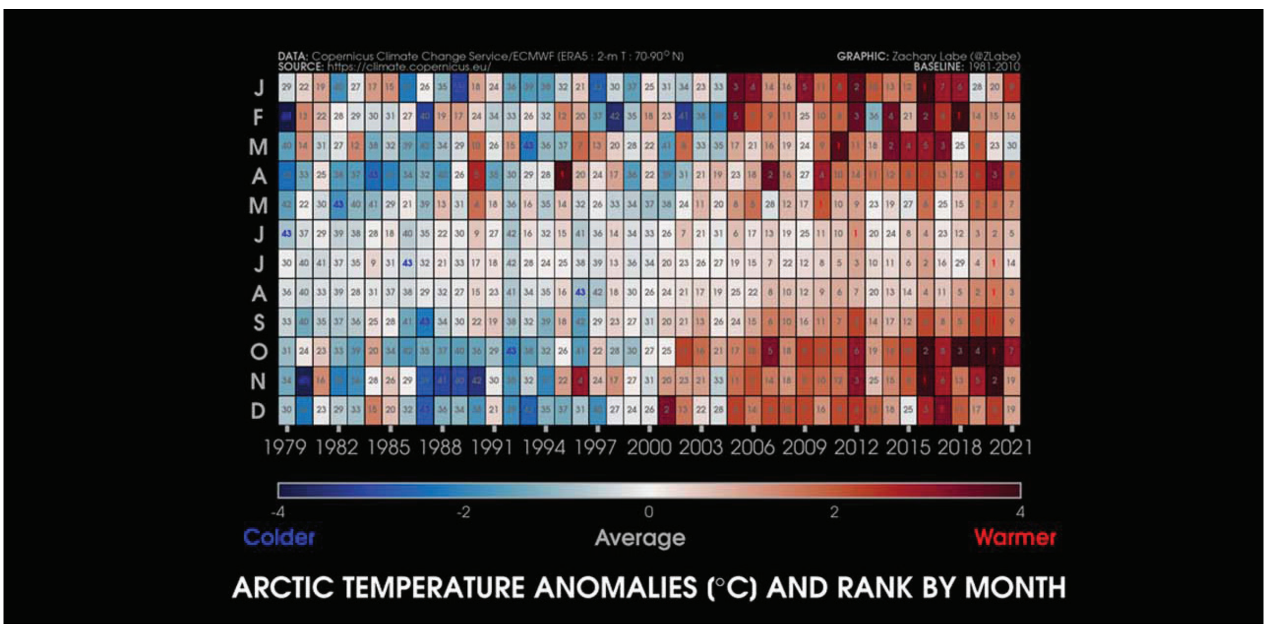
Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This line graph shows the reduction in mass of global glaciers beginning in 1950 and using the amount in 1970 as a refernce point. Over the past 70 years, an obvious trend of diminished glaciers emerges.



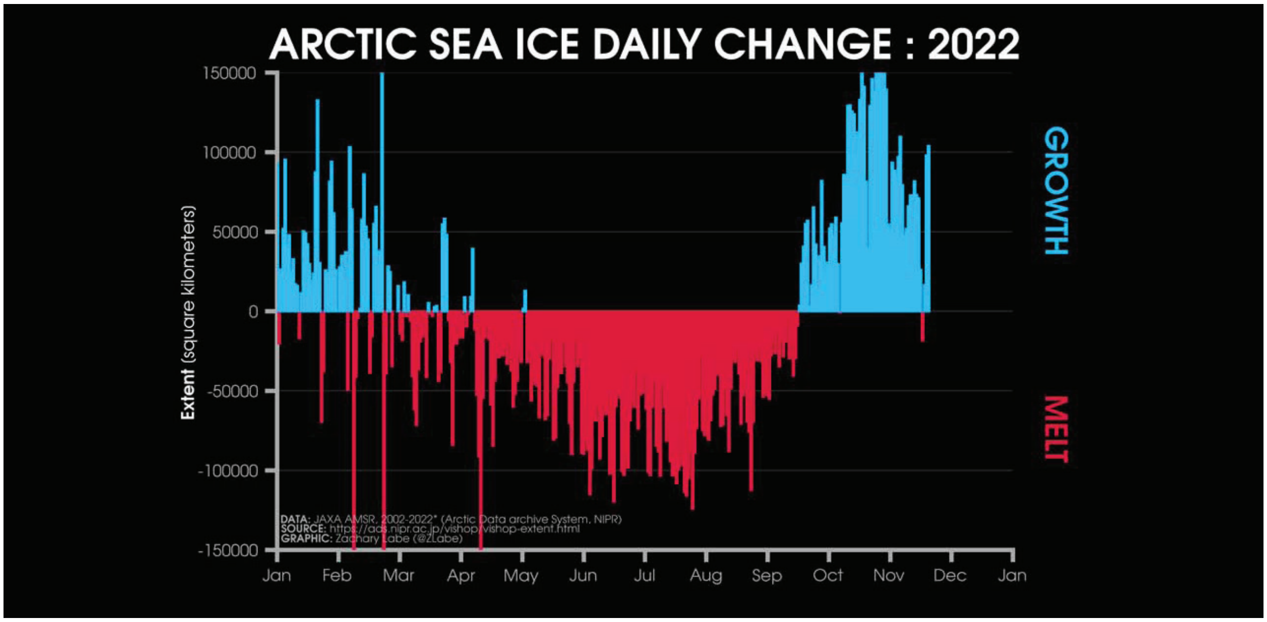
Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This graph seems to show both the up and down nature of temperature over a short period of time, but then the steady upward trend of the line as a whole beginning at about 1930.



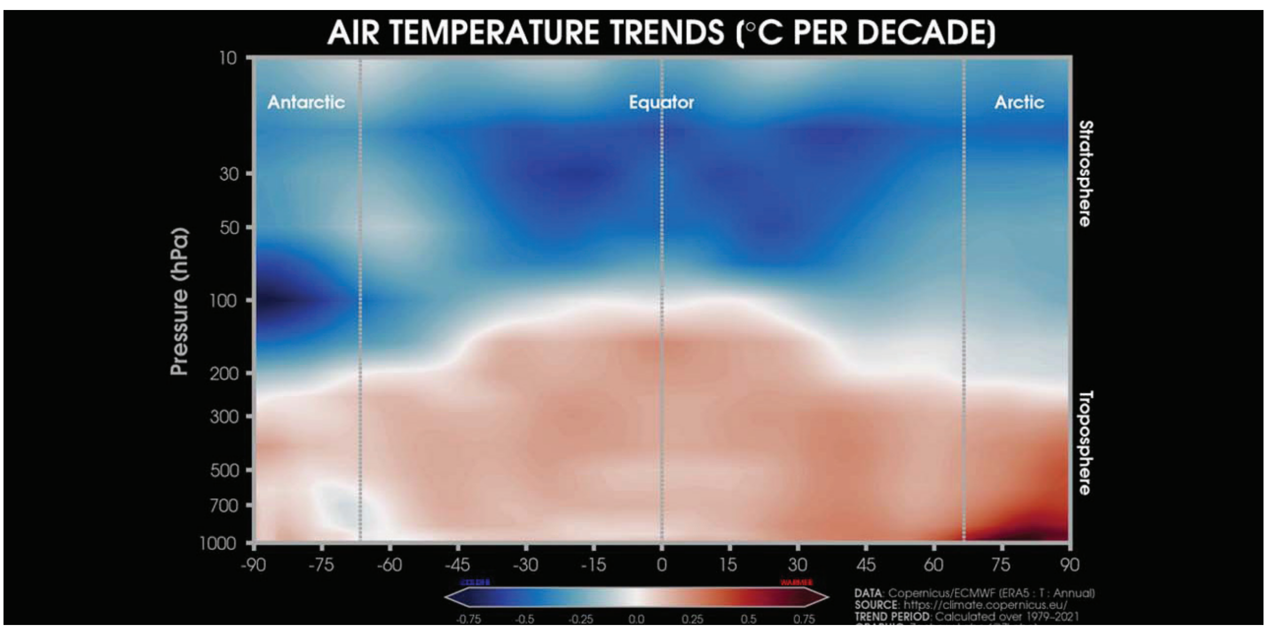
Data Visualization Courtesy of Zachary M. Labe, Ph.d.

Graphs with anomalies can help to show variation or differences in a data set over time. In this graph, we can see that around the early 1990s, the variation increased and the Arctic temperatures become increasingly warmer.



Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This shows the daily change of sea ice for the year 2022 for each month. Growth refers to freezing and we can compare the amount of freezing and thawing that happens over the course of the year and see the trend that emerges: more melting, then freezing.



Data Visualization Courtesy of Zachary M. Labe, Ph.d.

This visualization shows the ways in which mean air temperature changes at different places in the atmosphere.