



Learning Set 1

What Is Temperature and How Does It Differ across Earth's Surface?



TO: Scientific Research Team
FROM: The Cooperative Space Agency
SUBJECT: Exploring Earth's temperatures

The Cooperative Space Agency (CSA) suggests that you begin your investigation into the temperatures found on *Planet X* by first understanding temperatures found on Earth. In order to communicate with other scientists on this team, you must be able to use the same language. In your daily life, you may use the words temperature and heat interchangeably. To a scientist, however, they have different meanings. What is temperature and what is heat? How do they relate to one another?

In order to share information and communicate, scientists also use another type of language—the language of measurement. Like all other measurements, temperature is measured with a tool and communicated with a number and unit. How is temperature measured and what units are used to describe it?

From your earlier observation of different regions of Earth, you probably understand that not all regions are heated equally. As you study temperature patterns around the world you need to begin asking yourself why. Remain confident that everything you learn about temperature on Earth will be of value in your final analysis of *Planet X*.

More details will follow in another future bulletin.

Recall that your *Big Challenge* is to determine if *Planet X* has areas with surface temperatures that can support human life. You have brainstormed ideas about what makes an area habitable. You may have used words, such as “very hot” or “too cold.” But what do these words mean? Your next step is to construct some useful knowledge that will help you be more specific.

Read the urgent message on the left. You will find some smaller questions that will help you succeed with the *Big Challenge*.

1.1 Understand the Challenge

Think about the Questions

The questions for this *Learning Set* are *What is temperature* and *How does it differ across Earth's surface?* It is a good idea to think about what you already know about temperature. It is also important to think about what you are not sure about and what you would like to investigate.

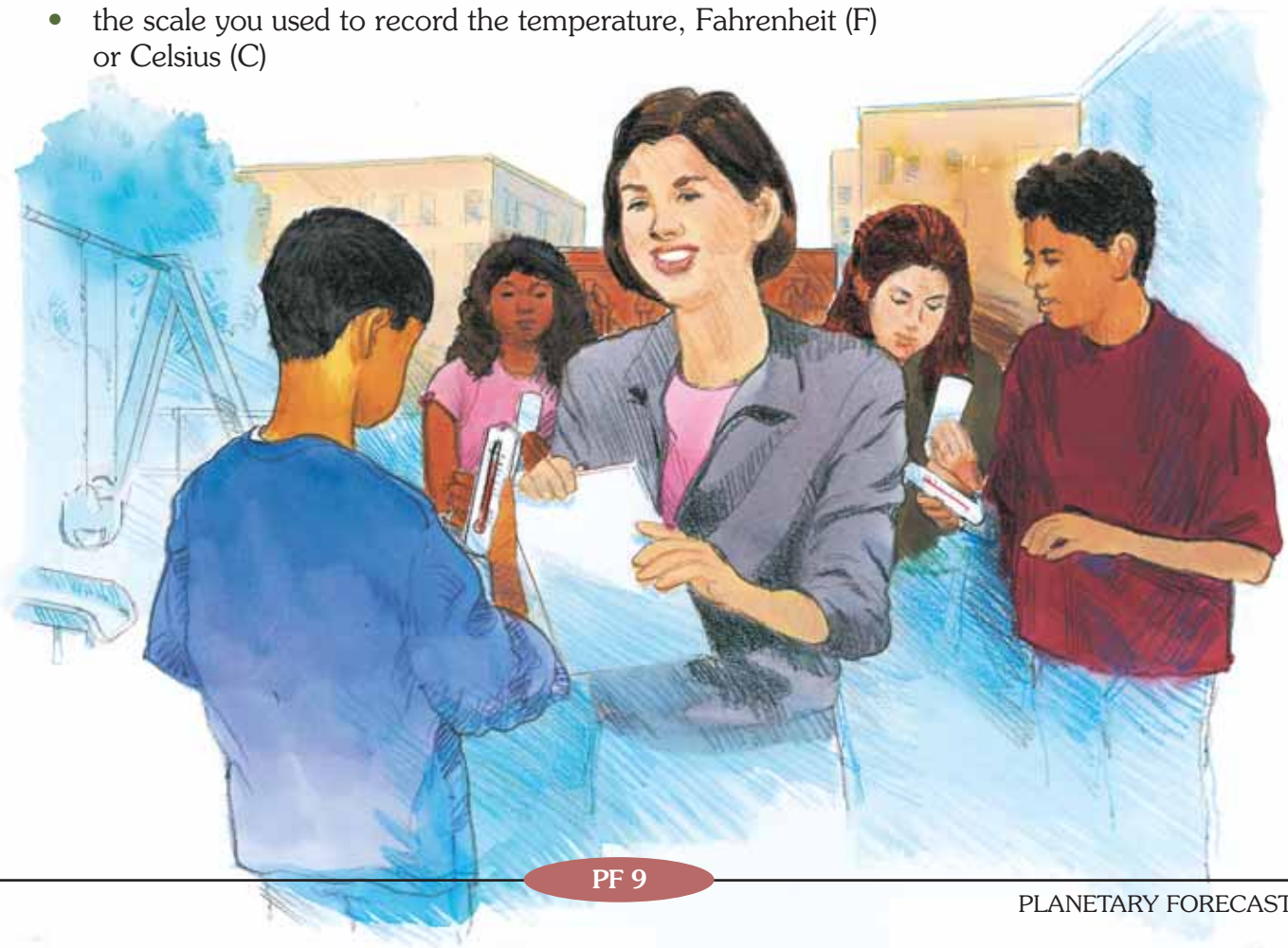
Get Started

Obtain a thermometer from your teacher. If your thermometer is made of glass or has glass parts, you must be very careful when handling it. With your teacher, go outside and choose a place to measure the temperature. Your teacher will tell you where you can go to measure. Record your temperature readings and the following information:

- the location where you measured the temperature
- the approximate height at which you held the thermometer while measuring the temperature
- the scale you used to record the temperature, Fahrenheit (F) or Celsius (C)



Be careful with glass thermometers. Alert your teacher immediately if a thermometer breaks.



When you return to your classroom, your teacher will record all your temperature readings on a chart. Discuss the following questions with the class:

- Were everyone’s temperature readings the same? If not, how different were they?
- What factors could have affected the temperature readings?

Your teacher will write the location and the height at which each reading was taken on the chart. Look at the chart again and discuss the following questions:

- What factors seemed to affect the temperature readings?
- What factor appeared to cause the biggest difference in the temperature readings?

Update the *Project Board*

Before you begin the investigations and readings in this *Learning Set*, it is a good idea to update the *Project Board*. Look at the last message you received from the CSA. It asked you to think about several questions. You may wish to add these questions to the *Project Board*. You may already have some ideas about the answers to these questions. You can add these to the board as well. The temperature readings you took outside the classroom may also have prompted some interesting questions. Note that questions you put on the *Project Board* should not have a yes/no answer. Also, the questions should help you in addressing the *Big Challenge*.

Which regions of a newly discovered planet have appropriate temperatures for a human colony?				
What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

1.2 Read

Measuring Temperature

What is Temperature?

You just used a thermometer to measure the outside **temperature**. Think about what you were actually measuring. You might say that you measured how hot or cold the air was. However, when scientists talk about temperature, they are referring to something more specific.

Air is made up of microscopic particles called **atoms** and **molecules**. Even though you cannot see these particles, you know they are there. You can feel them fill up your lungs when you breathe in, and you can fill up a balloon with them by blowing air into it.

Scientists have discovered that these particles are constantly moving. When these particles absorb energy, they move faster. This faster movement causes the air to feel warm to us. When we measure the temperature of air, we are actually measuring the speed at which the individual molecules and atoms in the air are moving. Scientists call the energy of moving objects “kinetic energy.” The temperature measured by a thermometer is the average kinetic energy of the atoms and molecules in the air around the thermometer.

temperature:
a measure of the average amount of kinetic energy found in the molecules of a substance.

atom: a tiny particle of matter.

molecule:
a group of atoms.



In summer, the high kinetic energy of the air molecules at this South Carolina beach keeps the temperature warm enough to swim.

How Do Scientists Measure Temperature?

In this Unit, we will be talking about **surface temperature**. The surface temperature is the temperature of the air a short distance above the ground.

The air closest to Earth's surface is not exactly the same temperature as the actual surface, but it is close. As Earth's surface begins to heat up or cool down, so does the air just above it.

Thermometers are the most familiar tools scientists use to measure temperature. A common type is a bulb thermometer. Bulb thermometers work very simply.

The bulb at the bottom of the thermometer is full of a liquid. When you place the bulb in a location that is hotter or cooler than the bulb, the bulb and its liquid heat up or cool down until they reach the same temperature as their surroundings. As with air, when the liquid heats up, the atoms and molecules in the liquid move faster. When the particles in a liquid move faster, they collide with each other and push each other farther apart. As the particles move faster in the liquid in the thermometer, the liquid expands. Trapped inside the narrow tube, the only place for the expanding liquid to go is into the tube. If you place the bulb in a cooler location, the liquid particles will move more slowly. They will move closer together. The liquid in the tube will now take up less space, and its level will drop down inside the tube.

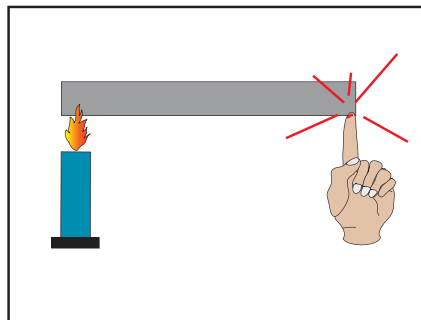
The marks on the side of the tube are a measure of how much the liquid has expanded. By measuring how much the liquid expands into the tube, you can measure the temperature of the liquid. The distance between the marks on the side of the thermometer is measured in units called degrees ($^{\circ}$). Degrees ($^{\circ}$) are the units scientists use to measure temperature. Just like meters (or feet) are used to measure distance, degrees are used to measure temperature.

You might wonder what causes the liquid in the bulb to heat up or cool off when it is placed in warm or cool air. Why doesn't it stay the same temperature? The answer is that the kinetic energy in the air gets transferred to the liquid in the bulb through a process called **conduction**. The moving particles in the air collide with the particles in the glass outside the bulb. These collisions cause the particles in the glass to move around.

surface temperature:
air temperatures measured around 1.25 m (4ft. 1in.) to 2 m (6ft. 7in.) above the ground.

conduction:
the transfer of heat energy from a substance of higher temperature to one of lower temperature through direct contact.

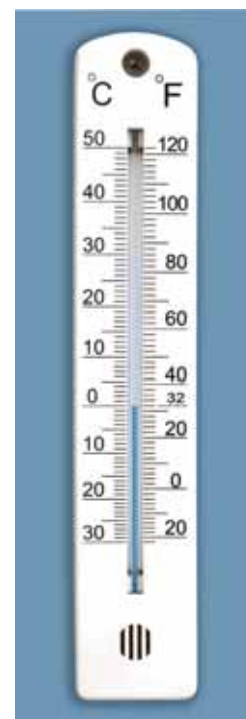
Conduction



The flame from the candle heats up the metal bar. When you touch the metal bar it feels hot. Heat is being transferred to your hand by conduction.

As a result, the glass's kinetic energy increases, and its temperature goes up. The particles in the glass then collide with the particles in the liquid, causing them to move faster as well. In this conduction process, the kinetic energy, or **heat**, gets transferred from the air to the glass and from the glass to the liquid. After a while, the average kinetic energy of the particles in the air, the glass, and the liquid all become equal. They all reach the same temperature.

There are different scales used to measure temperature. The thermometer in the picture at right shows the Fahrenheit and Celsius scales. When you write a temperature, you should always include the unit and scale, such as 0°C or 32°F . Fahrenheit is commonly used to measure air temperature in the United States. Most other countries use the Celsius scale. Celsius is the scale that most scientists use as well. In this Unit, you will use the Fahrenheit scale because that is what is commonly used in the U.S. to describe weather and climate.



Stop and Think

1. What makes some air feel hotter than other air?
2. What is the relationship between temperature and kinetic energy?
3. Why are the marks on a thermometer evenly spaced?
4. Why does the length that the liquid extends into the tube of a thermometer give you a measure of temperature?
5. What areas of Earth do you think have higher average surface temperatures? What areas do you think have lower average surface temperatures? Give your reasoning.

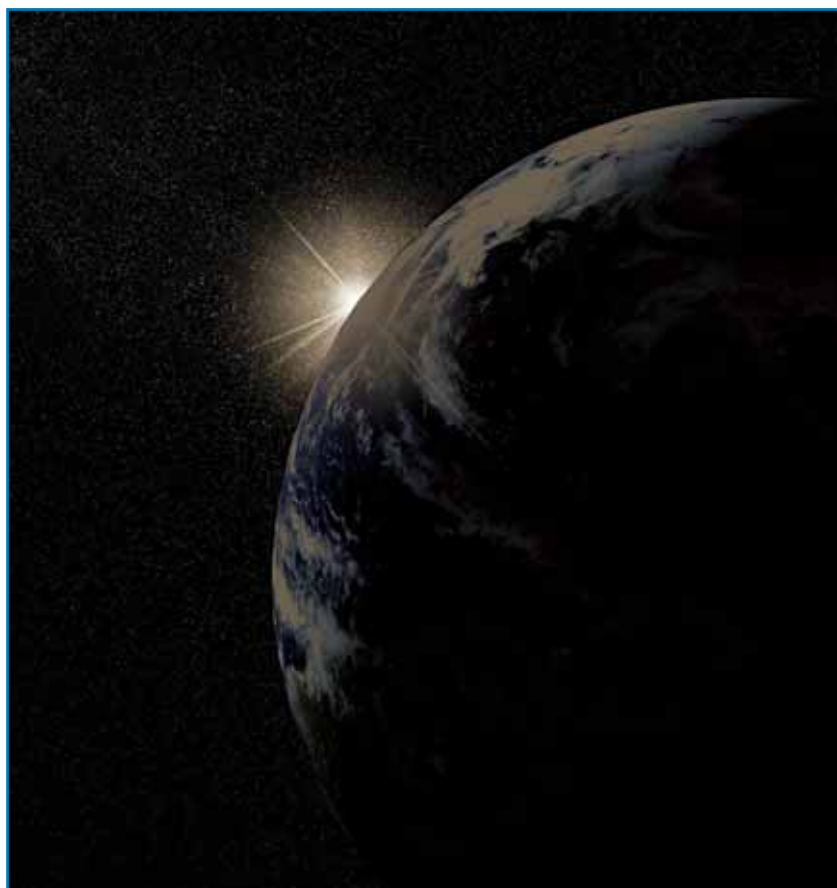
heat: a form of energy associated with the motion of particles or molecules.



What's the Point?

Your goal is to determine if *Planet X* has temperature ranges that can support human life. You will map the temperatures of this planet. Then you will decide where a colony of humans can be established. You know that *Planet X* is the same distance from its star as Earth is from the Sun, and its star is very similar to our Sun. You also know that the two planets are very similar. You will be able to apply what you are learning about temperatures on Earth to make recommendations about *Planet X*.

You are a member of the research team investigating this new planet. You will be required to discuss surface temperatures with others. You just learned some basic information about temperature. You should now be able to communicate about temperature with others.

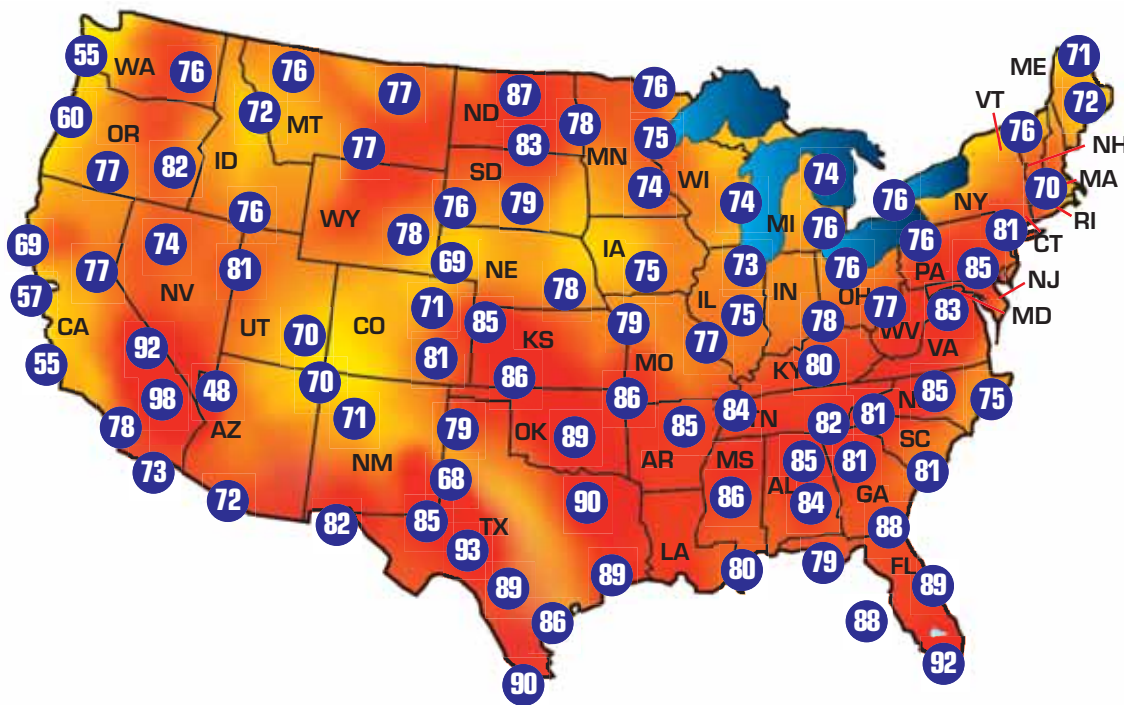


A view of Earth from space, showing its Sun.

1.3 Investigate

Creating a Prediction Map on Paper and in My World

In this activity, you will use color to show surface temperatures on a map. Then you will be able to see the surface temperatures in different parts of the world. As you do this activity, think about what causes the differences. Consider why you observe different temperatures around the world.



What Is a Visualization?

Scientists who study weather and climate cannot see the weather everywhere around the world. It would take a great deal of time to compare lists of information from different weather stations. Visualizations show a picture of the information. They make it possible to see all the information at once.

The map visualization shows temperatures in the United States on August 14, 2001. By using different colors to represent temperature ranges, you can quickly see which areas are warmer and which are cooler. Carefully observe the map and answer the following questions:

- Where are the highest temperatures on this map?
- Where are the lowest temperatures on this map?
- How are variations in temperature represented on this map?
- Using the temperatures shown, create a key for this map. The key should allow someone to use the map to identify the temperature of a location, even if the temperatures are not shown on the map.

Procedure:

Create a Prediction Map on Paper

1. You often make predictions. In science, predictions are a forecast of what you think will happen or the way things might be. They are based on what you know. In this activity, you will use what you know so far about temperature. You will make a prediction map of surface temperatures around the world.

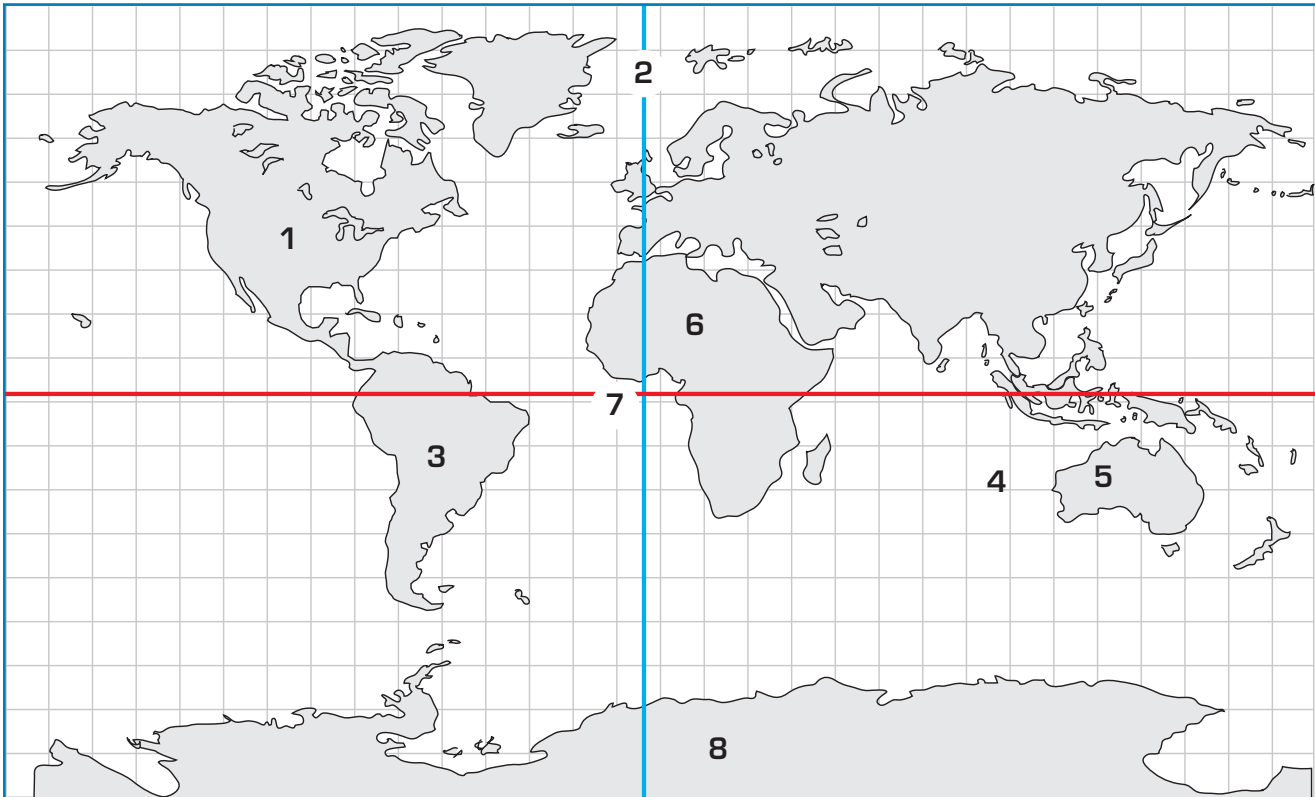
Get a world map from your teacher. Begin by making a color key using the information in the table.

These colors are similar to the colors you observed in the map of temperatures in the United States. They are also similar to the colors used in a real surface-temperature map to which you will later compare your prediction map.

2. Color your map based on what you think Earth's surface temperatures are like in July. Begin by coloring areas you know about. For example, you may want to locate North America and start there. You may also be familiar with areas that you have lived in, visited, read about, or studied. In some cases, you may know nothing about an area. It is fine to make an educated guess. When you do this, think about things such as where the area is located on Earth. Look for patterns in the temperatures of areas with which you are more familiar.

World Map Color Key	
Temperature	Color
-30°F to -11°F	purple
-10°F to 10°F	blue
11°F to 31°F	turquoise or green-blue
32°F to 70°F	yellow
71°F to 81°F	orange
82°F to 98°F and over	red

3. There are eight locations indicated on the map below.
- Give the reasons why you made the temperature predictions you did for these areas.
 - In what areas were you confident about your temperature predictions? What information did you use to make these predictions?



- In what areas were you less confident about your temperature predictions? What information did you use to make your predictions in these areas?
- Describe any patterns you observed while coloring your map. How do you think these patterns may have helped you complete the map?
- Describe any observations or thoughts you may have had while coloring your map that might explain why different regions on Earth's surface are different temperatures at the same time of the year.

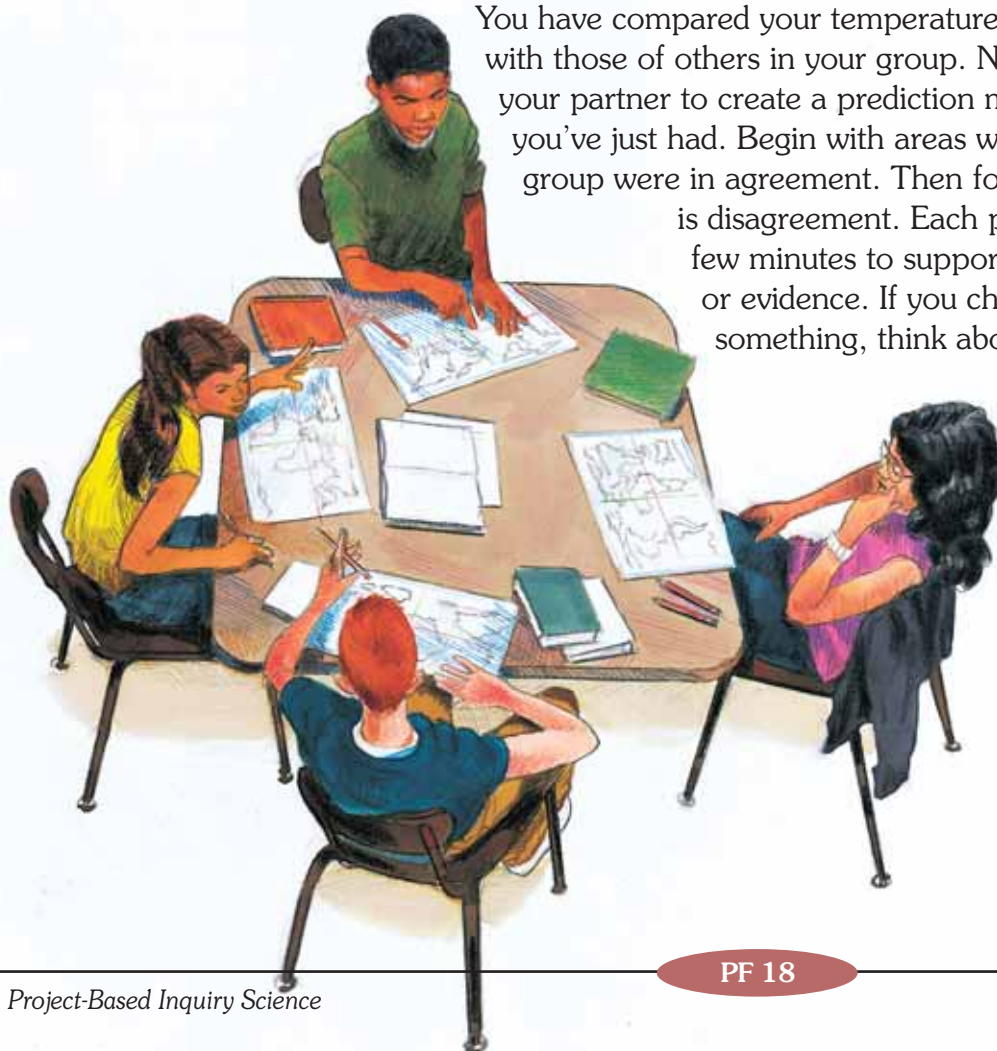
Conference

Teams of scientists often work together to solve problems. They hold group discussions. That is what you are going to do. During your discussion, you can present questions that you have. Sometimes if you do not have an answer, someone else might. You might also present a question that no one else had thought of. This can start your group thinking in a new direction.

Discuss your map with a partner and then with your group. Listen and observe as others present their maps to the group. As you present your prediction map, include answers to these questions:

- How did you decide what temperatures to use to color each area?
- How did you decide where to start and where to go to next?
- In which parts of the world do you feel very confident about your predictions, and which parts do you feel unsure about?

After everyone has presented their maps, take note of where there was agreement and where there were differences. Later on you will compare your predictions to a real surface-temperature map.

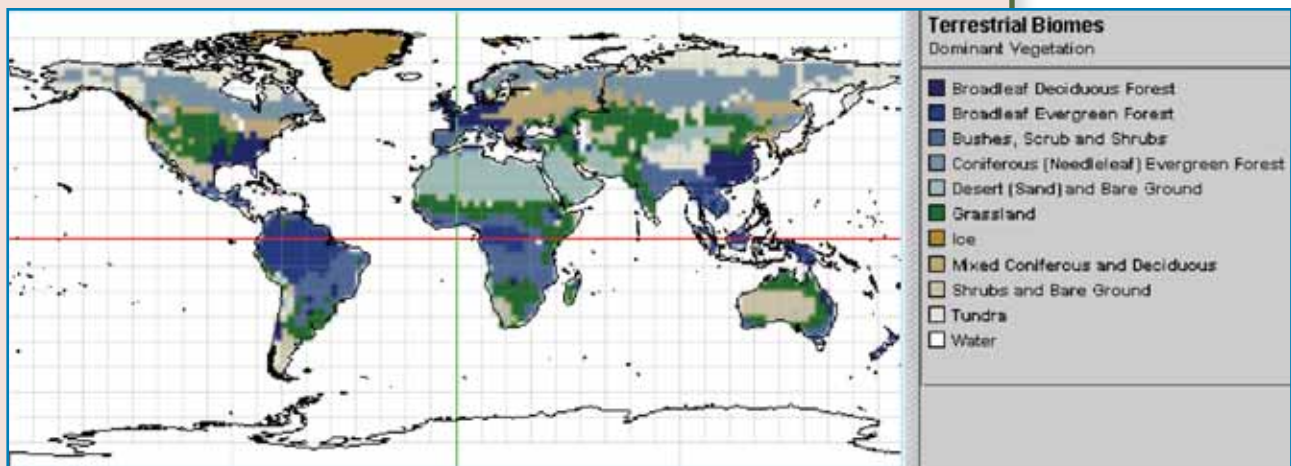


You have compared your temperature predictions for Earth with those of others in your group. Now, work again with your partner to create a prediction map based on discussions you've just had. Begin with areas where most people in the group were in agreement. Then focus on areas where there is disagreement. Each person should be given a few minutes to support their opinion with facts or evidence. If you change your mind about something, think about what made you change your mind. After you come to agreement on your prediction, you will begin working with a computer program called *My World*. You will use computer software to create a prediction map similar to the one you made here.

Using *My World*

As you use the software, *My World*, there are some words with which you should be familiar. You have already learned that scientists use visualizations to see things that they ordinarily would not be able to see. Computer technology has given scientists the ability to make amazing images. Sometimes these visualizations combine large amounts of information into a single image that a scientist can quickly look at and see what is going on.

Here is an example of a visualization that a scientist might use to study different types of plants found around the world.



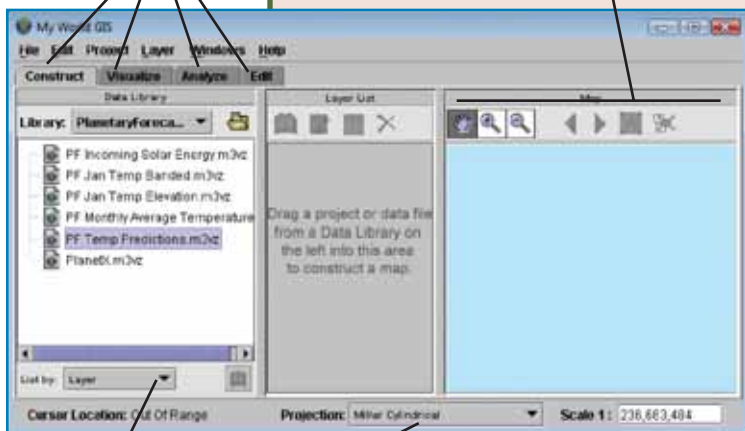
You can see which places have mostly bushes, scrub, and shrubs.

You can see which places are mostly desert. The different colors on the map help you visualize the different types of plants in different places.

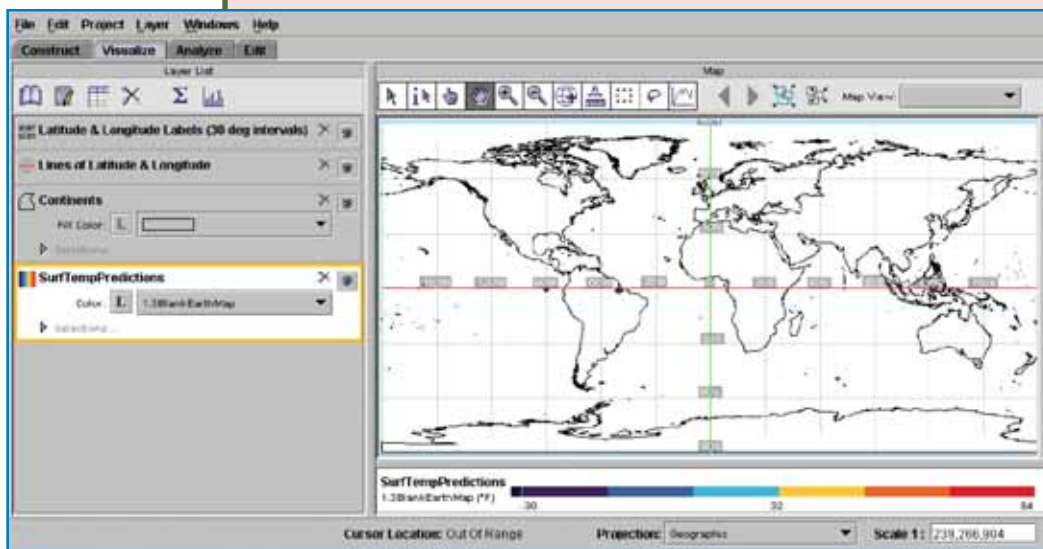
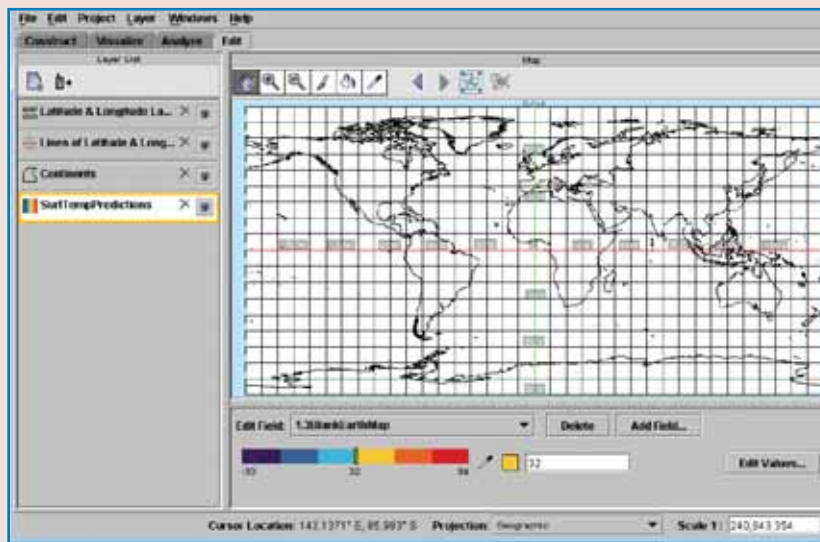
The color scheme is a set of colors that represent different data values. Each color stands for a range of numbers or a category. In the example above, each color represents a category. The map color key, or legend, shows what each color represents on the map.

Tabs

Toolbar



Drop-down menu



Procedure:

Create a Prediction Map in My World

1. Prepare a blank map.

- Open “My World” by double-clicking on the *My World* icon on your computer screen.
- In the “Construct” tab, select “Planetary Forecaster” from the Library drop-down menu.
- Double-click on “PF Temp Predictions” to open a blank visualization. The blank visualization will appear on your screen and the “Visualization” tab will be selected. You cannot “paint” your map in the Visualization screen.
- Select the “Edit” tab. Double-click “SurfTempPredictions” from the Layer List. Now you’ll be able to “paint” the blank temperature map. You will show your temperature predictions using “the paintbrush.”



2. Paint your “Prediction” Map.


- Click on the paintbrush  in the toolbar. It is at the top of your *My World* screen, below the Construct, Visualize, Analyze, and Edit tabs. Once it is selected, the paintbrush button should look white instead of gray.



- Notice the Brush Size bar at the bottom of the map. You can adjust the size of your paintbrush by clicking on the arrow and dragging it left and right on the Brush Size bar. The smallest size you can color is one square, or cell, on the grid at a time. If you drag the arrow to the far right side of the Brush Size bar, you can color a large square, ten cells tall and ten cells wide.



- Move the cursor over the color bar. This is the bar with the range of colors showing the color key. Position the paintbrush over the color you want to select and click. In the box to the right of the color bar, you can see what value is selected and the temperature it represents.

- d) **Move the paintbrush back over the map and click on a cell to paint it.** To color several cells without changing the brush size, hold down the mouse button and drag it over those cells.
 - e) **To paint a different part of the map,** change colors by placing the paintbrush over a different color on the color bar and click. If you change your mind about a temperature after you've painted it, just paint over it with a new color.
 - f) **Fit your map onto your screen.** Make sure you can see your entire map so that you do not miss coloring any areas. Click the "Zoom To All" icon  to fit the map into your screen. To make your screen bigger, click on the bottom right corner of the *My World* screen and drag the corner down and to the right. Click the "Zoom To All" icon again to fit the map into this larger screen.
3. **Save your file** following your teacher's instructions. It is important to save your file because you will need it for later activities. When you are finished saving, **select Quit from the File menu.**

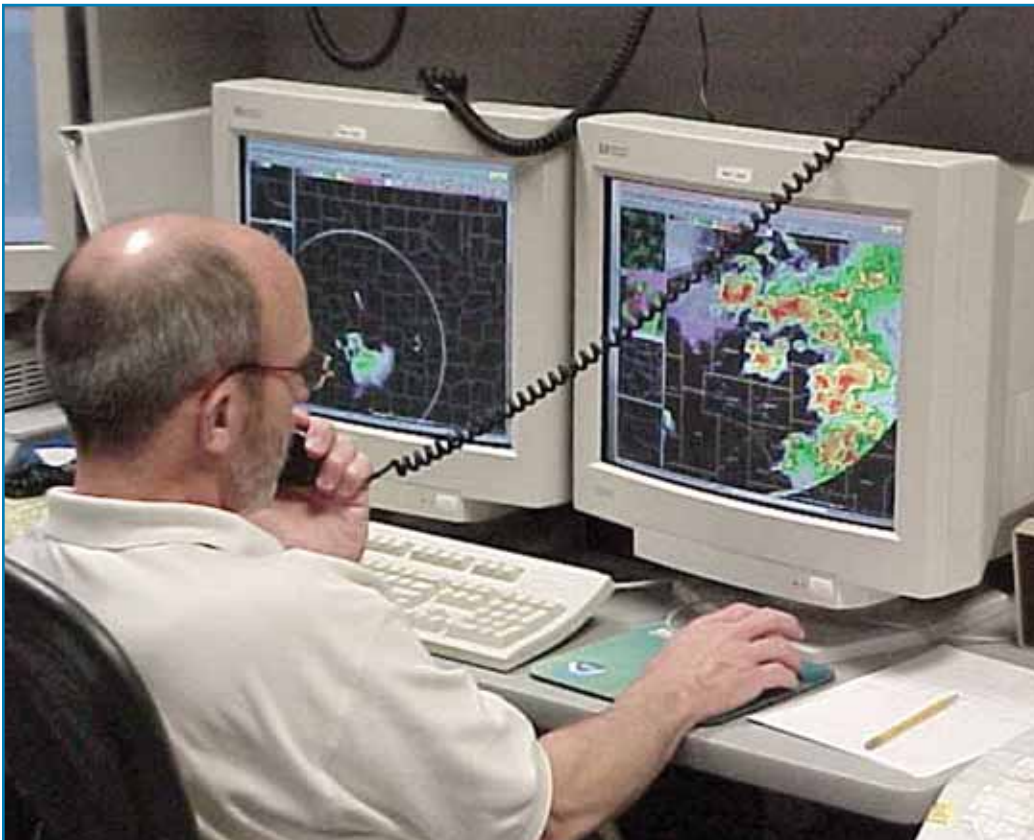
Reflect

Answer the following questions. Be prepared to share your answers with your group and your class.

1. What ideas guided your group as you created the prediction map? For example, you may have thought, "It is cold at the poles because there is snow and ice there."
2. Were there any areas where your group was unsure about the temperature predictions? What steps did you take to solve these problems?
3. While coloring your group map, were there any situations in which you needed more information? Describe what they were.
4. While painting your prediction map, what patterns did you observe? Were there certain parts of the map that seemed to have a lot of the same color?
5. Did your thinking change at all since you colored the first map on paper? Describe how and why.
6. How did the use of computer software make the task easier or more difficult? Describe your experience.
7. Make a list of all the information and skills that you gained from this investigation that you can apply to your *Planet X* challenge.

What's the Point?

The Cooperative Space Agency suggested that you learn more about surface temperatures on Earth so you can apply this information to *Planet X*. You are now familiar with the language, tools, and units of measurement used by fellow scientists. This will enable you to communicate with them easily and with accuracy. In completing this activity, you have learned how to communicate information in a form that is very easy. You have also used one of scientists' most important tools, the computer. In doing so, you have identified some of the things you and your class already know about surface temperatures on Earth. Perhaps you also identified some of the factors that influence them.



Scientists who study climate and weather often use computers to create visualizations.

1.4 Investigate

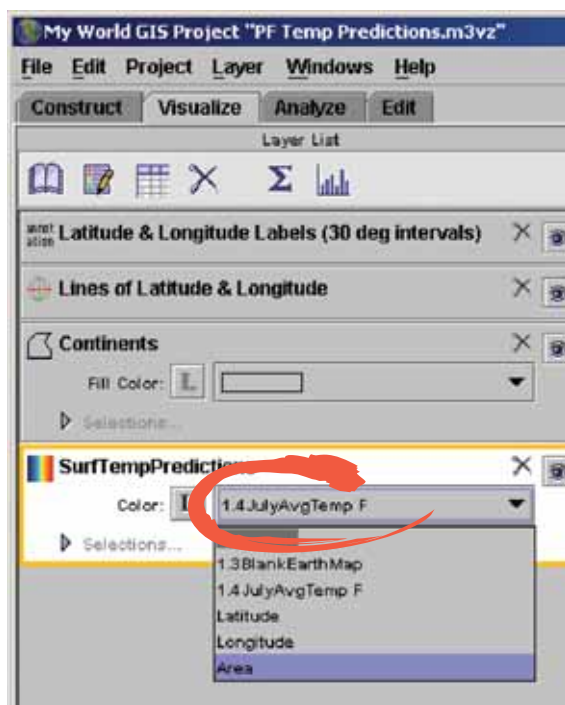
Compare Your Temperature Map to a Real-World Temperature Map

Scientists often compare their ideas to real data. In this activity, you will have the opportunity to do the same. You will open both the visualization you created on the computer and another one that contains actual data. As you study them, look for similarities and differences. By comparing the two maps, you will see if there are still things you need to learn.

Procedure: Comparing Maps

Begin by opening “My World.” Open Planetary Forecaster.

1. Open the temperature map you created earlier, showing your predictions of surface temperatures.
 - a) Locate the “Visualize” tab and click on it.
 - b) Click on the “SurfTempPredictions” layer in the Layer List. There is a drop-down menu within this layer showing different fields. The field containing your temperature predictions is currently selected.



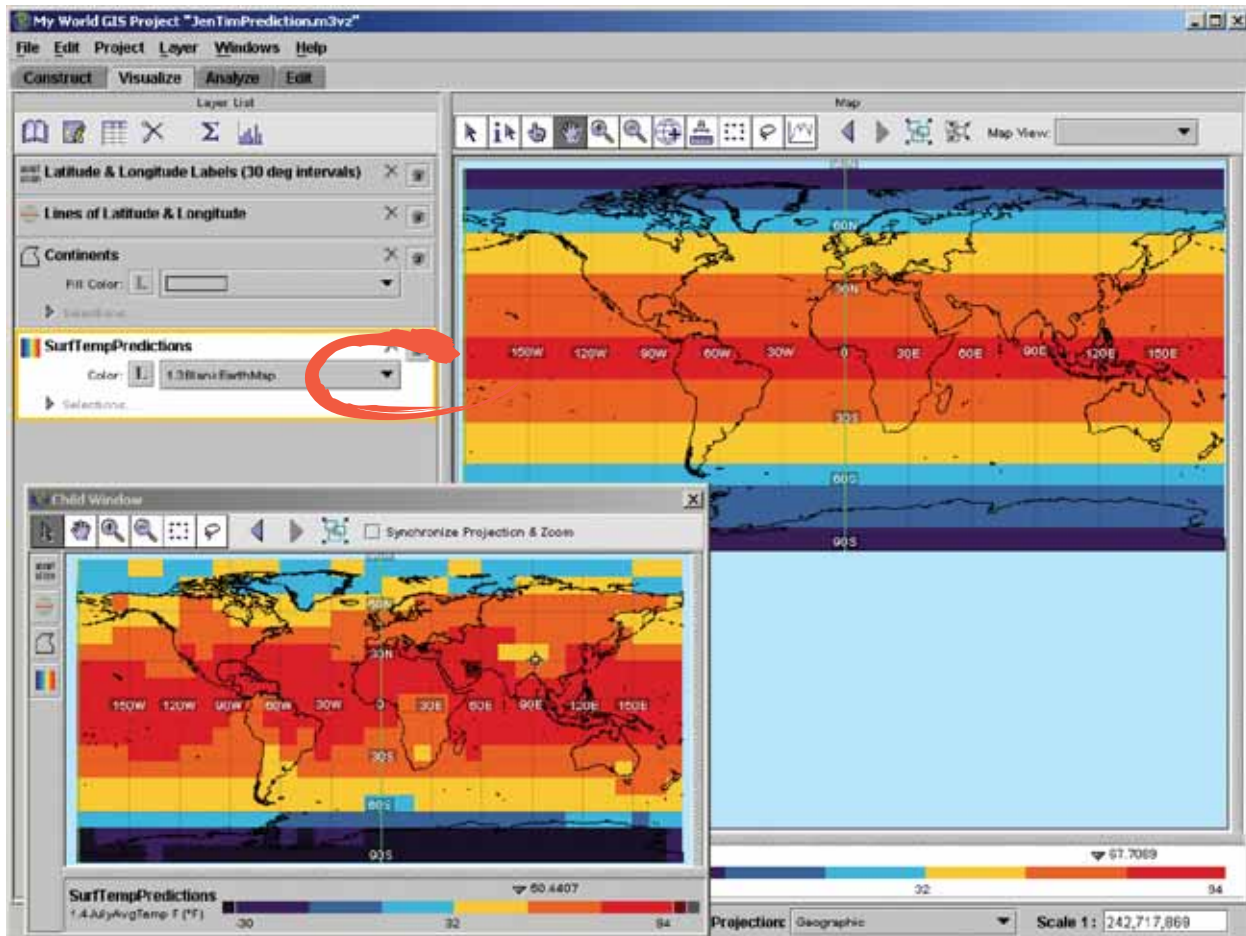
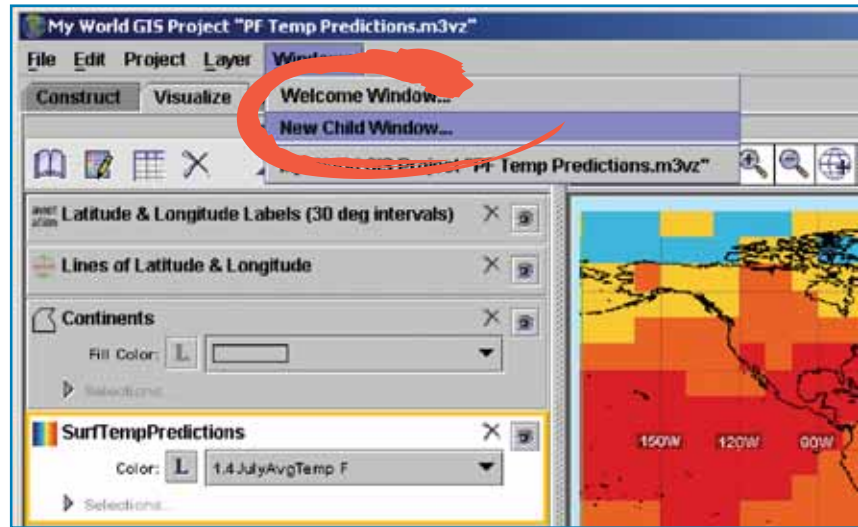
2. Open a real-world temperature map.
 - a) Click on the arrow on the right side of the drop-down menu. Select the other field in this layer, “1.4 JulyAvgTempF.” This will reveal a map with the actual measurement of surface temperatures in July.


The real temperature map shows the average temperatures in July over a period of twelve years, from 1982 to 1994. Temperatures are measured at thousands of weather stations around the world. This visualization was made by combining average July measurements from all of these sources. A computer program was used to calculate temperature estimates in locations where no measurements were available.

3. Compare the maps.

a) Go to the “Windows” menu and select “New Child Window.” This selection will open a second small window that contains the “1.4 JulyAvgTempF.”

b) Move the Child Window so you can see the Layer List in the original map. Click on the arrow on the right side of the drop-down menu to select the “1.3 BlankEarthMap field.” You can now view your Earth temperature predictions in the main window and the actual temperatures in the Child Window.



- c) Use the “Pointer” tool  to compare. When this button is selected, you can click on any cell on the map. The temperature bar at the bottom of the map will tell you the temperature value for that cell. With a Child Window open, you can click on either the Child Window or the Main Window. The temperature value for the cells in the same position in *both* windows will then be shown. Compare the two maps. Note where your predictions are close to the real temperatures and where they differ. You can track your location by looking at the “cursor location” at the bottom of your map.

Reflect

1. Identify a region on the Real Temperature Map where temperatures are in each of the temperature ranges listed below (one region for each temperature range). Use either the name of the region or its cursor location to identify the region.
 - 30°F to -11°F
 - 32°F to 51°F
 - 73°F to 94°F
2. List at least five places where your predictions are close to the real temperatures. Use either names or cursor locations to identify them.
3. List at least five places where your predictions are very different from the real temperatures. Use either names or cursor locations to identify them.
4. Where were you surprised to see that your map and the actual temperature map were different? Your answer might be an area or a continent. For example: at the North Pole, in the oceans, North America, Australia, Northern Asia.
5. Why might it be better to look at a map of average temperatures over many years rather than a map of the temperatures in any single July?
6. In the real temperature map, you notice variation. What do you think is influencing these variations in surface temperature?

What's the Point?

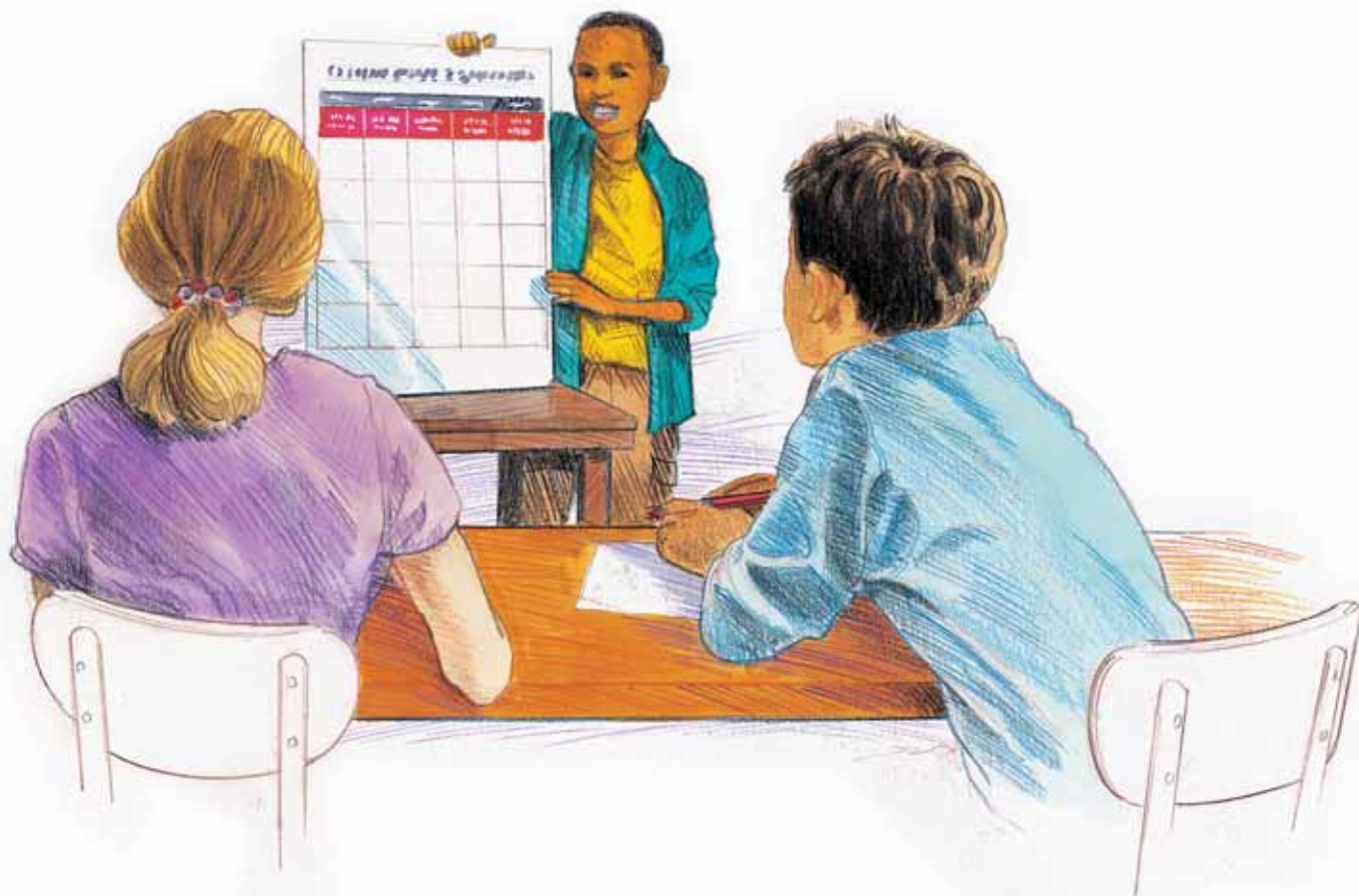
In this investigation, you used what you know about temperature to make informed predictions about surface temperatures around the world. You also used many of the same thinking skills and processes that scientists use to solve problems and answer questions. For example, you gathered information. Then you shared your ideas. As a group, you worked together to create a prediction map.

Scientists often make predictions based on what they know. They then test these ideas. They compare their predictions to data that they collect. You were able to compare your predictions to data on a computer. The data were collected by weather stations around the world. In the process, you were able to learn about temperature variations around the world. Investigations done by scientists often raise new questions. These can lead to new areas of research. Your investigation may have raised new questions as well. For example, you might wonder why there are temperature variations on Earth. You might also question how you could relate what you now know about surface temperatures on Earth to other planets like *Planet X*.

How you communicate information is also very important. Scientists may have huge amounts of data to work with. Scientists who study weather and climate collect a lot of data. Visualizations enable them to see and study the data much more easily.



Most deserts, like this one in the Southwest U.S., have extremely high surface temperatures during the daytime.



Update the *Project Board*

You now have an accurate map showing the surface temperatures on Earth in July. You may have observed some patterns on this map. You may have seen where the hottest temperatures are found or where the coldest temperatures are found. At this point, you may have some ideas about what causes these temperature variations. You can add these ideas to your *Project Board*. You should also have a better idea about what you need more information about.

As a class, update the *Project Board*. Some information may need to be moved from *What do we think we know?* to *What do we need to investigate?* New questions will be added, which you will soon investigate.

1.5 Explore

Which Locations are Habitable on Earth?

To determine which locations are habitable on Earth, you have to look at a lot of data. Visualizations are one way that people can look at large amounts of data very easily. Think about daily temperatures. Suppose you took a temperature reading every hour for one day. Chances are the readings would all be different. Now suppose that you were asked what the temperature was that day. Think about how you would answer this question. It would take a lot of time to give 24 temperature readings. It might be better to give one or two temperatures that describe the overall day. Learning how to do this will help you communicate the information requested by the CSA. Read the following bulletin to see what the CSA would like to know.



TO: Scientific Research Team
FROM: The Cooperative Space Agency
SUBJECT: Temperature requirements for the new space colony

Other research teams in charge of design and engineering have reported that it will be possible for humans to live on *Planet X*, as long as temperatures are found to be in a certain range. The engineers have designed a temporary source of energy. It will be able to support about 5000 people if used well. They have asked that you find a region with average surface temperatures between 25°F and 85°F. Humans can survive in temperatures that are lower or higher than this. However, if you can find this temperature range, it will reduce the amount of energy needed for heating and cooling.

CSA is pleased with your progress to date. You may want to refer back to the visualizations you created to locate any regions in the requested temperature range. In the meantime, please familiarize yourself with daily and monthly average temperatures. This will be important as you move ahead in determining factors that will affect average surface air temperatures on *Planet X*.



The temperature on this Virginia beach changes from hour-to-hour. To report on a day's temperature, you might report a range or an average.

average: a number you get when you add two or more numbers together and then divide the total by the number of numbers you added.

daily average temperature: the sum of the highest and lowest temperatures from midnight to midnight divided by two.

monthly average temperature: the sum of all of the daily average temperatures for a given month divided by the number of days in the month.

Learn about Daily and Monthly Average Temperatures

Recall the last Urgent Message sent by the CSA. Think about what they are asking for in terms of temperature ranges. They are *not* looking for a place that never gets warmer than 85°F or colder than 25°F. They are asking for a location where the **average** temperature for any given month is between 25°F and 85°F. That means some days could be as high as 90°F or even higher. Other days could get as low as 15°F or even lower. These hotter and colder temperatures will affect the average temperature. However, the average can still be inside the given range.

Daily average temperatures are calculated by averaging the highest and lowest temperatures over a 24-hour period. These are usually measured from midnight to midnight. For example, the daily average temperature for a day with a high temperature of 60°F and a low temperature of 40°F would be 50°F.

$$60^{\circ}\text{F} + 40^{\circ}\text{F} = 100^{\circ}\text{F}$$

$$100^{\circ}\text{F} \div 2 = 50^{\circ}\text{F}$$

When solving problems that involve units, whether it is time, temperature, or any measurement, always include the units.

Monthly average temperatures are calculated by adding up all of the daily average temperatures. Then the sum is divided by the total number of days in that month. On Earth, this means that you would divide by a different number of days depending on the month. For example, to find the monthly average temperature for June you would add up the daily average temperatures for all 30 days in June and divide the total by 30. To find the monthly average temperature for January, you would add up the average temperatures for the 31 days in January and divide the total by 31.



Stop and Think

Use the temperature data below to answer the following questions.



Temperature Data			
Day	Daily Low (°F)	Daily High (°F)	Daily Average (°F)
1	71	89	
2	65	93	
3	81	84	

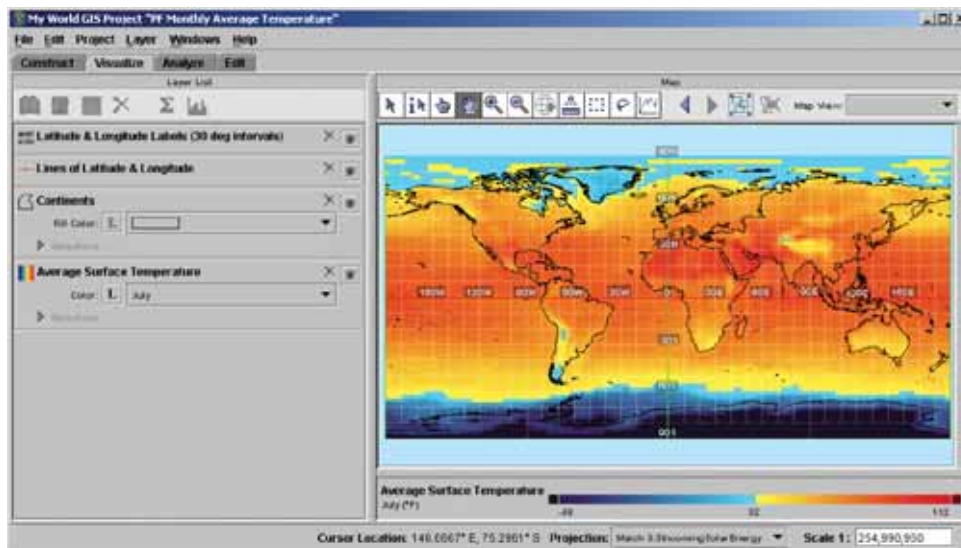
1. Which day had the highest daily high?
2. Which day had the lowest daily high?
3. Without calculating, estimate which day had the highest average temperature.
4. Calculate the average temperature for each of the three days. Compare your answer to your estimate.
5. Can a day with a high temperature greater than 85°F still have an average temperature that is less than or equal to 85°F? Support your answer.
6. Could a location with any of these average daily temperatures fit the temperature criteria requested by the CSA?

Procedure: Explore the Case on Earth

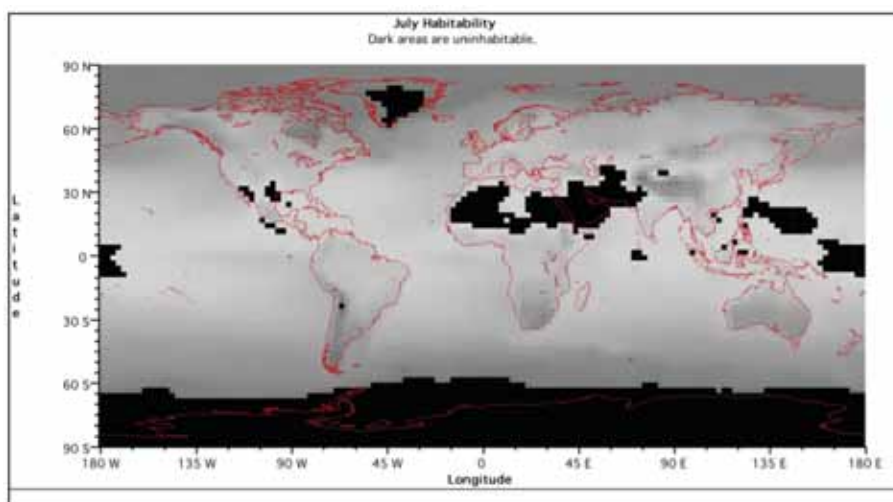
Patterns in Surface Temperatures

Data, such as daily and monthly average surface temperatures, can be shown on a map. At the top of the next page is a map of average July surface temperatures. Look at that map, and find the places on the map that are habitable according to the CSA guidelines. Remember, you are looking for average temperatures of 25°F to 85°F. Study the map and look for similarities and patterns.

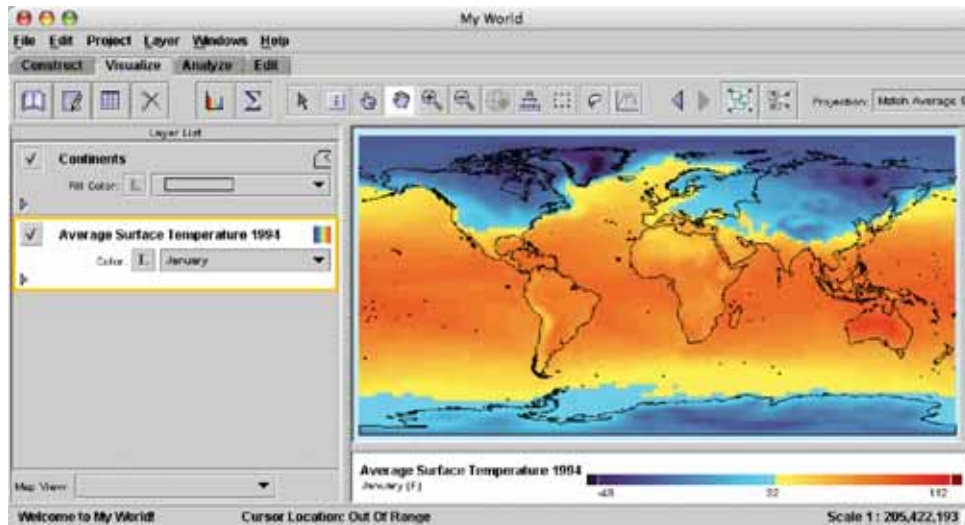
My World visualization of Average Surface Temperature in July.



1. Identify a region that is habitable according to CSA guidelines.
2. Identify a region that is not habitable according to CSA guidelines.
3. What might make a location too hot or too cold to be habitable?
4. Describe the general pattern of temperatures along the Equator.
5. Lorelei noticed that the Equator temperatures were all similar around the whole world. Do you agree with Lorelei? Why or why not?
6. Describe the general pattern of temperatures near the poles.
7. Tim noticed that in July the South Pole was cold but still warmer than the North Pole. Do you agree with Tim? Why or why not?
8. How would you describe the pattern in surface temperatures moving from the Equator to the poles? How would you answer if someone asked you why this was so?



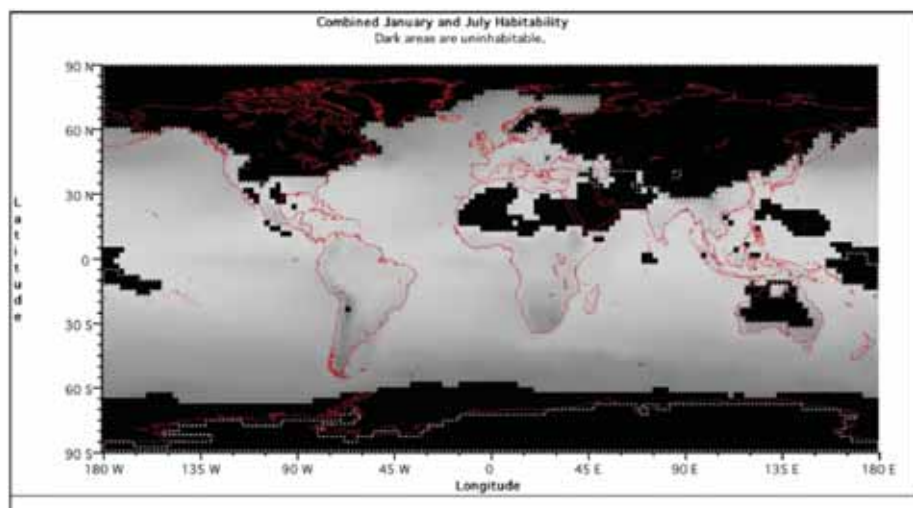
9. Look at the map at left. The dark areas on this map indicate the areas that are uninhabitable in July. Why would any of these places be uninhabitable?



My World visualization of Average Surface Temperature in January.

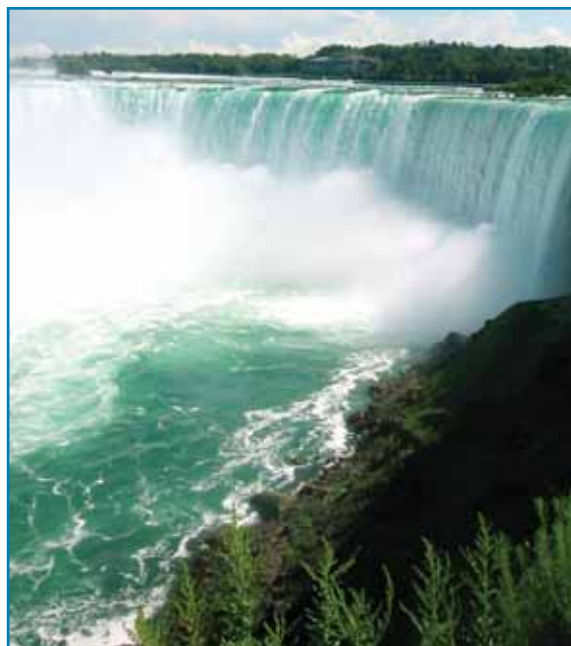
Now look at a map showing average surface temperatures for January. Compare this map to the one for July.

10. Identify a region that is habitable according to CSA guidelines.
11. Identify a region that is not habitable according to CSA guidelines.
12. Which places are habitable in both January and July?
13. Mike noticed that the latitudes along the Equator were about the same temperature on both Monthly Average Temperature Maps. Do you agree with Mike? How would you answer if someone asked you why this was so?
14. Mary noticed that around North America the land and water were different temperatures. She did not notice that on the July map. Do you agree with Mary? How would you answer if someone asked you why this was so?
15. Michelle noticed that the Southern Hemisphere was warmer than the Northern Hemisphere in January. Do you agree with Michelle? How would you answer if someone asked you why this was so?
16. Look at the map at right. The dark areas on this map indicate the areas that are uninhabitable in July and January. Why would any of these places be uninhabitable?





Niagara Falls in winter.



Niagara Falls in summer.



Mount Rainier in spring.

17. Look at the images at the top of this page. They are photos of the same place, one taken in winter and one in summer. Why do you think some places experience such wide temperature variations at different times of the year?
18. Look at the image to the left. How do you think there can be snow on a mountaintop at the same time there are spring-like conditions near the base?
19. Look back at the January and July surface-temperature maps. What other factors may cause temperature variations? Observe both surface-temperature maps and record your answer.

What's the Point?

You have worked with different surface-temperature maps. As you did so, it probably became obvious that there are variations across Earth's surface. You have observed temperature differences between the Equator and the poles. You also observed differences between January and July. You can now calculate and understand average daily temperatures and average monthly temperatures. This will be important as you proceed with the *Big Challenge*.



Ice breaking up in the summer in Northern Canada.



Learning Set 1

Back to the Big Challenge

Which regions of a newly discovered planet have appropriate surface temperatures for a human colony?

The challenge for *Planetary Forecaster* asks a very big question. The best way to answer this big question is to break it down into smaller questions. You began this *Learning Set* by asking the smaller questions: *What is temperature and How does it differ across Earth's surface?*



TO: Scientific Research Team
FROM: The Cooperative Space Agency (CSA)
SUBJECT: Exploration of new planet

The CSA has completed its research to help you determine the habitable regions of *Planet X*. CSA has identified the four factors they think have the greatest effect on *Planet X*'s surface temperatures. These factors are

- shape of the planet
- tilt of the planet's axis
- land/water differences
- surface elevation

Your task is to investigate how these factors affect temperatures on Earth. You will then use what you learn to predict the temperature ranges of *Planet X*. Use your predictions and the temperature requirements to identify which parts of *Planet X* are habitable. You will be asked to make a final report to the CSA. It should include your ideas of where a colony might be established. Your report should explain how you came up with your plan.

The CSA will continue to gather information about each of the above factors. CSA will send new data to you as it becomes available. Fellow scientists, you are about to join the search for a new frontier! Good luck with your investigation!

You learned that Earth's temperature varies. Temperature can be specific to very small areas. Temperature can change constantly as you move small distances. However, you saw that temperatures on Earth seem to have a pattern. When you looked at average temperatures over longer periods of time, you observed large areas of similar temperature.

You considered areas that are habitable on Earth using the CSA criteria. You now know that the CSA feels that habitable areas on *Planet X* must have average monthly temperatures of 25°F to 85°F. Understanding these points is very important for identifying areas on *Planet X* that are suitable for a colony.

Read the bulletin to the left.

You now know the full details of your challenge. You are ready to begin your investigation of the four factors identified by the CSA.

Update the *Project Board*

Discuss the bulletin with your class. As a class, update the *Project Board*, listing any ideas or investigation questions that resulted from the activities you completed. By now you should have some very good ideas about the factors that cause temperature variations. You should also have some evidence to support your ideas. The next steps will be to start asking questions about some of the factors that influence Earth's temperatures. You can then see if these factors will apply to *Planet X* as well.

