

WILDEST WEATHER IN THE SOLAR SYSTEM



TEACHER'S GUIDE



Wildest Weather in the Solar System

Engage Students

Introduce the Lesson

The sun and all objects that revolve around it make up our solar system. What keeps all of these objects, including all of the other planets and Earth, from flying off into space? It is gravity. Like everything in our solar system, the weather on planets depends on the sun and gravity. The sun's gravity keeps all of these objects, including Earth and all of the other planets, in orbit. What the weather is like on a planet depends on six things:

- the shape of its orbit
- its average distance from the sun
- the tilt of its axis
- how fast the planet rotates as it revolves around the sun
- its own gravity
- its atmosphere

Because these things are very different for each planet, our solar system has wild weather. We are going to explore some of these differences for ourselves, so pack your bags and spacesuits and get ready for a whirlwind, planet-hopping tour of the Wildest Weather in the Solar System.

Activate Prior Knowledge

Display the poster, "Wildest Weather in the Solar System." Have students explain differences that they can observe between in inner planets and the outer planets. (The inner planets are smaller than the outer planets. The inner planets appear to be solid while the outer planets look like big balls of gas.)

Ask students which planets they know about, which they think they know something about, and which they know nothing about. Then ask students what they think of when they think of wild weather. Have students share the worst weather they have experienced. If in a moderate climate, students may share wild weather that they have read about or seen in movies or on television.



Front : The Inner Planets



Back : The Outer Planets

National Geographic Connection

Join National Geographic on a spectacular journey to witness the most beautiful, powerful, and mysterious weather phenomena in the solar system. Look for *Wildest Weather in the Solar System*, coming soon to digital fulldome theaters and planetariums worldwide.

For more information about the show, additional classroom activities, videos, interactive white board lessons and more resources from National Geographic, visit: <http://wildestweathershow.com>

Explore the Poster

Meet the Planets

Display the poster, “Wildest Weather in the Solar System.” Remind students that one Earth year is the time it takes for Earth to make one revolution around the sun. Have students predict whether each planet has a longer or shorter year than Earth. Use this chart to confirm students’ responses:

Planet	Longer or Shorter than Earth?	Year Length (in Earth Years)
Mercury	shorter	0.24
Venus	shorter	0.63
Earth	---	1
Mars	longer	1.88
Jupiter	longer	11.86
Saturn	longer	29.46
Uranus	longer	84.01
Neptune	longer	164.79

Then divide students into eight groups and assign one planet to each. Hand out a photocopy of each planet’s Fact Sheet (see blackline masters at the end of this guide) to members of that group. Have students study the sheet and choose five facts to share with the class about the weather on their planet. The facts should include the information they think is most important to explain what kind of weather their planet has and why.

Show students the animation of the planets’ orbits at <http://janus.astro.umd.edu/SolarSystems>. Call students’ attention to the shapes of the orbits and the comparative speed of each planet’s revolution. Then point out the column on their Fact Sheets titled “Orbit Shape.” Have each group work together to draw their planet’s orbit shape, using the animation as reference. Be sure to note which planets swing closer to and farther from the sun during their revolution.

Once the groups have completed drawing their orbits, have each group share the facts they chose with the class. Lead a discussion about each planet, its weather, and how the planet’s distance from the sun, its orbit, its tilt, and its atmosphere affect the weather.

The Weather Report

Have students imagine that they are weather reporters working for a television station. Model presenting a weather report to the class on today’s weather in your area. Then tell students that the weather is turning wild. Ask: *How would you report on wild weather such as a hurricane or a tornado? How would you report on a lightning and thunder storm? A monsoon? A dust storm?*

Tell students that on the planets in the poster, the weather is even wilder than what they would ever experience on Earth. Then tell students that they have a new job: Planetary Weather Reporter.

Explain that they will write a weather report for the planets. Have students regroup in their planet group. Define a day as a period in which one side of the planet is facing the sun and a night as when the other side is away from the sun, or dark.

To help students write their weather reports, give each group the following four handouts and preview each handout as a class.

1. Planet Fact Sheet (1 per planet group)
2. The Space Locker

The “Planet Fact Sheet” handouts give the planetary facts. The “Space Locker” handout lists the equipment and clothing that groups will need for their reports from different planets. Have each group create a weather report for their assigned planet. They should imagine they are on the planet during some wild weather. As a weather reporter, they should tell the people watching the report what the weather feels like, what is happening around them, and why the weather feels that way. When students have finished preparing discuss the science behind the weather (see page T3). Then have students revisit their weather reports and make changes based on what they now know about what causes weather and the tools used to measure it.

Extend the Learning

The Student Planet Search is an activity that guides students in finding and comparing facts about their planet with students in other groups. Distribute a copy to each student, have each student write his or her name and planet at the top and then set a time period to allow students to quickly find other students with planets that match the descriptions in each box.

Discuss the Science

Weather on Earth

Explain weather by saying: “Weather” is the changes that happen in the atmosphere. The atmosphere is the layer of gases that surround a planet. Changes in Earth’s atmosphere, such as air currents and wind, affect the weather.

Ask: *What are some examples of changes in weather?* (snow, rain, wind, etc.) Then, explain the role of the sun in weather. Say: *The sun warms the atmosphere and Earth. Weather is caused by the unequal heating and cooling from the sun over different places.* Be sure that students understand that these changes can cause weather ranging from dry, clear, still days to a hurricanes, tornados, and monsoon.

Ask students to describe what they know of how seasons change on Earth. Point out that seasonal changes on Earth are caused by Earth’s tilt. Compare Earth to a spinning top. Tell students: As a top spins, its center line can lean at an angle. Earth’s center line leans at an angle, too. Because Earth tilts, different places in the world get more or less sunlight during different times of the year.

Measuring Weather

Discuss how we measure weather by using tools, such as thermometers to measure temperature and rain gauges to measure rain. Scientists use satellites and radars to measure storms. They use barometers to measure air pressure, or the force of the atmosphere. A tool called an anemometer measures wind speed. Hygrometers measure the amount of moisture in the air. Weather radars show areas of wet weather, such as snow, rain, hail, sleet, and predict its strength. Weather radars can tell us if wild and dangerous weather is coming our way, and if so, how fast. Lead a discussion with the class about why scientists want to measure and to predict weather. (They can help predict the weather so people can prepare for the day or keep safe in extreme weather conditions.)

Further explain the tools by telling students that a barometer measures the pressure of the atmosphere. The pressure of the atmosphere is the weight of the Earth’s atmosphere on the surface of Earth. The pressure is created by the pull of Earth’s gravity. The atmospheric pressure changes from one location to another because of the amount of air above the place where the measurement is made. If you go higher, the pressure drops. With too little air pressure, such as on top of a mountain, it can be hard to breathe.

Ask students why measuring wind speed and direction with anemometers might be important to life on Earth. (Possible responses: High winds can cause damage to living things and homes. Captains and crew of airplanes and ships and fishermen need to know the air speed and direction so they can make adjustments. People who work in construction or play sports need to know if it’s safe to work or play their games.)

Explain that a hygrometer measures the amount of moisture, or water vapor, in the air, known as humidity. By knowing the percent of humidity in the air, as well as the temperature, scientists can tell what the heat index is. Heat is important to those who work and play outside. It is important to farmers who must make sure that their animals and plants are not harmed by too much heat. Have students share experiences when they were outside on a hot, humid day. If students are unfamiliar with what a humid day feels like, tell them that the air feels heavy and wet. Then have students share experiences on hot, dry days. If students are unfamiliar with dry heat, explain that it often doesn’t feel as hot as it actually is. On hot, dry days, people often don’t notice when they lose a lot of water due to sweating. Ask: *What should people do when there’s low humidity?* (Drink a lot of water.)

Planetary Weather

Have students think about how weather may be different on other planets. Discuss how distances from the sun and the presence or absence of atmosphere may affect a planet’s weather. Explain that although Mercury has no atmosphere, it does have extreme changes in temperature.

Ask: *How do we know what the weather is like on other planets?* Explain that scientists use telescopes, space probes, and space travel to explore other planets. For example, there is a special telescope in Chili that looks for the presence of gas and water on Mars. Space probes have visited the surface of some planets, including Mars, and an Australian telescope searches other stars for planets like Earth. Lead a discussion about why scientists would look for other planets like Earth. (Earth has the ideal distance from the sun and atmosphere to support life as we know it.)

Mercury FACT SHEET

The Facts

Mercury is much smaller than Earth, but, it is a very heavy planet. Mercury has an iron center. It has no atmosphere. It doesn't store heat like the Earth. Its days are hot enough to melt metal. Yet, with no atmosphere, Mercury lets the heat escape during the night. Its nights are freezing cold.

Weather Fact: Mercury's extreme orbit makes the weather even more wild. When it is at its closest point to the sun, the heat is ten times more powerful than it is on Earth. When it is at its farthest point from the sun, the heat is only four times more powerful than it is on Earth.

On the Poster	Geography	Weather Notes	Exploration
Mercury is the closest planet to the sun, so you might think it's the hottest. Think again. During the day, the temperature soars to 427° C, but at night it drops to -183° C. Without an atmosphere, this hot and cold planet doesn't have much weather.	Mercury is full of pits and craters from asteroids slamming into the surface.	Mercury rotates very slowly. It only turns completely three times during two of its years. This makes the days hot and long and the nights cold and long. At the poles, there is almost no change in temperature.	The first spacecraft to orbit Mercury was <i>Messenger</i> in March 2011.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	2°	1 day = 58.65 Earth days	1 year = 0.241 Earth years	Mercury has no seasons, but the temperature does change.	none

For my visit to Mercury, I will need:

For my weather report, I will talk about:

Venus FACT SHEET

The Facts

Venus has thick clouds and a lot of carbon dioxide. These trap heat on the planet and keep Venus very hot. Some scientists believe that originally, Venus was like Earth—covered with oceans and seas. This was when our sun was a young star and not as hot as it is now. Over time, the sun became hotter. Any water on Venus evaporated and more carbon dioxide was released from its rocks.

Weather Fact: Venus has the hottest surface of any planet in the solar system.

On the Poster	Geography	Weather Notes	Exploration
Every day is a cloudy day on Venus. The atmosphere is almost completely made of carbon dioxide, causing a blistering runaway greenhouse effect. The temperature is about 484° C. During storms, lightning streaks, thunder booms, and sulfuric acid rains.	Venus has a dry, rocky surface. Venus rotates backwards. On Venus, the sun rises in the west and sets in the east.	Sulfuric acid rains on the planet. The air is so hot, though, that the rain evaporates before reaching the ground. Above its equator, Venus has winds that blow up to 350 km per hour.	Venus has had more visits than any other planet. Space probes have orbited or landed on the planet.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	177.3°	1 day = 243.01 Earth days	1 year = 0.615 Earth years	The thick atmosphere keeps temperatures even throughout the year.	carbon dioxide

For my visit to Venus, I will need:

For my weather report, I will talk about:

Earth FACT SHEET

The Facts

Earth may not be the best name for the third planet from the sun. That's because anyone looking at the planet from space would see a planet that's mostly covered with water. Most of Earth's surface is water. Liquid water, an atmosphere, and mild temperatures, makes life here possible. They also cause weather.

Weather Fact: Earth has far more different kinds of weather than any other planet in the solar system.

On the Poster	Geography	Weather Notes	Exploration
You may think that Earth has some weather extremes. Temperatures can soar to 58° C down to -90° C. Nearly 2,000 thunderstorms erupt around the planet at any given moment. The largest snowflake to ever drift downward was 28 cm wide.	Earth's surface is mostly water. On land, there are landforms such as mountains, valleys, canyons, and prairies. It has a rocky surface.	Earth has mild temperatures compared to other planets. Many kinds of weather can happen at the same time all over the planet.	Satellites in space watch the weather on Earth. They take photos, which they send back to scientists. These scientists then use the photos and other tools to predict the weather.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	23.45°	24 hours	365.25 days	Earth has four seasons. Near the Equator, the weather is nearly the same all year long. The weather becomes more extreme as you get farther from the Equator.	nitrogen, oxygen, and carbon dioxide

For my visit to Earth, I will need:

For my weather report, I will talk about:

Mars FACT SHEET

The Facts

Mars looks red in our sky at night. You can see it without a telescope. Many early scientists thought that the red color means the planet is hot. The color actually comes from a rusty material in its rocks and dust. On average, the temperature is -63°C (-81°F). If you go there, bring a lot of blankets!

Weather Fact: The atmosphere on Mars is very thin. So the sun heats it quickly. Mars also has a lot of thin dust. The sun and the dust cause the worst dust storms in the solar system. Sometimes, the whole planet is covered in a dust storm.

On the Poster	Geography	Weather Notes	Exploration
The Red Planet doesn't have much of an atmosphere, but it still has lots of weather. On the coldest days, temperatures fall to -125°C . Tornadoes and dust storms can sweep across the planet.	Mars has a rocky surface covered with red dust. Landforms such as plains, craters, mountains, and canyons cover the surface. At its poles, it has huge polar ice caps. There is also frozen water just below the surface. The air is full of methane gas.	Mars often has dust storms. Sometimes they cover the entire planet. Its orbit is oval shaped. That means each season is very different from the others. Robots have also found fog and frost on Mars.	On Earth, an observatory in Paranal, Chile, looks for methane and water. The Mars Reconnaissance Orbiter, the rover <i>Opportunity</i> , and the polar lander <i>Phoenix</i> all explore Mars. In March 2010, the rover <i>Spirit</i> completed its research on the surface.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	25.19°	1 day = 1.029 Earth days	1 year = 1.881 Earth years	Mars has four seasons, but they are not all the same length of time. Spring is the longest and winter is the shortest.	carbon dioxide

For my visit to Mars, I will need:

For my weather report, I will talk about:

Jupiter FACT SHEET

The Facts

Jupiter is the biggest planet in the solar system. Its mostly made of gas, but it has a solid core about the size of Earth. All the gas creates a lot of pressure.

Weather Fact: Rainy seasons on Earth may be extreme, but they don't last too long. Not on Jupiter! This planet has the oldest storm in the solar system. The storm, called the Red Spot, has been swirling around for more than 300 Earth years.

On the Poster	Geography	Weather Notes	Exploration
Hydrogen and helium make up most of Jupiter. Ammonia crystals form the giant planet's uppermost clouds. Storms rip through its atmosphere. Lighting explodes in the clouds. The Great Red Spot is the planet's largest storm. It's so large that it could hold two or three planets the size of Earth.	Jupiter has clouds of ammonia floating high in the atmosphere. Its average temperature is -140°C . At the center of the planet's core, it is even hotter than the sun. Scientists believe the core may be Earth-like: rock with a metallic ball in the center.	Its dense atmosphere and rapid rotation cause powerful weather. Storms with winds blowing as fast as 800 km per hour form, join, grow, and change from white to red.	Measurements made by ground instruments and spacecraft show temperatures reaching as high as 21°C and an atmospheric pressure 10 times greater than on Earth.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	3.12°	1 day = 0.411 Earth days	1 year = 11.862 Earth years	Jupiter's seasons last three Earth years.	hydrogen and helium

For my visit to Jupiter, I will need:

For my weather report, I will talk about:

Saturn FACT SHEET

The Facts

Italian astronomer Galileo Galilei was the first person to look at Saturn through a telescope. What he saw was a giant planet. We now know this planet is mostly made of gas. About 755 Earths could fit inside Saturn. It is surrounded by a series of rings.

Weather Fact: Keeping up with the clouds on Saturn might be a bit of a challenge. They travel at around 1,771 km per hour.

On the Poster	Geography	Weather Notes	Exploration
You might know Saturn for its magnificent rings. Yet its atmosphere is nearly as impressive. Wicked winds whip around the planet at 1,800 kilometers/hour. Storms burst from the clouds but usually don't last long. A storm that erupted in 2010 grew a tail that wrapped around the whole planet.	Saturn is mostly a huge ball of hydrogen and helium. However, it has a rocky core. The planet is surrounded by rings made up of gas, rocks, dust, and icy particles.	Fast winds blow around the planet. They can travel five times faster than any winds on Earth. The average temperature is -178°C . That makes the weather on Saturn mostly cold and windy.	In July 2011, <i>Cassini</i> spacecraft spotted storms on Saturn.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	26.73°	1 day = 0.428 Earth days	1 year = 29.45 Earth years	Saturn's seasons last seven Earth years.	hydrogen and helium

For my visit to Saturn, I will need:

For my weather report, I will talk about:

Uranus FACT SHEET

The Facts

From Earth, Uranus looks like a pale blue dot. Uranus really is blue! It has an atmosphere of hydrogen, helium, and methane. It is the methane that makes it look blue.

Weather Fact: Uranus is tilted over on its side. That means it's not the equator that faces the sun, it's the poles. Its north pole faces the sun for half the year and then its south pole faces the sun for the other half.

On the Poster	Geography	Weather Notes	Exploration
Uranus is much smaller than Jupiter and Saturn. Still, storms the size of the United States whip around it. This amazing world is also tilted on its side, so it looks like it's tumbling around the sun. It takes 84 Earth years for this giant world to orbit the sun once. Its north and south poles each point toward the sun for half of this time.	Uranus is made of rocks and ice. It has a thick atmosphere of hydrogen, helium, and methane. The atmosphere is so dense that scientists think it could allow a person to float, just like in water.	The average temperature is -197°C . Winds blow up to 900 km per hour. Storms can cover almost 5 million square km. Scientists have observed dark spots on its clouds. They think the spots are huge and extreme storms.	Astronomers using land telescopes have reported seeing belts of clouds, but <i>Voyager 2</i> spotted no belts when it flew by in 1986. The Hubble Telescope has found some rings around the planet.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	97.86°	1 day = 0.748 Earth days	1 year = 84.01 Earth years	Each of Uranus's seasons lasts 20 Earth years. The sun shines on each pole for half a year. This causes a seasonal difference in the thickness of the atmosphere over each pole.	hydrogen, helium, and methane

For my visit to Uranus, I will need:

For my weather report, I will talk about:

Neptune FACT SHEET

The Facts

Neptune may be the size of 60 Earths, but it's not very dense. It has a core of ice and rocks. It also has a lot of atmosphere, which means it has a lot of weather. Its outer atmosphere is about the coldest place in the solar system. The temperature at this planet's center point, though, is about 5,000° C.

Weather Fact: Neptune's storms are so big, they could swallow up the entire Earth.

On the Poster	Geography	Weather Notes	Exploration
Little heat and light reaches the last planet in our solar system. Temperatures plunge to -218° C. Some of the fastest winds in the solar system roar across the planet. Winds reach 2,100 kilometers/hour. Storms, such as the Great Dark Spot, also whip around the planet.	Neptune is a gas giant. It has a dense rocky core that may be surrounded by a layer of water. It has a poisonous atmosphere.	Winds can blow up to 2,100 km per hour. When it's warm out, the temperature can reach 0° C.	The first close-up view was seen by the <i>Voyager 2</i> spacecraft. It saw the Great Dark Spot. In 2002, the Hubble Telescope photographed a full rotation. Telescopes have also seen brightening at its south pole. This may mean that Neptune has seasons.

Orbit Shape	Tilt of Axis	Day	Year	Seasons	Atmosphere
	29°	1 day = 0.802 Earth days	1 year = 165 Earth years	Neptune has four seasons, each lasting 40 Earth years.	hydrogen, helium, and methane

For my visit to Neptune, I will need:

For my weather report, I will talk about:

The Space Locker

Here are some of the things you may need when you visit the planets to do your planetary weather report. Study the weather and the environment for your planet and then choose the best equipment and clothing for your trip. List the items on your Fact Sheet.



SPACE PACKING LIST

Spaceship with Landing Capability (allows you land on a planet)
Range: 500 million km

Orbiter Spacecraft with Lander (The spacecraft orbits planet. It has an optional lander for visiting a planet.)
Range: 10 billion km

Spacesuit with Air Conditioner Backpack

Spacesuit with Heater Backpack

Spacesuit with Combined Air Conditioner and Heater Backpack

Oxygen Tanks for Breathing

Anchor and Anchor Cable (to prevent the reporter from blowing away in high winds)

Lightweight Clothing

Heavy, Warm Clothing

Waterproof Raincoat

Acid-proof Raincoat

Student Planet Search

Fill in the chart by finding a classmate whose planet matches each box. If there no planet that fits for an answer, write in the word *none*. For example, your planet might be the hottest. Continue until you have filled in all the boxes.

Name of a planet that has a hotter temperature than yours.	Name of a planet with a colder temperature than yours.	Name of a neighboring planet, either closer or further from the sun.
Name of a planet with a longer day in Earth days than yours.	Name of a planet with a shorter day in Earth days than yours.	Name of a planet closer to the sun than yours.
Name of a planet with a longer year in Earth years than yours.	Name of a planet with a shorter year in Earth years than yours.	Name of a planet further from the sun than yours.