CHICAGO BOTANIC GARDEN

Activity 2.4: Climate Change Around the World

Grades 5 – 6

Materials
- Student handouts
- Computer with Internet access
- Pens or pencils
- Overhead projector (optional)
- Printer (optional)

Description: Up until now, students have focused on only on temperature when evaluating the impacts of climate change. Now, through a brainstorm and discussion, students will discuss and add other climatic factors to their analysis. They will investigate how changes in atmospheric carbon dioxide levels affect not only temperature, but also may create changes in regional precipitation and cloud cover. ***Option 1***: Students then use the MY NASA DATA website to determine whether global patterns of climate change are directly reflected in their city and in cities around the world. They discuss why different locations around the world are affected differently or to different degrees by changing climates. ***Option 2***: The teacher chooses cities (including your own) and generates graphs using MY NASA DATA, and provides students with copies of those graphs that students use to complete the activity.

Math Extension 1: Converting Celsius to Kelvin: Students will consider the different ways of measuring temperature and as a class, will use a formula to convert the temperatures of their assigned city from Kelvin to Celsius. If students are not familiar with the Kelvin scale, they should complete this activity before starting Activity 2.4.

Math Extension 2: Precipitation in millimeters/day: Students discuss rainfall in the context of the rate of rainfall over a period of time and practice converting from inches to centimeters to millimeters in preparation for looking at the MY NASA DATA precipitation graphs, which show rainfall in mm/day. If students are not familiar with the rate/time parameters, they should complete this activity before starting Activity 2.4.

Total Time: Two to three 45-minute class periods

Prior Knowledge: Students should be familiar with Kelvin temperature measures and precipitation measured in millimeters/day. Math extensions converting Kelvin to Celsius and precipitation over time are included as supplements to this activity to ensure students are prepared. These activities should be completed prior to Activity 2.4 if students are not familiar with these units of measurement.

National Science Education Standards
A1.D Develop descriptions, explanations, predictions, and models using evidence.
A1.E Think critically and logically to make the relationships between evidence and explanations.

AAAS Benchmarks
4B/M14: Earth has a variety of climates, defined by average temperature, precipitation, humidity, air pressure, and wind over time in a particular place.

4B/H5 Climatic conditions result from latitude, altitude, and from the position of mountain ranges, oceans, and lakes. Dynamic processes such as cloud formation, ocean currents, and atmospheric circulation patterns influence climates as well.

Resources

- NOAA/National Weather Service severe weather safety guide http://www.nws.noaa.gov/os/severeweather/
- NOAA/ National Severe Storms Laboratory provides basic and applied research focuses on understanding severe weather processes, developing weather observation technology, and improving forecast tools, with emphasis on weather radar, hydrometeorology, and forecast and warning improvements. http://www.nssl.noaa.gov/
- The Weather Channel provides current national weather forecasts and radar, and historical weather data. http://www.weather.com/
- NASA global precipitation data including monthly and annual anomaly precipitation analyses. Dataset 1 covers the period 1900–88, while the extended and updated Dataset 2 covers the period 1850–1995. http://data.giss.nasa.gov/precip_dai/

Guiding Questions

- What variables make up climate, in addition to temperature?
- How are climate variables changing over time in individual cities?
- How do these variables compare across different cities throughout the world?
- How can we use NASA and NOAA climate data to represent changes in global and regional precipitation, temperature, and cloud cover?
- What are the changes in average temperatures, precipitation, and cloud cover over time in different regions around the world, and how do those change compare to those variables on our home city?
- Are global changes in climate variables (temperature, precipitation, and cloud cover) different across regions? What are the differences and similarities of the impacts of climate change on regions around the world?

Assessment(s)

- Graphs generated from MY NASA DATA
- Climate Change Around the World Handout

Vocabulary

Precipitation: Rain, sleet, hail, snow, and other forms of water falling from the sky

Cloud Cover: Refers to the fraction of the sky obscured by clouds when observed from a particular location

Pre-Activity

- Familiarize yourself with the MY NASA DATA website http://mynasadata.larc.nasa.gov/las/getUI.do.

- Review the NOAA Paleoclimatology website to learn about weather events and climate trends over the past 100 years. http://www.ncdc.noaa.gov/paleo/ctl/100.html
- ***Option 2***: choose at least four cities, one of which should be the city in which the school is located, generate graphs, and make copies for students to use as they complete the activity.

NOTES

- Depending on students' familiarity with computers and the amount of time you have, you may have them work with the MY NASA DATA site to generate their own graphs. Alternatively, you may generate graphs of a number of different cities yourself and provide those to students as handouts to use to answer the questions. In either case, make sure that one of the graphs that students are using is the one for their own home city.
- MY NASA DATA works best using the Mozilla Firefox web browser. It also works with Google Chrome. Internet Explorer is not supported.

Procedure

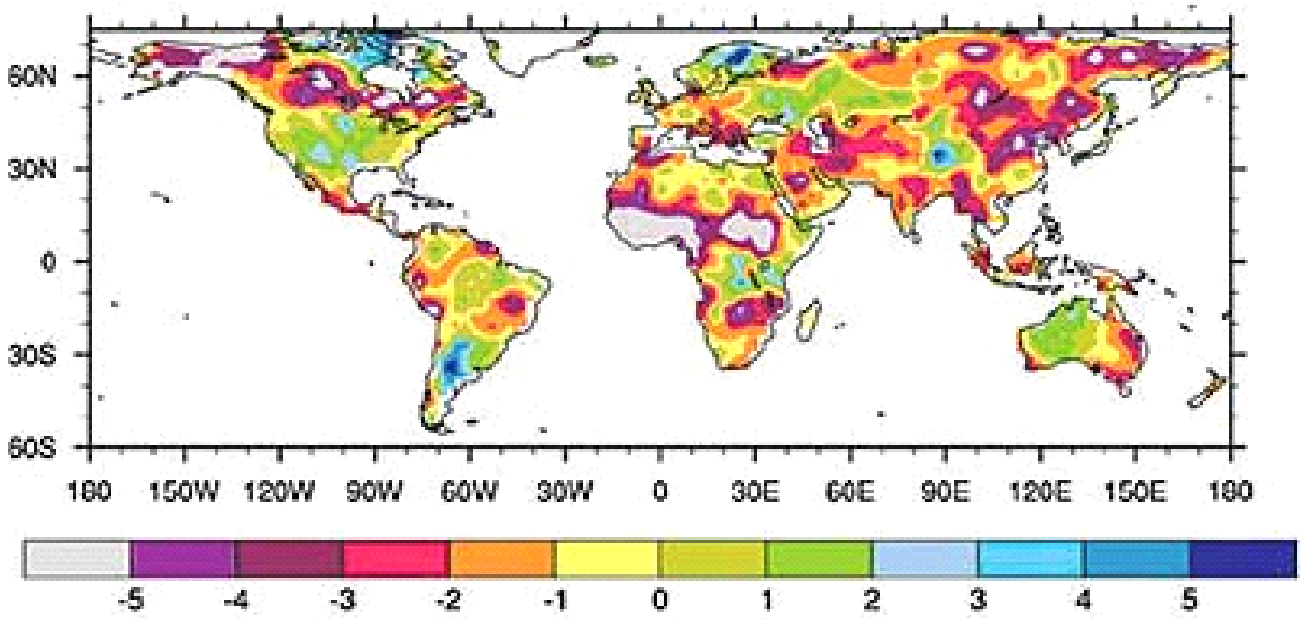
1. Review the conclusions of Activity 2.3. Discussion questions might include:
    - What did looking at past temperatures tell us about temperature over very long periods of time? (it changes slowly, naturally)
    - What was different about our graph of temperatures over the past 100 years from the rest of the historical temperature graphs that we looked at?

2. Transition the discussion to other aspects of climate, Write answers on the board, so students can refer to them during their investigation. Discussion questions might include:
    - We've looked only at temperature so far, what are other elements that make up climate? (precipitation—how much and when; cloud cover)
    - Do you think these elements of climate might change if the climate changes? In what ways might they change? (more/less rain, etc.)
    - Have they changed globally? Have they changed in our city and in other cities around the world? Do you think the changes would be the same everywhere in the world?
    - What data would we need to find out whether precipitation and cloud cover have changed?

3. Tell students that they are going to use real data from NASA to find out whether other climate factors have changed, in addition to temperatures, in their city and in other cities around the world.

4. If you have already generated graphs, assign students a city. If students will be creating their own graphs, you can either assign cities or allow students to choose a city. **Make sure one group of students has the city in which your school is located**. The map below will help you find cities that will illustrate the contrast across regions. Some suggestions that provide interesting comparisons are:

Your School's City/State	Houston, Texas, U.S.A.	Iriba, Chad
Alice Springs, Australia	Brisbane, Australia	Neuquen, Argentina
Gurupi, Brazil	Edmonton, Alberta, Canada	Nzerekore, Guinea
Beijing, China	Shanghai, China	El Obeid, Sudan
New Delhi, India	Noril'sk Russia	Phoenix, Arizona, U.S.A.



This depiction of linear trends in the Palmer Drought Severity Index from 1948 to 2002 shows drying (reds and pinks) across much of Canada, Europe, Asia, and Africa and moistening (green) across parts of the United States, Argentina, Scandinavia, and western Australia. (Illustration courtesy Aiguo Dai and the American Meteorological Society.)

5. Distribute the "**Climate Change Around the World**" instructions and worksheet to students. If students are not using MY NASA DATA distribute the worksheet and graphs, do not distribute the instructions.

6. If students are generating their own graphs, break students into groups of two to three per computer and walk them through the creation of the first graph so they have the idea. Then have them complete the other graphs and their handouts. Alternatively, hand out one set of city graphs that you generated earlier to each student group and have them answer the questions using those graphs.

7. Give them at least 30-40 minutes to generate their graphs and complete the handout. They may need assistance in figuring out the MY NASA DATA site even if they are familiar with

computers. Alternatively, hand out the graphs you generated from the MY NASA DATA site ahead of time and have student complete the activity using those graphs.

8. Once students have created their graphs and done their analysis, bring the class back together for the closing discussion.

9. Discuss the results of their graphing activity. Begin with the group that analyzed the data for your home city and state. Have them report back their results and write them on the board. Begin a full class discussion of the results for their home city and compare them with the data from other cities. Discussion questions might include:
    - Did you see trends in your data? (because the data is fairly short term, trends may not be immediately obvious)
    - Are the trends from our city consistent with the U.S. data?
    - Are trends from other locations consistent with U.S. data?
    - Why might they be different?
    - Are there any patterns in the trends?
    - Are different climates, regions, or continents, reacting differently to the increase in global temperature?
    - What might be some impacts on the lives of the people who live in different areas of the world that have different trends? (e.g. people who live in places with less or more precipitation, on coasts, etc.)

10. Summarize by emphasizing that climate change is not simply temperature increase. Because all Earth systems interact with each other, it affects other aspects of climate, including precipitation and cloud cover. Lab sheets may be collected as an assessment, and should be placed in student portfolios.

***NOTE**: If you do not have time to implement all four units of the curriculum, you may skip to the concluding activity "Faces of Climate Change" (Activity 4.2) to illustrate the impacts of changing climates on people around the world.*

Useful Internet Resources

- NOAA/National Weather Service severe weather safety guide http://www.nws.noaa.gov/os/severeweather/
- NOAA/ National Severe Storms Laboratory provides basic and applied research focuses on understanding severe weather processes, developing weather observation technology, and improving forecast tools, with emphasis on weather radar, hydrometeorology, and forecast and warning improvements. http://www.nssl.noaa.gov/
- The Weather Channel provides current national weather forecasts and radar, and historical weather data. http://www.weather.com/
- NASA global precipitation data including monthly and annual anomaly precipitation analyses. Dataset 1 covers the period 1900–88, while the extended and updated Dataset 2 covers the period 1850–1995. http://data.giss.nasa.gov/precip_dai/

Math Extension 1: Converting Kelvin to Celsius

Description: Students will consider the different ways of measuring temperature, and as a class, will use a formula to convert the temperatures of their assigned city from Kelvin to Celsius. This activity should be done before Activity 2.4, using a previously generated temperature graph for your city using MY NASA DATA. Students can then use the formula to convert the temperature scale on the Y axis of the city graph they are assigned in Activity 2.4.

Materials
- Overhead projector or LCD
- Graph of your city's temperatures from MY NASA DATA for projecting
- Student worksheet
- Pencils

Total Time: 30 minutes

Background Information

Temperature: Temperature is a degree of heat or cold that can be measured using a thermometer. It's also a measure of how fast the atoms and molecules of a substance are moving. Temperature is measured in degrees on the Fahrenheit, Celsius, and Kelvin scales.

Fahrenheit: The Fahrenheit scale was developed in 1724 and is based his scale on two reference points of temperature. The zero point is determined by placing the thermometer in brine: he used a mixture of ice, water, and ammonium chloride, a salt. This is a frigorific mixture which automatically stabilizes its temperature at 0 degrees F. The second point, 100 degrees, was human body temperature. Fahrenheit noted that using this scale, water boils at about 212 degrees.

Celsius Scale: The Celsius scale was created by Anders Celsius in 1744 and uses the freezing and boiling temperatures of water at sea level as a standard. 0 degrees Celsius (or 32 degrees Fahrenheit) is the freezing point of water, and 100 degrees Celsius (or 212 degrees Fahrenheit) is the boiling point of water at sea level. There are 100 divisions (or degrees) in between these two points, and each division represents a degree Celsius. To convert a temperature from Fahrenheit to Celsius use this equation: C = (degrees F - 32) x 5/9.

The Kelvin Scale: The Kelvin scale was developed in 1848 by Lord Kelvin (William Thomson). The Kelvin scale is an absolute scale, meaning that 0 is the lowest temperature possible. If the temperature is a measure of the average kinetic energy of the particles in a substance, then the temperature where there is no molecular movement would be 0 kelvins (K), or absolute zero. Thomson calculated that absolute zero was equivalent to −273 degrees Celsius on the air thermometers of the time. Currently, this temperature only exists in theory; it has never been reached, but scientists have come extremely close.

Procedure

1. Introduce temperature and the three different scales. Ask students if they heard the weather report for that day. Ask them what the temperature was supposed to be? Ask if any students know what units that temperature is in. (Fahrenheit).

2. Compare this to the temperature units they use in science class (Celsius) and explain that there are three different ways of measuring temperature. They are familiar with two of them, but in certain areas of science, especially in astronomy, they use a third different measure called Kelvin.

3. Explain that NASA uses Kelvin when they record temperatures using their satellites and so the temperature graph that they will be looking at in this activity is in Kelvins. To get a better idea of the temperatures in their city, they will practice converting from Kelvin to Celsius before they start looking at their own NASA data.

4. Project the MY NASA DATA graph of temperature for your city using an LCD projector or overhead projector. Hand out copies of the student worksheets.

5. Explain that Kelvin uses the same scale as Celsius so it is easy to convert from one to the other. The difference is the temperature that each scale calls zero. Explain that in Celsius the temperature at which water freezes is zero, but it of course can get much colder than that, and then we get negative temperatures. In Kelvin there are no negative temperatures, instead, they just called the lowest possible temperature 0. At 0 Kelvins (K), the temperature in Celsius is -273 degrees. So, to calculate one of the temperatures if you are given the other, you would use the following equation: K = degrees C + 273. It's important to note that the degree symbol isn't used when expressing the temperature in Kelvins.

6. During the discussion, students should be prompted to write down the formula on their worksheet.

7. Have students convert the high and low temperatures on the Y axis on the graph and write them on their worksheet.

8. When students have finished, ask what the highest temperature on the graph is in Kelvin. Have them convert that to Celsius. Do the same with the lowest temperature.

9. Students should keep the worksheet, with the formula, for reference as they complete Activity 2.4.

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Converting Kelvin to Celsius

1. Based on the class discussion, write the formula for converting Kelvin to Celsius.

   Formula: _____

2. What is the current temperature today in Celsius? _____

   What is the temperature today in Kelvin? _____

3. Look at the graph your teacher is projecting measuring the historical temperatures in your city.

   What are the units on the Y axis? _____

4. Convert the highest temperature on the Y axis to Celsius _____

5. Convert the lowest temperature on the Y axis to Celsius _____

6. Convert the highest temperature on the graph to Celsius _____

7. Convert the lowest temperature on the graph to Celsius _____

Math Extension 2: Measuring Precipitation

Description: Students discuss rainfall in the context of the rate of rainfall over a period of time and practice converting from inches to centimeters to millimeters in preparation for looking at the MY NASA DATA precipitation graphs, which show precipitation in mm/day.

Total Time: 30 minutes

Materials
- Recent weather reports for days with precipitation. These can be from the newspaper or printed from the Internet. If possible, try to find some reports that use metric and some that use standard measures
- Pencils
- Student journals
- Rulers with metric and standard measures

Procedure

1. Ask students if they remember the last time it rained. Was it a heavy rain? Did it last just a few minutes or all day? Did all the rain fall at once or did it come down a little at a time?

2. Ask students whether it would be possible for it to rain exactly the same amount, one inch total, on two different days if one day it rained for two hours and the second day it rained for six hours. Have them think this through aloud in a class discussion. The conclusion will be that yes, it could rain the same amount even though the time period is different because the rain is falling at a different rate.

3. Introduce the formula for rate of increase

   Total increase / Total time = rate of rainfall/hour

4. Have students use the formula to calculate the rate of precipitation in the scenario proposed in step two.

   Day 1 = 1 inch of rain/2 hours = .5 inches/hour
   Day 2 = 1 inch of rain/6 hours = .167 inches/hour

   On Day 1 rain was falling faster than on Day 2.

5. Explain that precipitation (rain, snow, hail, sleet, and other forms of water falling to the ground) is measured in units over a given time period. In the United States, when the weather is reported, precipitation is commonly represented in inches per 24-hour period. This means that if 1 inch of rain fell in a 24-hour period and water wasn't absorbed by the ground and did not flow downhill, after the storm there would be a layer of 1 inch of water covering the ground.

6. Explain that in science we always use metric units used for measuring, so when you look at scientific measures of precipitation rather than weather reports, they will be in millimeters or centimeters. Remind students that 10 millimeters = 1 centimeter. You may have students look at their ruler to compare inches, centimeters, and millimeters.

7. Introduce the formulas for converting back and forth between inches and centimeters.

   Centimeters to inches: cm x 0.39* = in

   Inches to centimeters: in x 2.54 = cm

   *rounded to the nearest hundredth

8. Have students practice converting centimeters to inches and inches using the actual precipitation measures from the recent weather reports. Also have them covert from inches to millimeters and centimeters to millimeters.

9. When students are comfortable with the conversion, you may proceed to Activity 2.4.

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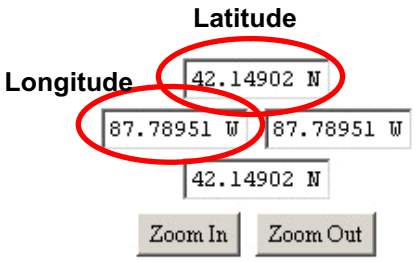
Directions: Climate Change Around the World

Use NASA data to make the same type of graph for your location.

1. **Find the latitude and longitude of the city you will be researching and record it on your handout.**
    a. Go to the Project BudBurst Geocoder at http://eo.ucar.edu/geocode/pbbcoder.html
    b. Type the city and country into the text box above the map.
    c. Click the **GEOCODE** button.
    d. The latitude and longitude of you city will be displayed above the map.
    e. Write the latitude and longitude, including the direction (north/south for latitude and east/west for longitude).

2. **Generate your graphs**
    Part A – Temperature
    1. Open your web browser and go to the MY NASA DATA website. Either type in the following address http://mynasadata.larc.nasa.gov/las/getUI.do, or click on the desktop link your teacher has created.
    2. Click the checkbox on the **UPDATE PLOT** button on the far left of the top menu bar. This will update your graph and make sure that your graphs update as you make selections for precipitation, cloud cover, and carbon dioxide.
    3. Click on the **DATASET** button in the upper left hand corner. The datasets window will open.
    4. Click on the **+** sign next to "Land Surface."
    5. Click on the **+** sign next to "Surface Conditions."
    6. Select **MONTHLY SURFACE SKIN TEMPERATURE (SRB).**
    7. Click the **CLOSE** button at the top of the datasets window. Your selection will be saved.
    8. Scroll down to **LINE PLOTS** and select **TIME.**
    9. Select the full time range available using the "Start date/time" and "End date/time" drop-down menus.
    10. Enter the latitude of your city in the top text box and the longitude in the left text box to the right of the map.
    11. Your graph will update on the right side of the web page
    12. Click on the **PRINT** button on the far left of the top menu bar. This will show your graph in a separate window.
    13. Print or save your graph.



To PRINT your graph
a. Right click on the image.
b. An options menu will open.
c. Select **PRINT.**
d. Your teacher will give you instructions on what printer and options to select.

To SAVE your graph

a. Right click on the image.
b. An options menu will open.
c. Select **SAVE IMAGE AS.**
d. Select **DESKTOP** from the "Save in" drop-down menu.
e. Type the name of your graph in the **FILE NAME** text box. Name your graph so that you will know what is in the file.
   - Begin the file name with your name or your initials, so you know it is your file.
   - Leave a space.
   - Then type the climate variable the graph represents (Temperature, Precipitation, Cloud Cover or CO_2).

     Example: JSB Temperature

f. Select the file type: GIF (*.gif)
g. Click **SAVE.**
h. The file will appear on your desktop.

Part B – Cloud Cover

1. Click the **CHOOSE DATASET** button on the far left of the top menu bar.
2. Click on the **+** sign next to "Atmosphere."
3. Click on the **+** sign next to "Clouds."
4. Click on the **+** sign next to "Cloud Coverage."
5. Select **MONTHLY CLOUD COVERAGE (ISCCP).**
6. Select the full time range available.
   Follow steps 9-12 to print or save your graph.

Part C – Precipitation

1. Click the **CHOOSE DATASET** button on the far left of the top menu bar.
2. Click on the **+** sign next to "Atmosphere."
3. Click on the **+** sign next to "Precipitation."
4. Select **MONTHLY PRECIPITATION (GPCP).**
5. Select the full time range available.
   Follow steps 9-12 to print or save your graph.

Part D – Carbon Dioxide

1. Click the **CHOOSE DATASET** button on the far left of the top menu bar.
2. Click on the **+** sign next to "Atmosphere."
3. Click on the **+** sign next to "Air Quality."
4. Select **MONTHLY CARBON DIOXIDE IN TROPOSPHERE (ARIS ON AQUA).**
5. Select the full time range available.
   Follow steps 9-12 to print or save your graph.

Name:_____ **Date:**_____ **Room:**_____

Expanding the Climate Model

Answer questions 1-5 as a group using the graphs you generate. Answer questions 6 and 7 from the following whole class discussion.

Part 1: Researching Your City

1. Write the name of the city and country that you are researching, and their latitude and longitude below.

   City, Country: _____

   Latitude:_____ Longitude: _____

2. From your graphs, can you determine any trends in temperature, precipitation, and cloud cover in the city you are researching? Discuss each graph separately.

   Temperature Trends:

   Precipitation Trends:

   Cloud Cover Trends:

3. What can you determine from the graph of CO_2 in the atmosphere?

4. How do your CO_2 and climate variable graphs compare? What conclusions can you draw, if any? Use your data to support these conclusions.

5. Based on your data, what do you predict will happen to the climate in your city in the future?

Part 2: Comparing Across Cities

6. Compare your city's graphs with at least one other group of students. Note their city, and describe how your temperature, precipitation, and cloud cover graphs compare to theirs. Use the data to explain your answers.

   Comparison City and Country: _____

   Temperature Comparison:

   Precipitation Comparison:

   Cloud Cover Comparison:

7. Is the climate changing in the same way in both your cities? What does your data tell you about how climate is changing globally?

Part 3: Global Comparisons
Answer the following questions as you discuss the results of your data analysis as a class.

8. Based on the data that you and your classmates have analyzed, describe the similarities and differences in trends in temperature, precipitation, and cloud cover around the world. Support your answer with examples from your discussion.

9. Based on the data that you and your classmates have analyzed, describe the similarities and differences in trends in carbon dioxide around the world. What conclusions can you draw?

10. You've heard the term "Global Warming" to describe changing climates. Explain why "Climate Change" is a more accurate way of describing what is happening to climate today.

11. What might be some impacts on the lives of the people who live in different areas of the world that have different trends?

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TEACHER ANSWER KEY

Converting Kelvin to Celsius

1. Based on the class discussion, write the formula for converting Kelvin to Celsius.

   Formula: _____

2. What is the current temperature today in Celsius? _____

   What is the temperature today in Kelvin? _____

3. Look at the graph your teacher is projecting measuring the historical temperatures in your city.

   What are the units on the Y axis? _____

4. Convert the highest temperature on the Y axis to Celsius _____

5. Convert the lowest temperature on the Y axis to Celsius _____

6. Convert the highest temperature on the graph to Celsius _____

7. Convert the lowest temperature on the graph to Celsius _____

TEACHER ANSWER KEY

Expanding the Climate Model

Answer questions 1-5 as a group using the graphs you generate. Answer questions 6 and 7 from the following whole class discussion.

Part 1: Researching Your City

12. Write the name of the city and country that you are researching, and their latitude and longitude below.

    City, Country: _____

    Latitude:_____ Longitude: _____

13. From your graphs, can you determine any trends in temperature, precipitation, and cloud cover in the city you are researching? Discuss each graph separately.

    Temperature Trends:

    Precipitation Trends:

    Cloud Cover Trends:

14. What can you determine from the graph of CO_2 in the atmosphere?

15. How do your CO_2 and climate variable graphs compare? What conclusions can you draw, if any? Use your data to support these conclusions.

16. Based on your data, what do you predict will happen to the climate in your city in the future?

Part 2: Comparing Across Cities

17. Compare your city's graphs with at least one other group of students. Note their city, and describe how your temperature, precipitation, and cloud cover graphs compare to theirs. Use the data to explain your answers.

    Comparison City and Country: _____

    Temperature Comparison:

    Precipitation Comparison:

    Cloud Cover Comparison:

18. Is the climate changing in the same way in both your cities? What does your data tell you about how climate is changing globally?

Part 3: Global Comparisons
Answer the following questions as you discuss the results of your data analysis as a class.

19. Based on the data that you and your classmates have analyzed, describe the similarities and differences in trends in temperature, precipitation, and cloud cover around the world. Support your answer with examples from your discussion.

20. Based on the data that you and your classmates have analyzed, describe the similarities and differences in trends in carbon dioxide around the world. What conclusions can you draw?

21. You've heard the term "Global Warming" to describe changing climates. Explain why "Climate Change" is a more accurate way of describing what is happening to climate today.

22. What might be some impacts on the lives of the people who live in different areas of the world that have different trends?

