GLOBE Educator One-Week Pacing Guide: Experiencing a Solar Eclipse

This product is supported by the NASA Heliophysics Education Activation Team (NASA HEAT), part of NASA's Science Activation portfolio.

Phenomenon: Solar Eclipses **Grade Level:** 3-12	**Guiding Question:** What do scientists learn about Earth's atmosphere from solar eclipses?	**Contact:** Reach out to the GLOBE Program GLOBE Observer Eclipse Team if you have questions.
Further Investigation: What is GLOBE Observer Eclipse? and The GLOBE Program's main website		
Optional: Become a GLOBE Trained Teacher: GLOBE Protocol Training		
Access GLOBE Pacing Guides: https://www.globe.gov/web/nasa-langley-research-center/home/resources		
Revision Date: 8-10-2023		

Standards - These standards are supported by the activities in this guide but not completely covered.		
Elementary	**Performance Expectations:** ● 5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.	**Disciplinary Core Ideas:** ● ESS1.A The Universe and its Stars ● ESS1.B Earth and the Solar system
	Science and Engineering Practices: ● Analyzing and Interpreting Data ● Engaging in Argument from Evidence	**Crosscutting Concept:** ● Patterns ● Scale, Proportion, and Quantity

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

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Middle	**Performance Expectations:** ● MS-ESS1-1 Develop and use a model of the Earth-Sun-Moon system to describe cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.	**Disciplinary Core Ideas:** ● ESS1.A The Universe and its Stars ● ESS1.B Earth and the Solar System
	Science and Engineering Practices: ● Developing and Using Models	**Crosscutting Concepts:** ● Patterns ● Cause and Effect ● Scale, Proportion and Quantity
High	**Performance Expectations:** ● HS-ESS1-4 - Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	**Disciplinary Core Ideas:** ● ESS1.A The Universe and its Stars ● ESS1.B Earth and the Solar System
	Science and Engineering Practices: ● Developing and Using Models ● Use Mathematical and Computational Thinking	**Crosscutting Concepts:** ● Patterns ● Cause and Effect ● Scale, Proportion and Quantity

Background Information and NASA Connection

Remember to never look directly at the Sun without proper safety equipment.

What is a solar eclipse?

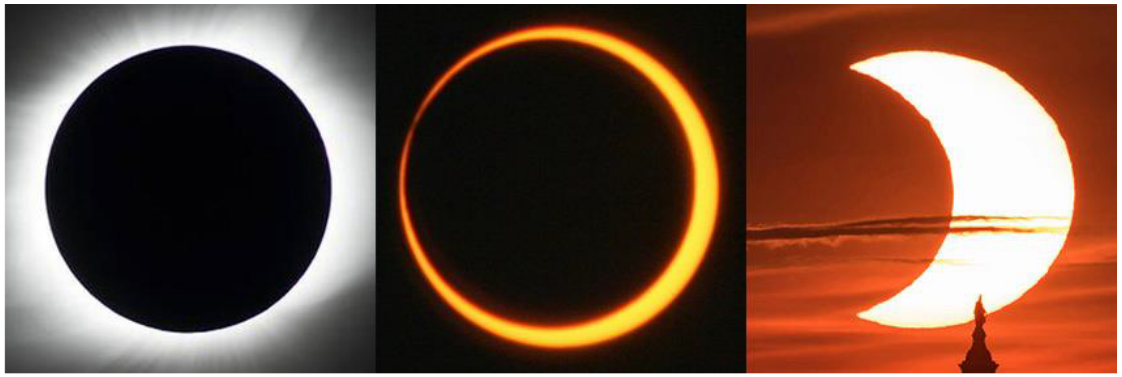
A solar eclipse occurs when the Moon is between the Sun and Earth, and with the right conditions, the Moon casts a shadow on Earth's surface.

The Moon's shadow has two parts. The penumbra is the faint outer shadow of the moon. Partial eclipses are seen from within this shadow. The umbra is the dark inner shadow of the moon. Total eclipses are seen from within this shadow.

The phenomenon of a solar eclipse is possible because even though the Sun is about 400 times larger than the Moon, the Sun is about 400 times farther away from Earth than the Moon is. This ratio of the size and distance of these objects makes them appear the same size in the sky.

What are the different types of solar eclipses?

A **total solar eclipse** occurs when the Moon completely blocks the Sun; a **partial solar eclipse** occurs when only part of the Sun is blocked by the Moon. A third type of solar eclipse happens when the the Moon is farther away in its orbit around the Earth making it appear smaller, only blocking 90% of the Sun's disk. Although technically a partial solar eclipse, this type of eclipse is called an **annular solar eclipse**.



Total Solar Eclipse | Annular Solar Eclipse | Partial Solar Eclipse

From left to right, these images show a total solar eclipse, annular solar eclipse, and partial solar eclipse. A hybrid eclipse appears as either a total or an annular eclipse (the left and middle images), depending on the observer's location. Credits: Total eclipse (left): NASA/MSFC/Joseph Matus; annular eclipse (center): NASA/Bill Dunford; partial eclipse (right): NASA/Bill Ingalls

Total vs. Partial Solar Eclipses

The difference between a **total and partial eclipse** is where in the Moon's shadow the observer is located. Observers in the **umbra** shadow will experience a **total solar eclipse**. Observers in the **penumbra** shadow will experience a **partial solar eclipse**. The umbra shadow is much smaller, making experiencing a total solar eclipse more rare.

The Moon's shadow has two parts. The penumbra is the faint outer shadow of the moon. Partial eclipses are seen from within this shadow. The umbra is the dark inner shadow of the moon. Total eclipses are seen from within this shadow.

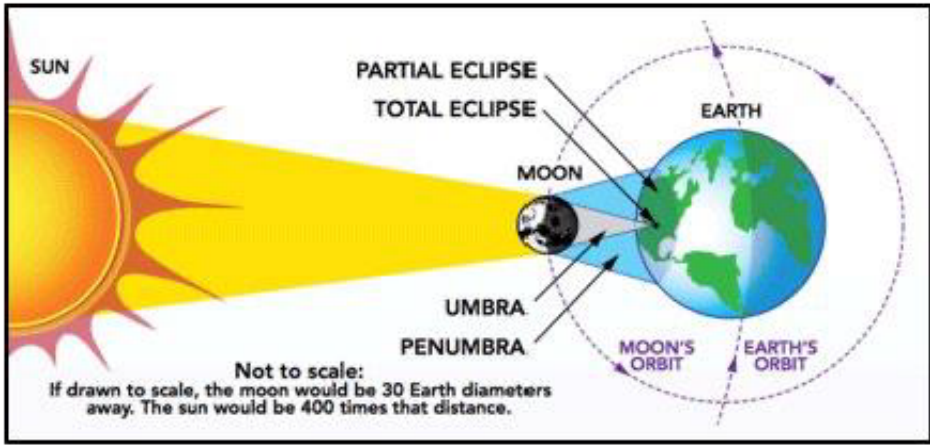


Image Credit: NASA

Total vs. Annular Solar Eclipses

The difference between a **total and annular eclipse** is the distance between the Moon and Earth. The reason that the Moon is not always the same distance from Earth is because the shape of the Moon's orbit around Earth is in the shape of an **ellipse**, or an oval. During a solar eclipse, if the Moon is closer to **perigee**, the eclipse will be total. If the Moon is closer to **apogee**, the eclipse will be annular.

This graphic shows the difference between a Moon at its closest point to Earth, when supermoons occur, and at its farthest. Credit: NASA/JPL-Caltech.

Solar Eclipse Safety

Always use the proper safety equipment to observe the Sun. Solar filters are 1000 times darker than sunglasses and block all infrared and UV light, and nearly all visible light. If you don't have solar eclipse glasses or a solar filter for your telescope or binoculars, there are **indirect ways** to safely observe the Sun, like using a **pinhole projector**.

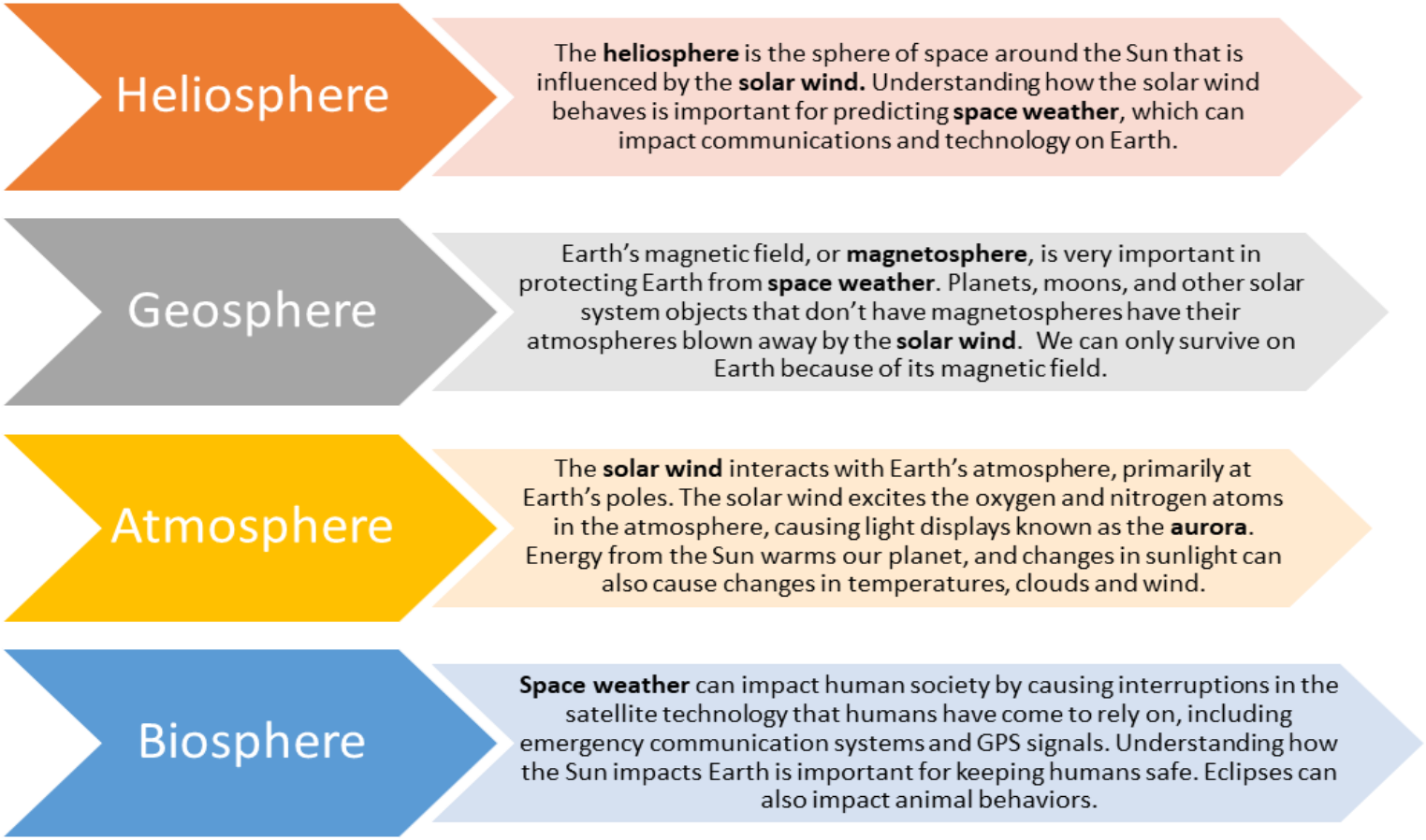
Eclipse glasses and sunglasses. Sunglasses are not safe to wear to observe a solar eclipse., Image Credit: NASA.

Why does NASA study solar eclipses?

"Studying the innermost part of the corona – visible only during total solar eclipses – is key to answering fundamental questions about how heat and energy are transferred from the Sun out into the solar wind, the constant stream of particles that the Sun spews into the solar system. The solar wind can impact humans and technology at Earth, so understanding how it becomes accelerated at the Sun can help predict its impacts at home.

Total solar eclipses provide an opportunity to study Earth's atmosphere under uncommon conditions. In contrast to the global change in light that occurs every day at dusk and dawn, a solar eclipse changes illumination of Earth and its atmosphere under a comparatively small region of the Moon's shadow. This localized blocking of solar energy is useful for studying the Sun's effects on our atmosphere, especially the upper atmosphere, where the Sun's energy creates a layer of charged particles called the ionosphere. Understanding this region is important because it's home to many low-Earth orbit satellites as well as communications signals, such as radio waves and the signals that make GPS systems work, and changes there can have significant impacts on our technology and communication systems. Scientists are also interested in how changes in sunlight impact clouds, temperatures, wind and animal behaviors.

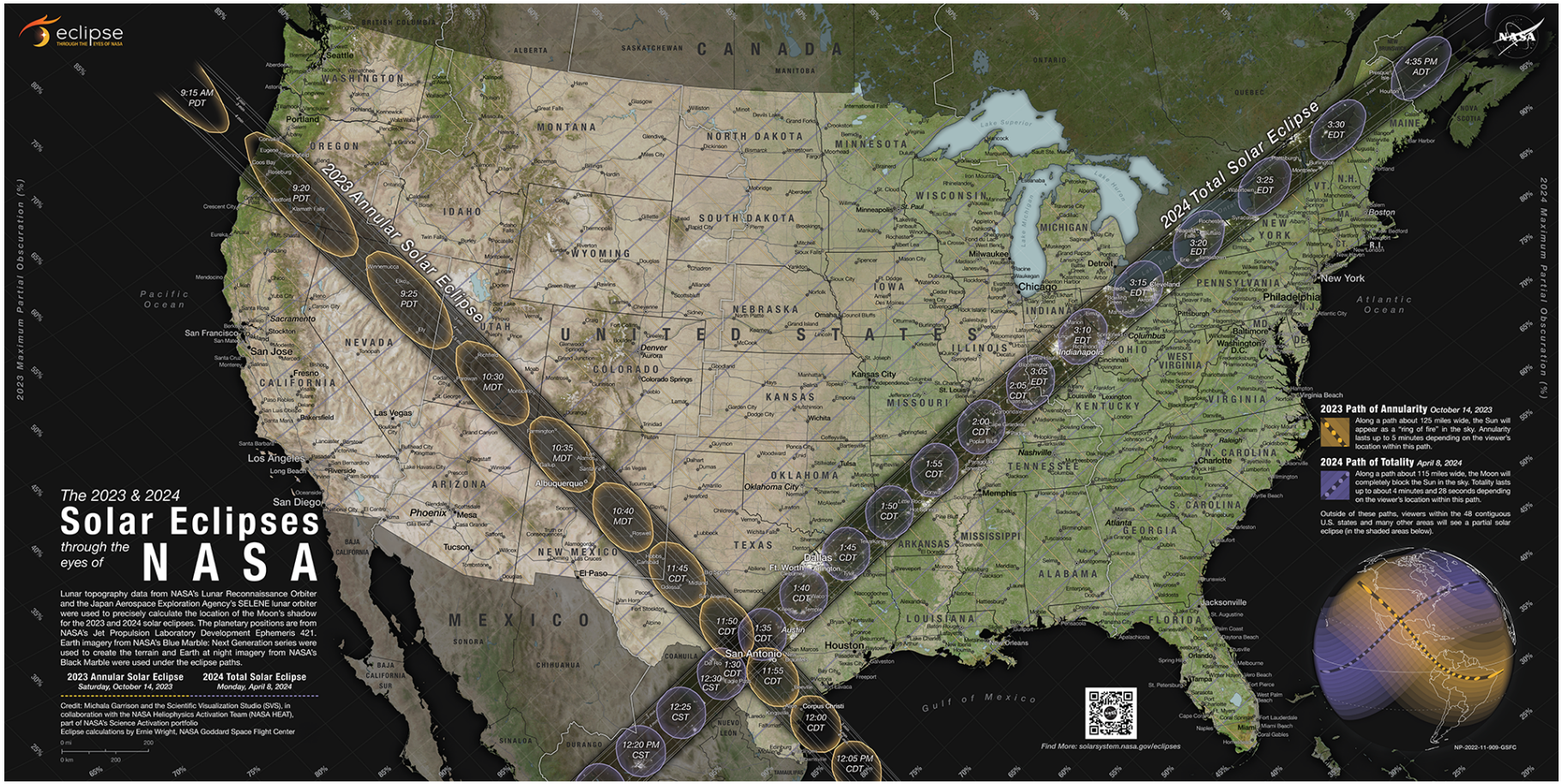
Scientists use instruments called coronagraphs to block the Sun's light in a manner similar to a total eclipse, but these instruments still struggle to reveal the region of the corona closest to the Sun, where many important processes occur." More information is available at [NASA Eclipse Science.]



Space weather from the Sun's heliosphere interacts with Earth's geosphere, atmosphere and biosphere., Credit: NASA.

Eclipse Locations

NASA's 2023 and 2024 Solar Eclipse Map shows the path of the 2023 annular eclipse and the 2024 total eclipse. The video A Tour of NASA's 2023 and 2024 Solar Eclipse Map explains how to interpret the map.



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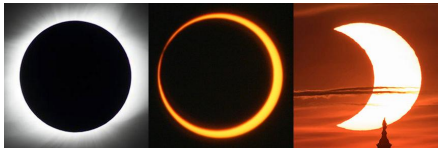
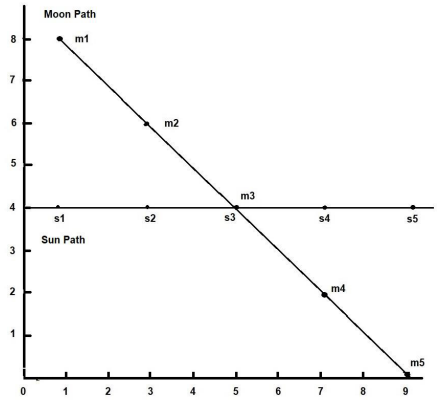
Activities		Assessment Options
Day 1: What are the Different Types of Solar Eclipses ● Complete the My NASA Data What are the Different Types of Solar Eclipses Lesson Plan. **Materials:** ● piece of yarn ● two pushpins ● a piece of cardboard larger than a piece of paper ● a piece of paper ● a pencil ● Student Sheets (optional)		Formative Assessment: Completed model and/or student sheets. ***Connection to guiding question:*** *What are the different types of solar eclipses?* ***Answer:*** *partial, total, annular and hybrid*
Day 2: Modeling Solar Eclipse Geometry ● Complete the My NASA Data Lesson Plan Modeling Solar Eclipse Geometry ○ For Grades 3-5 use Modeling Sun-Moon Positions for Solar Eclipses **Materials:** ● 1 sheet of 8.5 x 11 graph paper ● 2 disks approximately the size of a quarter, ● One disk approximately the size of a nickel ● Pencil ● Ruler ● Optional students sheets found in lesson	 'Moon and Sun Paths' mathematical model graph. Credit: NASA	Formative Assessment: Completed data tables and question answers. ***Connection to guiding question:*** *What is necessary for a total solar eclipse?* ***Answer:*** *The Sun, Moon and Earth have to be positioned correctly so that the Moon blocks the light from the Sun and casts a shadow on Earth.*

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Activities		Assessment Options
Day 3: Safely Observing the Sun ● Complete the My NASA Data Interactive Lesson Safely Observing the Sun ● Reminder: You can use a pinhole projector even when there is not an eclipse. **Materials:** Slide deck in interactive lesson. Items for pinhole projector. Options are in the lesson. Additional Options for pinhole projectors: ● Pinhole Prediction Activity (found in the Extensions section of Safely Observing the Sun Lesson Plan) ● 3D Print Files for Pinhole Projectors ○ 2023 Annular Solar Eclipse - USA Map - NASA Pinhole Projector File ○ 2024 Total Solar Eclipse - USA Map - NASA Pinhole Projector	 View the eclipse with special eclipse glasses.  Regular sunglasses are not safe to view the eclipse.	Formative Assessment: pinhole projector observations. ***Connection to guiding question:*** *What type of eclipse will you be viewing? What is your plan to safely view the eclipse?* ***Answer:*** *Answers will vary depending on the location and date. The 2023 eclipse will be an annular eclipse, some locations will have a partial eclipse. The 2024 eclipse will be a total eclipse, but some locations will experience a partial eclipse. Plans to safely view the eclipse should emphasize that the only way to look directly at the Sun safely is when wearing eclipse glasses or during complete totality. There is no time during an annular eclipse when the glasses are not needed. Alternatively, a pinhole projector may be used.*

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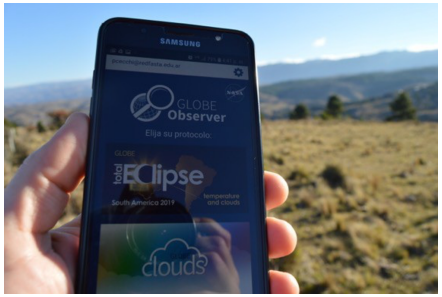
Activities		Assessment Options
Day 4: GLOBE Observer Eclipse Tool **Annular Eclipse - October 14, 2023 or Total Eclipse April 8, 2024** **Remember to never look directly at the Sun without proper safety equipment. Only make observations if you can do so safely and legally.** Make observations during an eclipse using the GLOBE Program GLOBE Observer Eclipse Tool. If the app is not available, use the data collection sheet and enter data later, or use the journal page. **Materials:** ● GLOBE Program GLOBE Observer Eclipse Tool OR ● Journal Page		Formative Assessment: Within groups, develop consensus on observations using evidence and submit observations. ***Connection to guiding question:*** *What changes did you notice during the eclipse?* ***Answer:*** *Accept reasonable responses.* Optional Instructional Video: GLOBE Observer Eclipse App

Activities		Assessment Options
Day 5: How does a Solar Eclipse Affect Air Temperature? ● Complete the My NASA Data Mini Lesson How does a Solar Eclipse Affect Air Temperature? **Materials:** student sheets found in mini lesson		Formative Assessment: Mini Lesson questions. ***Connection to guiding question:*** *What was the overall air temperature impact of the 2017 eclipse? What did you experience?* ***Answer****:* ● *In the penumbra, there was approximately a 2-4 degrees temperature drop in many locations.* ● *In the umbra, there was approximately a 1-3 degrees temperature drop in many locations.* ● *Not all locations are the same, and with careful examination, you may find some locations with temperature increases.* ● *Most locations in the umbra have a greater temperature variation.* ● *Personal experiences may vary.* ***Connection to NASA:*** *Why is NASA interested in your eclipse observations?* ***Answer:*** *NASA can study the effects of a solar eclipse on the Earth system. This includes clouds, temperatures, wind and living things. NASA scientists are trying to answer how these conditions change during eclipses.*

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Additional Resources		
Online Activities	Audience	Description
Lunar and Solar Eclipses	Elementary	NASA Science SpacePlace Lunar and Solar Eclipses
What is the Difference between a Solar Eclipse and a Lunar Eclipse?	Elementary and Middle School	My NASA Data Mini Lesson. In this activity students will examine NASA data to determine the differences between a solar and lunar eclipse.
Solar Eclipse Story Map	Middle and High School	In this My NASA Data interactive story map lesson students will learn how living with a star can teach us about our universe. Through a series of learning activities, students will examine the benefits and hazards of living with a star, describe and/or demonstrate how we use eclipses to study the Sun and its features, and investigate how our Sun may be used to learn about other stars and our universe.
Explore Solar Eclipses	MiddleSchool	In this My NASA Data interactive activity students will make observations about the objects, size, distance, and motion of the Sun, Earth, and Moon during a solar eclipse and manipulate slides to show the relationships.
Observing the Sun During a Solar Eclipse	Middle and High School	This My NASA Data interactive takes students through the basic mechanics of a solar eclipse, using a NASA Space Place Handout, including an optional eclipse art activity.
Calculating Ratios of an Eclipse	Middle School	In this My NASA Data interactive activity students will calculate the ratio of the size of the sun to the moon and the distance of the sun and moon from Earth to determine the type of solar eclipse possible.
What is Space Weather?	Middle and High School	In this My NASA Data interactive, students will learn the basics of space weather by engaging in a short interactive which introduces key terms: space weather, sunspot, solar flare, coronal mass ejection, and solar wind. Students will be able to identify the causes and hazards of space weather.

Additional Resources (continued)		
Online Activities	Audience	Description
What Elements are in Your Body?	Middle and High School	This My NASA Data interactive guides students through exploring how stars create the elements that make up the universe and life itself. Students will be able to identify the key elements in their bodies that were created from exploding stars.
What do Scientists Learn about the Universe from Observing Solar Eclipses?	Middle and High School	In this My NASA Data lesson plan, students will compare the methods scientists use to study the Sun, including drawings made during a total solar eclipse in the 1860's, modern coronagraphs, and advanced imagery gathered by NASA's Solar Dynamics Observatory
Hands-On Activities	Audience	Description
What is the Sun's Corona?	Middle and High School	My NASA Data Mini Lesson. In this activity students will compare different methods for observing the Sun's corona and make predictions about what they will observe during the April 8, 2024 total solar eclipse.
Why don't we have Solar Eclipses every Month?	Middle and High School	In this My NASA Data lesson plan, students will analyze past and future eclipse data and orbital models to determine why we don't experience eclipses every month
How to Safely Observe an Eclipse	All	In this My NASA Data lesson plan learners will explore several ways to safely observe a solar eclipse.
Modeling Sun-Moon Positions for Solar Eclipses	Elementary School	In this activity, students will model the geometry of solar eclipses using quarters and a nickel to represent the Sun and Moon (not to scale). The goal for this activity is to visually show how the Sun and Moon move near the eclipse season and how the timing of their arrival determines whether you have a total eclipse, a partial solar eclipse, or no eclipse at all.

Additional Resources (continued)		
Online Activities	Audience	Description
Modeling Solar Eclipse Geometry	Middle and High School	In this activity, students will model the geometry of solar eclipses by plotting a few points on a piece of graph paper, and using quarters and a nickel to represent the Sun and Moon (not to scale). The goal for this activity is to visually show how the Sun and Moon move near the eclipse season and how the timing of their arrival determines whether you have a total eclipse, a partial solar eclipse, or no eclipse at all. Learners will create a graph for all three.
NASA eClips Launchpad: Solar Eclipses	Middle School	Join NASA to learn more about solar eclipses, especially the awe-inspiring phenomenon of total eclipses. Find out about the unique geometry and the distances and sizes of the sun and moon as seen from Earth that allow us to witness the sun's corona or actually be in the path of totality.
NASA eClips Guide LitesInteractive Lesson: Solar Images	All	In this activity participants will create a picture of the sun that can then be examined with colored filters to simulate how specialized instruments enable scientists to capture images and view different features of the sun.
Videos and Reading	Audience	Description
NASA HEAT	All	NASA Heliophysics Education Activation Team website
What is a Solar Eclipse	Middle School	My NASA Data Mini Lesson. In this activity students will make observations about the objects, size, distance, and motion of the Sun, Earth, and Moon during a solar eclipse.
NASA Space Place Eclipses	Elementary and Middle School	Online resources about solar and lunar eclipses.

Additional Resources (continued)		
Videos and Reading	Audience	Description
New NASA Map Details 2023 and 2024 Solar Eclipses in the US	Middle and High School	Based on observations from several NASA missions, the map details the path of the Moon's shadow as it crosses the contiguous U.S. during the annular solar eclipse on October 14, 2023, and total solar eclipse on April 8, 2024.
NASA Solar System Exploration - Eclipse Science	Middle and High School	Read about why NASA observes solar eclipses, recent solar eclipse science and additional resources.
NASA eClips Guide Lites Interactive Lesson: Solar Images	All	In this activity participants will create a picture of the sun that can then be examined with colored filters to simulate how specialized instruments enable scientists to capture images and view different features of the sun.

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