NATIONAL GEOGRAPHIC

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LESSON

Environmental Conditions in Our Solar System

Students explore the difference between weather and climate, analyze environmental conditions on Earth and other planets, and design a space probe that can withstand extreme weather on other planets.

GRADES

6 - 8

SUBJECTS

Earth Science, Astronomy, Meteorology, Engineering, Mathematics

CONTENTS

5 Activities

Program

WILDEST WEATHER IN THE SOLAR SYSTEM

ACTIVITY 1: EXTREME WEATHER ON EARTH

| 30 MINS

DIRECTIONS

1. Activate students' prior knowledge about extreme weather on Earth.
Ask: *What do you know about extreme weather on Earth?* Have students brainstorm a list of weather-related words and phrases. Write their responses on the board. Then ask students to sort the list into logical categories, such as types of weather, tools to measure weather, and effects of weather.

2. Discuss a photo gallery of extreme weather.

Tell students they will look at a photo gallery of extreme weather and then watch a video about weather. Display the photo gallery Extreme Weather. Invite volunteers to read aloud each caption. Then, show the National Geographic video "Weather 101." Ask students to describe the extreme weather events. Then ask: *What are the necessary conditions for each weather event to occur?* Elicit responses from students such as: differences in circulating air masses, clashing warm and cool air masses (fronts), and jet streams. Ask: *What are the factors that affect extreme weather?* Elicit responses from students such as: the sun (temperature), water (precipitation), and other atmospheric conditions like jet stream, pressure, wind, humidity, and clouds.

3. Have students complete the worksheet Weather Investigation.
Distribute a copy of the worksheet Weather Investigation to each student. Read aloud the directions and go over the provided answer. Allow students to gather and organize the information they have learned about weather and atmospheric conditions present for each type of weather. Their answers should include the following:

- Tornado: clouds, strong wind, rain, hail
- Hurricane or cyclone: strong wind, heavy rain
- Blizzard: heavy snow, ice, cold temperatures
- Dust storm: strong winds, arid conditions
- Flood: heavy rainfall
- Hail storm: cold or warm temperatures, rain, ice
- Ice storm: freezing rain

After students have completed the worksheet, ask: *What patterns do you see?*

4. Have students make connections between weather and climate.
Ask: *What is climate? How does climate relate to weather?* Some students may understand that the climate in areas closer to the Equator has fewer extremes than in the areas farther away from the Equator. Make sure students understand that the term *weather* describes conditions in the atmosphere over a short period of time. The term *climate* describes weather patterns of a particular region over a longer period, usually 30 years or more. Climate is an average pattern of weather for a particular region. Build background by providing the following example: The weather in Wisconsin can vary from day to day. Some days can be very warm, with record temperatures over 100˚ Fahrenheit (F), with other summer days not even reaching 70˚ F. Winter temperatures can vary just as much. The climate however, is a trend over an extended period of time. Temperature trends in the Midwest show an overall warming of between 0.3˚ F to 1.8˚ F from data collected during the period of 1895-2006.

Informal Assessment

Ask students to orally describe:

- examples of weather on Earth and the atmospheric conditions present
- the difference between weather and climate

OBJECTIVES

Subjects & Disciplines

Earth Science

- Meteorology

Learning Objectives

Students will:

- list and find patterns in the conditions required for weather events to occur
- describe the similarities and differences between weather and climate

Teaching Approach

- Learning-for-use

Teaching Methods

- Brainstorming
- Discussions
- Multimedia instruction
- Visual instruction

Skills Summary

This activity targets the following skills:

- Critical Thinking Skills
  - Analyzing
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

- **(5-8) Standard D-1:**

Structure of the earth system

Preparation

BACKGROUND & VOCABULARY

Background Information

The term *weather* describes conditions in the atmosphere over a short period of time. *Climate* describes weather patterns of a particular region over a longer period, usually 30 years or more. Climate is an average pattern of weather for a particular region. Identifying patterns in the atmospheric conditions of extreme weather events can help you understand Earth's weather system.

Prior Knowledge

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Recommended Prior Activities

- Design a Space Probe
- Extreme Weather in Our Solar System
- Jupiter's Great Red Spot
- Measuring Weather
- Space Probes

Vocabulary

Term	Part of Speech	Definition
air mass	*noun*	a large volume of air that is mostly consistent, horizontally, in temperature and humidity.
air pressure	*noun*	force pressed on an object by air or atmosphere.
atmosphere	*noun*	layers of gases surrounding a planet or other celestial body.
blizzard	*noun*	storm with high winds, intense cold, heavy snow, and little rain.
climate	*noun*	all weather conditions for a given location over a period of time.
dust storm	*noun*	weather pattern of wind blowing dust over large regions of land.
Equator	*noun*	imaginary line around the Earth, another planet, or star running east-west, 0 degrees latitude.
extreme weather	*noun*	rare and severe events in the Earth's atmosphere, such as heat waves or powerful cyclones.
flood	*noun*	overflow of a body of water onto land.
front	*noun*	boundary between air masses of different temperatures and humidities.
hail	*noun*	precipitation that falls as ice.
hurricane	*noun*	tropical storm with wind speeds of at least 119 kilometers (74 miles) per hour. Hurricanes are the same thing as typhoons, but usually located in the Atlantic Ocean region.
jet stream	*noun*	winds speeding through the upper atmosphere.
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
temperature	*noun*	degree of hotness or coldness measured by a thermometer with a numerical scale.
weather	*noun*	state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness.

FUNDER

LOCKHEED MARTIN

ACTIVITY 2: EXTREME WEATHER IN OUR SOLAR SYSTEM | 45 MINS

DIRECTIONS

1. Build background on how scientists learn about weather on other planets.
Ask: *How do we know about weather in our solar system? If manned space flights have only traveled to the moon, how do we know about environmental conditions on other planets?* Explain to students that, for decades, NASA has been sending space probes—unmanned spacecraft—to measure and record conditions on the inner and outer planets of our solar system. Before that, scientists analyzed conditions on other planets with observations made by telescope. Tell students that in this activity they will look at the information scientists have gleaned about these distant destinations. They will learn more about space probes in later activities.

2. Have students brainstorm characteristics of extreme weather on other planets.
Explain to students that Jupiter and Saturn are mostly made up of gas. They are millions of miles farther from the sun than Earth. Ask: *How do you think these conditions affect weather there? How do you think extreme weather on other planets compares to extreme weather on Earth?* Record students' responses on the board.

3. View and take notes on the video "Solar System 101."
Show students the National Geographic video "Solar System 101." If needed, show the video more than once. Allow students time to record notes about new information that gives them insight into weather in our solar system.

4. Have students complete the worksheet Planet Investigation.
Distribute a copy of the handout Environmental Conditions in Our Solar System to each student. Read aloud the directions and answer any questions students may have. Have them use the information in the handout to compare and contrast weather in our solar system. Then distribute a copy of the worksheet Planet Investigation to each student. Read aloud the directions and answer any questions students may have. Have them use the information in the handout to complete the worksheet. Emphasize that in worksheet questions five and six, there are no right answers, but students should use what they learned from the video and the handout to think carefully about their ideas. Make sure students understand that weather on other planets may be dramatically different from weather on Earth.

Informal Assessment

Ask students to orally explain which planets they think may be good candidates for weather study. Have them list the factors that support their answers.

Extending the Learning

You can use this series of activities to prepare students to design their own space probe. If so, let students know that each of these activities is leading to that goal and encourage them to note any probe design ideas as they move through the activities.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Astronomy
- Meteorology

Learning Objectives

Students will:

- identify atmospheric conditions of the planets in our solar system
- determine which weather conditions may be possible given the atmospheric conditions on other planets

Teaching Approach

- Learning-for-use

Teaching Methods

- Brainstorming
- Discussions
- Multimedia instruction
- Visual instruction

Skills Summary

This activity targets the following skills:

- Critical Thinking Skills
  - Analyzing
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard D-3:**
Earth in the solar system

Preparation

BACKGROUND & VOCABULARY

Background Information

Scientists and astronomers are interested in learning more about our solar system. Before any exploration can be done, even via remote sensing by probes or satellites, weather must be considered. Data must be collected through observations from Earth to determine the possible environmental conditions the hardware must be able to withstand.

Prior Knowledge

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Recommended Prior Activities

- Design a Space Probe
- Extreme Weather on Earth
- Landing a Space Probe or Rover
- Measuring Weather
- Space Probes

Vocabulary

Term	Part of Speech	Definition
extreme weather	*noun*	rare and severe events in the Earth's atmosphere, such as heat waves or powerful cyclones.
mantle	*noun*	middle layer of the Earth, made of mostly solid rock.
mean	*noun*	mathematical value between the two extremes of a set of numbers. Also called the average.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
space probe	*noun*	set of scientific instruments and tools launched from Earth to study the atmosphere and composition of space and other planets, moons, or celestial bodies.
unmanned	*adjective*	lacking the physical presence of a person.
weather	*noun*	state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness.

FUNDER

LOCKHEED MARTIN

ACTIVITY 3: MEASURING WEATHER | 30 MINS

DIRECTIONS

1. Activate prior knowledge about instruments used to measure weather.
Ask: *What instruments do scientists use to measure weather?* Students will likely be able to name a thermometer, but they may not be able to name any other instruments that measure weather. Explain to students that there are many more tools scientists use to measure weather. They even use their eyes as important instruments for measuring visibility and making observations.

2. Have small groups create decks of cards.
Divide students into small groups. Distribute one copy of the worksheet Instruments That Measure Weather to each group. Have the group cut apart the cards to create a deck and divide the cards evenly among group members.

3. Have small groups match illustrations and descriptions.
Ask students to look at all of the illustrations of instruments that measure weather. Have each group choose one student to start the activity. The starting student will read the clues on the back of a card. The student who thinks they have the matching illustration will give it to the starting student and explain why they think it is a match. Then the student to the left reads the clues on the back of the next card, and play continues around the circle until all illustrated cards have a matching description.

4. Have students use the photo gallery Instruments That Measure Weather to check answers.

Display the photo gallery and have a whole-class discussion to check groups' answers. (Answers: Instrument 1: thermometer; Instrument 2: barometer; Instrument 3: hygrometer; Instrument 4: anemometer; Instrument 5: precipitation gauge; Instrument 6: sling psychrometer; Instrument 7: wind vane; Instrument 8: weather satellite; Instrument 9: observations; Instrument 10: visibility; Instrument 11: pyranometer) Finally, have groups glue together the matching cards until they have a full deck of 11 cards to use as flashcards.

5. Have students make connections to weather on other planets.
Have a whole-class discussion about the questions below. In between each, allow students time to discuss the question in their small groups and then report back to the whole class:

- *Which instruments do you think would be most valuable in determining weather on other planets? Why?*
- *Which would not be helpful at all? Why not?*
- *What modifications would be required for the instrument to handle the conditions on another planet?*

Informal Assessment

Use the student-created flashcards to check students' comprehension of what each tool is and how it measures weather conditions.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Meteorology

Learning Objectives

Students will:

- define and describe weather-measuring instruments
- describe units of measure for different types of weather measurement instruments
- determine which instruments would not be helpful on other planets

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Simulations and games

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
- Critical Thinking Skills
  - Analyzing
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

- **(5-8) Standard A-1:**

Abilities necessary to do scientific inquiry

- **(5-8) Standard E-2:**

Understandings about science and technology

Preparation

BACKGROUND & VOCABULARY

Background Information

Scientist use a variety of instruments to measure weather. Before we can collect data on other planets, we must understand what data is collected on our own planet, and how it is collected.

Prior Knowledge

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Recommended Prior Activities

- Design a Space Probe
- Extreme Weather in Our Solar System
- Extreme Weather on Earth
- Space Probes

Vocabulary

Term	Part of Speech	Definition
anemometer	*noun*	a device that measures wind speed.
barometer	*noun*	an instrument that measures atmospheric pressure.
hygrometer	*noun*	device for measuring humidity, or the amount of water vapor in the air.
observation	*noun*	something that is learned from watching and measuring an object or pattern.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.

Term	Part of Speech	Definition
precipitation gauge	*noun*	device for measuring rain or other forms of liquid precipitation, usually in millimeters. Also called a rain gauge, udometer, pluviometer, or ombrometer.
pyranometer	*noun*	device for measuring the amount of sunlight reaching a planet's surface. Also called a solarimeter.
sling psychrometer	*noun*	device for measuring humidity that uses two thermometers: one measures the air temperature while the bulb of the other is kept cool and moist. The sling psychrometer is whirled around until moisture from the wet bulb evaporates.
thermometer	*noun*	device that measures temperature.
visibility	*noun*	the ability to see or be seen with the unaided eye. Also called visual range.
weather	*noun*	state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness.
weather satellite	*noun*	instrument that orbits the Earth to track weather and patterns in the atmosphere.
wind vane	*noun*	device that rotates to show the direction the wind is blowing. Also called a weather vane.

FUNDER

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ACTIVITY 4: SPACE PROBES | 30 MINS

DIRECTIONS

1. Build background about space probes.

Show students the National Geographic video "Space Probes." Then explain to students that a space probe is an unpiloted, unmanned device sent to explore space. A probe may operate far out in space, or it may orbit or land on a planet or a moon. It may make a one-way journey, or it may bring samples and data back to Earth. Most probes transmit data from space by radio. Ask: *Why do you think there are so many different types of space probes?* Elicit from students that they collect different science information about very different environments. The probes must be able to withstand the different extreme environments to collect data.

2. View and discuss a variety of space probe images.
Display the photo gallery Space Probes. Invite volunteers to read aloud each caption as you scroll through. Then, as a class, discuss and list on the board how structures of probes are different. Ask: *What types of equipment do different probes include? How do you think equipment would be protected from different weather and environmental conditions?*

3. Explore space probe measurement on the Cassini probe.
Explain to students that a space probe records observations of temperature, radiation, and objects in space. Different probes have different mission objectives. There are lunar (moon) probes, solar (sun) probes that measure solar radiation, and probes that investigate the terrain on rocky planets or the gases on gaseous planets. Introduce the *Cassini* space probe. Display the web page NASA: Cassini Solstice Mission—Inside the Spacecraft and explore the diagram together. Ask:

- *What types of instruments does this probe have?*
- *Why do you think information collected by this probe may be important to scientists?*
- *Which instruments would you include on a probe of your own design to observe weather on other planets?*

Informal Assessment

Based on information from this activity, have students write a paragraph with ideas about instruments they would want to include on a probe of their own design. Have them include at least one idea from a space probe they have observed today, but encourage them to include new ideas too.

Extending the Learning

Use National Geographic *Explorer* Magazine's poster Saturn's Wildest Weather to give students more information about the *Cassini* space probe and weather conditions on Saturn.

OBJECTIVES

Subjects & Disciplines

Earth Science

- Astronomy

- Engineering

Learning Objectives

Students will:

- describe different types of probes and their usefulness in exploring other planets
- discuss instruments that probes use and identify the information probes are able to gather and report

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Visual instruction

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Understanding

National Standards, Principles, and Practices

NATIONAL SCIENCE EDUCATION STANDARDS

- **(5-8) Standard E-1:**

Abilities of technological design

- **(5-8) Standard E-2:**

Understandings about science and technology

Preparation

BACKGROUND & VOCABULARY

Background Information

Scientists and astronomers are interested in learning more about our solar system. A space probe is an unpiloted, unmanned device sent to explore space. Most probes transmit data from space by radio.

Prior Knowledge

["extreme weather conditions", "tools used to measure weather"]

Recommended Prior Activities

- Design a Space Probe
- Extreme Weather in Our Solar System
- Extreme Weather on Earth
- Measuring Weather

Vocabulary

Term	Part of Speech	Definition
moon	*noun*	natural satellite of a planet.
orbit	*verb*	to move in a circular pattern around a more massive object.
orbit	*noun*	path of one object around a more massive object.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
solar radiation	*noun*	light and heat from the sun.

Term	Part of Speech	Definition
space probe	*noun*	set of scientific instruments and tools launched from Earth to study the atmosphere and composition of space and other planets, moons, or celestial bodies.
temperature	*noun*	degree of hotness or coldness measured by a thermometer with a numerical scale.
terrain	*noun*	topographic features of an area.
transmit	*verb*	to pass along information or communicate.
unmanned	*adjective*	lacking the physical presence of a person.
weather	*noun*	state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness.

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ACTIVITY 5: DESIGN A SPACE PROBE | 50 MINS

DIRECTIONS

1. Introduce the mission.

Ask students to imagine they are scientists or engineers designing a new space probe to explore our solar system. Have each student choose a planet as a destination for the probe from this list: Mercury, Venus, Mars, Jupiter, Uranus, or Neptune. Have them use worksheet content from previous Wildest Weather activities to review the weather factors on that planet, including possible extreme weather. Have students list any considerations they can imagine related to the environment and weather on the planet, including what the space probe will look like, what size it will be, and how their probe will travel the distance to reach that destination.

2. Review instruments that measure weather.

Have students review and take notes on the different types of weather instruments they might want to include on their space probes. Ask students to consider how they might need to modify instruments to collect information far from Earth and to withstand the weather on their selected planet. Have students add to their notes.

3. Have students create the design.
Provide each student with multiple sheets of blank drawing paper. Have each student sketch a space probe that lands on or hovers above the chosen planet. Require students to include the following:

- at least three instruments that will measure at least two different weather conditions
- labels of the parts of the probe
- a scale bar or expected measurements of the finished product

Emphasize to students that scientists and engineers make many modifications and changes, even during the drawing stages. Students may determine that certain instruments may interfere with other instruments by either causing inaccurate readings or possibly causing damage. For example: perhaps an anemometer is placed too close to a thermometer. The anemometer could come into contact with the thermometer and break it, or it could cause an inaccurate temperature reading due to the air circulation.

4. Conduct peer evaluation.
Explain to students that the engineering and design process involves a great deal of review. Many people give input into the design of a space probe that costs millions of dollars. Display the Space Probe Design Rubric. Tell students that you will use the rubric to evaluate their finished projects. Allow them to ask questions about it. Then explain that first, students will seek feedback on the initial design from their peers in class. Distribute copies of the worksheet Space Probe Design Feedback to each student. Then divide students into small groups of up to four. Have each student partner with the others in their group to give and get feedback on their design for about five to seven minutes. The student whose space probe design is being evaluated should complete the worksheet for their probe. They can fill in ideas from their three reviewers as well as their own ideas based on the feedback.

5. Have students finalize their drawings or build models at home.
Have students use the design feedback from peer evaluation to finalize their drawings. Give students the option of working on their designs at home, if they would like to create a three-dimensional model of their probe.

6. Have students name their space probes and write brief descriptions of their designs.
Have each student create a unique name for their space probe and write a brief paragraph describing their space probe and what it does, including any special features.

7. Have students publish or present their space probes.
Hang students' space probe designs in a central place in the classroom. Ask each student to present their design, using their writing and the drawing or model.

Modification

For blind peer evaluations, which may lead to more valuable feedback, label the space probe designs with numbers. If you have more than one class, you can allow one class to evaluate the probes for another class.

Rubric

Use the Space Probe Design Rubric to grade each student's final product, the drawing or model, plus the paragraph description and design review form.

Extending the Learning

Have students build a simple model of the Cassini space probe, using the illustrated assembly instructions and parts on the following web page: NASA: Cassini Solstice Mission—Build a Simple Paper Model.

OBJECTIVES

Subjects & Disciplines

Earth Science
- Astronomy
- Meteorology
- Engineering
- Mathematics

Learning Objectives

Students will:

- design a space probe to measure weather on another planet
- sketch and/or build a space probe
- give and get feedback from peer reviewers

- label and provide measurements for the space probe and instruments

Teaching Approach

- Learning-for-use

Teaching Methods

- Brainstorming
- Cooperative learning
- Hands-on learning
- Research
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Creativity and Innovation
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Creating
  - Evaluating

National Standards, Principles, and Practices

NCTM PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS

• **Geometry (6-8) Standard 4:**
Use visualization, spatial reasoning, and geometric modeling to solve problems
• **Measurement (6-8) Standard 1:**

Understand measurable attributes of objects and the units, systems, and processes of measurement

NATIONAL SCIENCE EDUCATION STANDARDS

- **(5-8) Standard E-1:**
Abilities of technological design
- **(5-8) Standard E-2:**
Understandings about science and technology
- **(5-8) Standard G-1:**
Science as a human endeavor

Preparation

BACKGROUND & VOCABULARY

Background Information

Scientists and astronomers are interested in learning more about our solar system. A space probe is an unpiloted, unmanned device sent to explore space. Most probes transmit data from space by radio. Designing or developing space probes, or any type of scientific instrument, is a complex process. Scientists and engineers make many modifications and changes, even during the drawing stages.

Prior Knowledge

["extreme weather conditions", "tools used to measure weather", "the function of space probes"]

Recommended Prior Activities

- Extreme Weather in Our Solar System
- Extreme Weather on Earth
- Measuring Weather
- Space Probes

Vocabulary

Term	Part of Speech	Definition
anemometer	*noun*	a device that measures wind speed.
engineer	*noun*	person who plans the building of things, such as structures (construction engineer) or substances (chemical engineer).
extreme weather	*noun*	rare and severe events in the Earth's atmosphere, such as heat waves or powerful cyclones.
model	*noun*	image or impression of an object used to represent the object or system.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
space probe	*noun*	set of scientific instruments and tools launched from Earth to study the atmosphere and composition of space and other planets, moons, or celestial bodies.
thermometer	*noun*	device that measures temperature.
weather	*noun*	state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness.

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