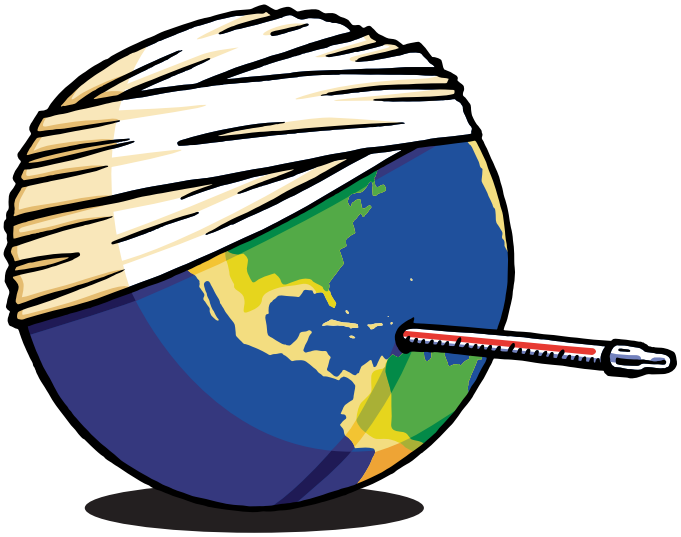
# GLOBAL AND GREAT LAKES CLIMATE CHANGE

(Background and Teacher Guide)



Over the past decades, much attention has been focused on the potential climatic effects of rising levels of atmospheric greenhouse gases, such as carbon dioxide and methane. Human activities as well as natural factors increase the levels of these gases in the atmosphere. A great deal of research has been done regarding the potential global significance of the increased greenhouse gas concentrations. In addition to receiving attention by the scientific community, global temperature fluctuations and other notable climate variations are causing a great deal of concern for average citizens worldwide. Advances in computer and communication technologies have allowed people to access and share large amounts of global climate information. The media have been an important part of this communications revolution, keeping the public informed on environmental issues. The information that we receive, however, can be conflicting and confusing.

Against a backdrop of controversy, government policy makers must decide whether or not to take action to reduce greenhouse gas emissions. Some policy makers argue that scientists do not agree on the problem, and therefore they oppose any specific timetables and actions for combating global climate change. Others call for the establishment of specific targets to cut the production of human-made greenhouse gases. The work of the Intergovernmental Panel on Climate Change [IPCC] supports the conclusion that "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Within the instrumental record of global surface temperature, which goes back to 1850, "eleven of the last twelve years (1995-2006) rank among the 12 warmest years" (IPCC 2007). Further, the report cites climate models predicting a global increase in temperature from 1.8 to 4.0 $^{o}$C by the end of the 21$^{st}$ Century.


IPCC, 2007: Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

# Teacher Activity A: Is the globe warming? Is there evidence in the Great Lakes region?

## BACKGROUND

A key to understanding the "global warming" debate is to understand how predictions are made. By recognizing the strengths and weaknesses of predictions based on one data record, for instance in observing temperature trends, the debate over global climate change can become easier to understand. The following activity deals with temperature *anomalies*, or departures from historic normal measures. If anomalies are increasingly positive, it would mean that warming is in progress. How many years does it take to make a trend discernible? Are global trends reflected in the temperatures we experience in the Great Lakes region?

**Objectives:** In this investigation, groups of students will graph data reflecting temperature anomalies over a short period in the recorded climate history of the world or in part of the Great Lakes region. Using only their own data, they will predict how their actual temperature anomaly trend might continue. That is, with limited data, what do they conclude about the future? As all student groups assemble and observe the trend of the 130-year data set, they may conclude that having a larger dataset offers more confidence in predictions. In addition to the science of the lesson, important conclusions can be drawn about how the construction of a graph scale can influence how the data are interpreted. After completing this investigation, students will be able to:

- Identify a trend in a set of graphic data.
- Evaluate and discuss the difficulties inherent in interpreting and forecasting long- and short-term trends.
- Analyze data, draw conclusions about whether temperature anomalies are evidence of global warming, and defend their conclusions.

**Materials:**

| | |
|---|---|
| Copies of Global and Cloquet-Great Lakes Temperature Anomaly Data.<br>Print the two pages on different colors of card stock and laminate for repeated use.<br>Cut apart on lines so each student/group gets one 26-year segment for graphing. | 1 per student/group |
| Graph paper copied from student pages, with origin [0] near the center of the Y axis and an X-axis divided to show actual versus predicted values. | 1 sheet per student/group |
| Colored pencils or markers for making graphs of actual and predicted data. | 1 set per student/group |
| Masking tape for mounting sequential data, for class observation of larger trends. | 1 per class |

**Time required:** 1-2 class periods

## ALIGNMENT

*National Framework for K-12 Science Education*:
SEP 2: Analyzing and interpreting data
CC 7: Stability and change
Core Idea ESS2.D: Weather and climate
Core Idea ESS3.D: Global climate change

*Great Lakes Literacy Principles*:
#3a,b,c,d,e: The Great Lakes influence local and regional weather and climate.
#6c: The Great Lakes and humans in their watersheds are inextricably interconnected.
#7e: Much remains to be learned about the Great Lakes.

*Climate Literacy Principles*:
#2b,c,e: We increase our understanding of the climate system through observation and modeling.
#5d,e,f: Earth's weather and climate vary over time and space.

## ENGAGE

Use a computer projector or smartboard to examine the temperature changes for the state of Wisconsin since 1960 at ***http://climatewisconsin.org/story/temperature-change***. Clicking on the side-by-side maps allows students to see that the temperatures from one decade to the next may not be greatly different, but comparing over longer time periods makes changes clear. The projected changes for decades 2020 and beyond are based on models that use trend analysis, just as students will practice in the activity.

## EXPLORE

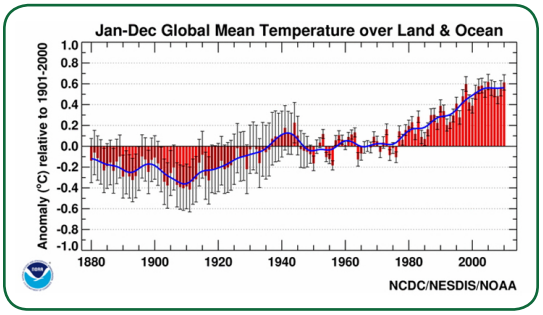
Students follow instructions to graph a segment of the total database and predict the anomalies to come based on the observed trend.

### Teacher's Notes:

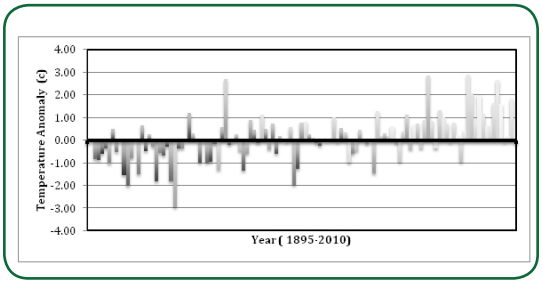
- Graph format: Vertical bar graphs are best for this kind of data, since the anomalies are really not connected across the years as a line graph would indicate. Students can plot increments of 0.2 degree on the Y axis and years on the X axis. They need to count how many years they have, and plan their graph so that the last year on their list is next to the center line on the graph paper. That way their ACTUAL anomalies end just as their PREDICTED anomaly line begins.
- Students typically start from the Y axis to plot the years of data, but it is important to have the LAST year of their actual data be graphed next to the vertical line down the center of the graph.
- Remind students that the numbers are not temperatures, but show how much the average temperature of each year differed from the 20th Century average.
- If modifying the activity for lower-level students, consider modifying the graph paper to have only the number of ACTUAL columns they will plot, and add the vertical scale before giving it to students. You might also provide rulers or another type of straight edge to help students correctly read years and temperature anomalies from the cards.
- If laminating the temperature lists for multiple uses, provide students with wet-erase markers so they can cross off values as they plot them.
- The word *data* is a plural noun. Set an example for student grammar by correctly saying things like "the data are…" or "annual data seem to indicate," or "what do the data show?"

## EXPLAIN

Students plot their results and predictions. Call the GLOBAL anomaly plotters to the front in order from earliest year to 2010. As they tape their graphs up for all to see, discuss how the existing numbers result in the predicted values. Fold progressive graphs so that the previous predictions are covered, and the latest prediction builds on a longer trend line. The resulting ACTUAL graph for global anomalies will look like this [without predictions]. The gray bars show the monthly extremes for each year. If you show the graph, point out that recent years have not had the extremes seen in some previous years.




Once the global set has been discussed, call the CLOQUET-GREAT LAKES anomaly plotters up to do the same thing with their graphs. If they used the same scale as for the global graph, the changes will appear large. Discuss why this would be so. [Cloquet data come from only one place, without averaging in the places that are extremely cold or extremely hot.]



**Teacher's Notes:**

Regional data are not collected separately for the Great Lakes. Instead, long term data from separate sites within states can show how climate change affects local areas. Cloquet [klo-KAY] is a small town in Minnesota, near the western tip of Lake Superior.

This can be a teachable moment for graph scales! The graph shown here for Cloquet has a Y-axis of -3.0 to 3.0, "vertically exaggerating" the differences. Plotting the two data sets on the same axis, one for global and one for Cloquet, would show the true magnitude of the variation in comparison to the globe. Sometimes people who report science choose their graph scales to make a point. They can claim that a trend is "not as great as it was feared," or is "even worse than anyone imagined," just by choosing a different vertical scale. Students should be alert to how data are portrayed in the media, so they can become wise consumers of science information.

The Cloquet data source is the U.S. Historical Climatology Network site at ***http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn_map_interface.html*** and you can use the site to find the mean annual temperatures of a location near you [not all locations have historical data]. If computers are accessible, student groups can compare several areas to see if temperatures are warming over time across the region. For Cloquet, we requested Monthly Data Download, by year, for all available years. To get the anomaly measure, take the average annual temperature from 1901-2000, and subtract that average from each year's annual temperature.

**Answers to Student Worksheet**

1. a. In early years the temperatures were below the century average.
   b. Over time, the annual global temperature has been increasing more and more above the century average. Accept various definitions that reference the increases above the average, as shown in the graph.
   c. Generally, people should have more confidence when predictions are based on larger amounts of data. There are some, however, who use the "need more data" cry to prevent action that really should be taken. Students may want to discuss how much is enough data.

2. a. Global warming does appear to be occurring. The trend is not as clear or consistent in the Cloquet-Great Lakes data, but the general pattern is toward higher temperature anomalies.
   b. Students should cite the length of the temperature record as evidence for their decision.
   c. Global data points are much more numerous. Be sure the students are thinking not about how many years are plotted, but how many measurements went into each average yearly number.
   d. Cloquet data do not include temperatures from the equator or the poles, as in global data. Cloquet numbers are only from a single point of latitude and longitude.

3. Answers will vary based on choice of location. Some factors that should be considered include proximity to large bodies of water, altitude of the area, percentage of land covered by urban structures, and such.

4 a. Blue: global temperature anomalies below average; red: global temperature anomalies above average
   b. Blue to red, suggesting a positive (warmer) departure from average global temperatures.
   c. From paragraphs 6 and 7 on the web page: They depict how much various regions of the world have warmed or cooled when compared with a base period of 1951-1980. (The global mean surface air temperature for that period was estimated to be 14°C (57°F), with an uncertainty of several tenths of a degree.) In other words, the maps show how much warmer or colder a region is compared to the norm for that region from 1951-1980. The period of 1951-1980 was chosen largely because the U.S. National Weather Service uses a three-decade period to define "normal" or average temperature. The GISS temperature analysis effort began around 1980, so the most recent 30 years was 1951-1980. It is also a period when many of today's adults grew up, so it is a common reference that many people can remember.
   d. 1880s: colder than average; 1970s: average (because this is considered a baseline temperature); 2000s: warmer than average. Arctic temperatures have undergone more change from average than other parts of the Earth.
   e. The gray patches represent areas where there was no data available at those times. They have decreased in size because more techniques to analyze global temperature data are available now than in the past.

**EXTEND**

1. Look at graphs of greenhouse gas concentrations over time at ***http://www.ecology.com/2011/11/22/greenhouse-gases-highest/#more-10808***. What relationships do you see between changes in global temperature and the levels of these gases? The IPCC's most recent [2007] assessment of data, including predictions, is at ***http://www.ipcc.ch/publications_and_data/ar4/syr/en/figure-spm-5.html*** and includes an important comparison between greenhouse gas increases and temperature scenarios.
2. Do Internet research on the phenomena of El Niño and La Niña and their effects on global temperature.
3. Have students plot each data set using Excel or similar graphing software. Assign a color to each data set. Have students generate a trend line for their graph. Assuming students have used the same scale, they can print their colored graphs with trend lines and hang them on the board end to end to see the complete data set. Sample graphs employing this technique are included for teachers to use in demonstrations.

**EVALUATE** Sample evaluation questions

1. Explain what is meant by a temperature anomaly.
   A temperature anomaly is a departure from a normal historic measure.
2. How would you describe the temperature anomalies of the last 10 years compared to the first half of the 20th Century?
   There are greater anomalies in recent years.
3. How does the graph of anomalies in one Great Lakes town compare to that for global anomalies with regard to
   a. Size of temperature anomalies for a given period?
      There are larger anomalies.
   b. Ease of spotting a trend in the temperature record?
      It is more difficult to spot a trend.
4. Why is the data set for a single location so different from that of the globe?
   Fewer data points are averaged into the measure.
5. Is Cloquet's temperature record a sign that global warming is occurring in the Great Lakes region? How is the answer to this question determined?
   It is a sign that the Cloquet area is warming, based on a general upward trend. However, the trend is not as clear as for the globe, and is not adequate for predicting a Great Lakes trend.
6. Discuss the implications of basing conclusions on limited data. Does this mean we should just continue to study climate without making decisions to deal with changing temperatures?
   Discussion should include the idea that we need a reasonable amount of credible scientific study. However, waiting for "enough" data should not prevent actions that would have a beneficial effect regardless of climate change.

**ADDITIONAL RESOURCES**

Global surface temperature anomalies, explanation and background from NOAA's National Climatic Data Center. Updated May 2011.
***http://www.ncdc.noaa.gov/cmb-faq/anomalies.php***

An excellent video clip explaining the difference between variations and trends can be found at
***http://www.youtube.com/watch?v=e0vj-0imOLw&feature=youtu.be***

The IPCC's most recent [2007] assessment of data, including predictions, is at
***http://www.ipcc.ch/publications_and_data/ar4/syr/en/figure-spm-5.html***

NOAA's State of the Climate Report, updated monthly: ***http://www.ncdc.noaa.gov/sotc/index.php***

Global warming in the Great Lakes, including state scenarios: ***http://www.ucsusa.org/greatlakes/*** Try the Migrating Climates interactive section to see how temperatures and precipitation in specific states will result in a climate more like somewhere else!

*Additional Great Lakes Climate Change lessons are available from Ohio Sea Grant.*
*Please call 614.292.8949 for more information.*

Original from Katzenberger, J., 1992. Is it getting hot or not? *Ground Truth Studies.* Aspen Global Change Institute, Aspen CO. ***http://www.agci.org/library/publications/about/publication_details.php?recordID=16846*** Updated from the adapted activity in *GLIMCES* © The Ohio State University, 1995.

Excel graph samples provided by Diane Desotelle, Minnesota Sea Grant

## GLOBAL ANNUAL TEMPERATURE ANOMALY DATA [$^0$C]

| Year | Global Temp Anomaly $^0$C | Year | Global Temp Anomaly $^0$C | Year | Global Temp Anomaly $^0$C |
|---|---|---|---|---|---|
| 1880 | -0.14 | 1906 | -0.20 | 1932 | -0.03 |
| 1881 | -0.06 | 1907 | -0.37 | 1933 | -0.16 |
| 1882 | -0.11 | 1908 | -0.39 | 1934 | -0.03 |
| 1883 | -0.15 | 1909 | -0.40 | 1935 | -0.06 |
| 1884 | -0.23 | 1910 | -0.39 | 1936 | -0.03 |
| 1885 | -0.19 | 1911 | -0.41 | 1937 | 0.07 |
| 1886 | -0.16 | 1912 | -0.34 | 1938 | 0.10 |
| 1887 | -0.24 | 1913 | -0.32 | 1939 | 0.09 |
| 1888 | -0.15 | 1914 | -0.16 | 1940 | 0.12 |
| 1889 | -0.10 | 1915 | -0.08 | 1941 | 0.18 |
| 1890 | -0.29 | 1916 | -0.28 | 1942 | 0.13 |
| 1891 | -0.25 | 1917 | -0.33 | 1943 | 0.12 |
| 1892 | -0.29 | 1918 | -0.22 | 1944 | 0.23 |
| 1893 | -0.32 | 1919 | -0.23 | 1945 | 0.10 |
| 1894 | -0.29 | 1920 | -0.20 | 1946 | -0.03 |
| 1895 | -0.21 | 1921 | -0.14 | 1947 | -0.04 |
| 1896 | -0.10 | 1922 | -0.22 | 1948 | -0.05 |
| 1897 | -0.13 | 1923 | -0.20 | 1949 | -0.08 |
| 1898 | -0.25 | 1924 | -0.18 | 1950 | -0.16 |
| 1899 | -0.13 | 1925 | -0.12 | 1951 | -0.00 |
| 1900 | -0.11 | 1926 | -0.02 | 1952 | 0.03 |
| 1901 | -0.16 | 1927 | -0.10 | 1953 | 0.12 |
| 1902 | -0.22 | 1928 | -0.09 | 1954 | -0.10 |
| 1903 | -0.34 | 1929 | -0.22 | 1955 | -0.12 |
| 1904 | -0.38 | 1930 | -0.03 | 1956 | -0.18 |
| 1905 | -0.26 | 1931 | 0.00 | 1957 | 0.06 |
| 1958 | 0.11 | 1984 | 0.09 | | |
| 1959 | 0.06 | 1985 | 0.07 | | |
| 1960 | 0.01 | 1986 | 0.16 | | |
| 1961 | 0.09 | 1987 | 0.30 | | |
| 1962 | 0.11 | 1988 | 0.30 | | |
| 1963 | 0.13 | 1989 | 0.22 | | |
| 1964 | -0.13 | 1990 | 0.39 | | |
| 1965 | -0.07 | 1991 | 0.34 | | |
| 1966 | -0.01 | 1992 | 0.20 | | |
| 1967 | 0.00 | 1993 | 0.23 | | |
| 1968 | -0.01 | 1994 | 0.30 | | |
| 1969 | 0.09 | 1995 | 0.41 | | |
| 1970 | 0.05 | 1996 | 0.28 | | |
| 1971 | -0.05 | 1997 | 0.48 | | |
| 1972 | 0.04 | 1998 | 0.60 | | |
| 1973 | 0.16 | 1999 | 0.42 | | |
| 1974 | -0.08 | 2000 | 0.39 | | |
| 1975 | -0.02 | 2001 | 0.52 | | |
| 1976 | -0.11 | 2002 | 0.58 | | |
| 1977 | 0.14 | 2003 | 0.58 | | |
| 1978 | 0.06 | 2004 | 0.54 | | |
| 1979 | 0.16 | 2005 | 0.62 | | |
| 1980 | 0.20 | 2006 | 0.56 | | |
| 1981 | 0.23 | 2007 | 0.55 | | |
| 1982 | 0.12 | 2008 | 0.48 | | |
| 1983 | 0.28 | 2009 | 0.56 | | |
| | | 2010 | 0.61 | | |

Teacher: Print and laminate page and cut sections apart. Each student or group should get either one GLOBAL temperature set or one GREAT LAKES set.

Data from ***ftp://ftp.ncdc.noaa.gov/pub/data/anomalies/usingGHCNMv2/***, data set ***annual.land_ocean.90S.90N.df_1901-2000mean.dat***.
Accessed 11/23/11

**CLOQUET - GREAT LAKES ANNUAL MEAN TEMPERATURE ANOMALY DATA [$^0$C]**

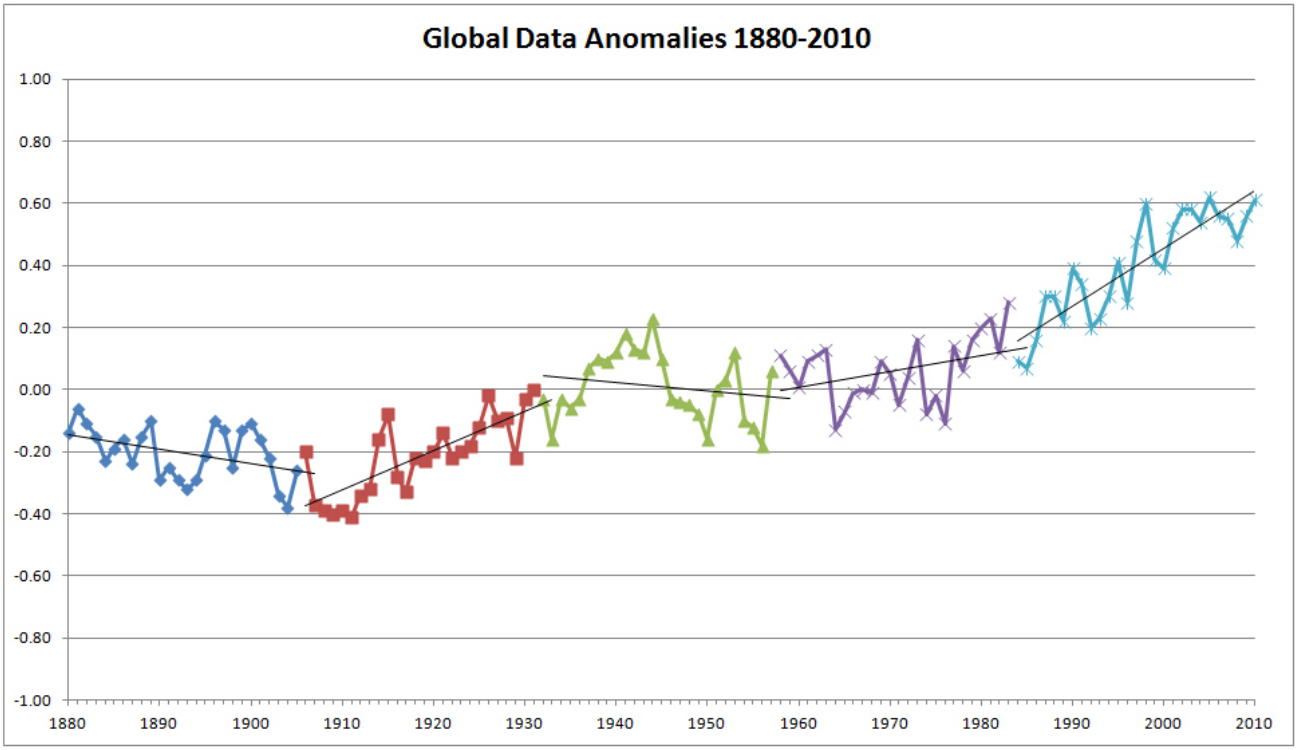
| Year | Cloquet Temp Anomaly $^0$C | Year | Cloquet Temp Anomaly $^0$C | Year | Cloquet Temp Anomaly $^0$C |
|---|---|---|---|---|---|
| 1895 | -0.85 | 1919 | -0.38 | 1942 | 0.50 |
| 1896 | -0.90 | 1920 | 0.03 | 1943 | -0.42 |
| 1897 | -0.62 | 1921 | 1.21 | 1944 | 0.73 |
| 1898 | -0.35 | 1922 | 0.30 | 1945 | -0.59 |
| 1899 | -1.04 | 1923 | 0.07 | 1946 | 0.17 |
| 1900 | 0.50 | 1924 | -0.99 | 1947 | -0.03 |
| 1901 | -0.52 | 1925 | -0.10 | 1948 | -0.11 |
| 1902 | -0.05 | 1926 | -0.99 | 1949 | 0.56 |
| 1903 | -1.56 | 1927 | -0.95 | 1950 | -1.97 |
| 1904 | -2.03 | 1928 | -0.19 | 1951 | -1.27 |
| 1905 | -0.82 | 1929 | -1.30 | 1952 | 0.75 |
| 1906 | -0.05 | 1930 | 0.59 | 1953 | 0.82 |
| 1907 | -1.49 | 1931 | 2.71 | 1954 | 0.24 |
| 1908 | 0.66 | 1932 | -0.22 | 1955 | 0.10 |
| 1909 | -0.50 | 1933 | -0.08 | 1956 | -0.12 |
| 1910 | 0.25 | 1934 | 0.25 | 1957 | -0.25 |
| 1911 | -0.29 | 1935 | -0.50 | 1958 | 0.01 |
| 1912 | -1.83 | 1936 | -1.36 | 1959 | -0.05 |
| 1913 | -0.58 | 1937 | -0.61 | 1960 | 0.06 |
| 1914 | -0.69 | 1938 | 0.90 | 1961 | 1.00 |
| 1915 | -0.29 | 1939 | 0.47 | 1962 | -0.11 |
| 1916 | -1.82 | 1940 | -0.12 | 1963 | 0.55 |
| 1917 | -2.94 | 1941 | 1.13 | 1964 | 0.35 |
| 1918 | -0.37 | | | | |
| Year | Cloquet Temp Anomaly $^0$C | Year | Cloquet Temp Anomaly $^0$C | | |
| 1965 | -1.01 | 1988 | 0.83 | | |
| 1966 | -0.59 | 1989 | -0.35 | | |
| 1967 | -0.49 | 1990 | 1.33 | | |
| 1968 | 0.45 | 1991 | 0.99 | | |
| 1969 | 0.07 | 1992 | 0.73 | | |
| 1970 | -0.19 | 1993 | -0.12 | | |
| 1971 | -0.03 | 1994 | 0.77 | | |
| 1972 | -1.45 | 1995 | 0.22 | | |
| 1973 | 1.27 | 1996 | -0.97 | | |
| 1974 | 0.16 | 1997 | 0.40 | | |
| 1975 | 0.28 | 1998 | 2.90 | | |
| 1976 | 0.17 | 1999 | 2.05 | | |
| 1977 | 0.61 | 2000 | 0.96 | | |
| 1978 | -0.14 | 2001 | 1.98 | | |
| 1979 | -0.97 | 2002 | 1.15 | | |
| 1980 | 0.37 | 2003 | 0.65 | | |
| 1981 | 1.14 | 2004 | 0.63 | | |
| 1982 | -0.43 | 2005 | 1.62 | | |
| 1983 | 0.63 | 2006 | 2.65 | | |
| 1984 | 0.73 | 2007 | 1.57 | | |
| 1985 | -0.39 | 2008 | -0.10 | | |
| 1986 | 0.90 | 2009 | 0.18 | | |
| 1987 | 2.86 | 2010 | 1.82 | | |

TEACHER: Each student or group should get either one GLOBAL temperature set or one GREAT LAKES set.

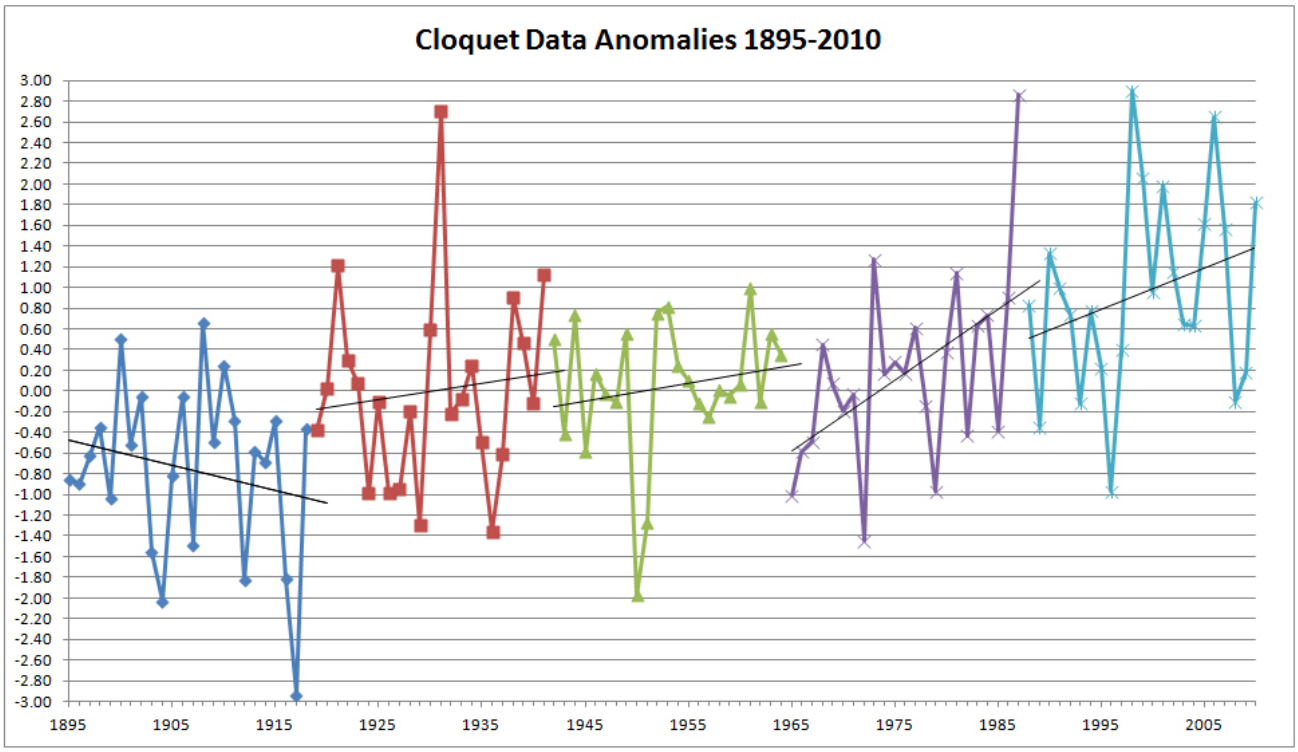
For the Cloquet data, you may wish to use the same Y-axis scale as in the global data, or expand the scale for easy interpretation and graphing.

***http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn_map_interface.html***

## COMBINED GLOBAL DATA SAMPLE




## COMBINED CLOQUET DATA SAMPLE




Graphs provided by Diane Desotelle, Climate Change Adaptation Extension Educator, Minnesota Sea Grant

# Student Activity A: Is the globe warming? Is there evidence in the Great Lakes region?

**BACKGROUND**

A key to understanding the "global warming" debate is to understand how predictions are made. Scientists have been recording temperatures around the world since the 1850s. Based on what they observe, they try to make predictions about the future. This lesson deals with temperature *anomalies*, or differences from the average expected temperature. How many years does it take to make a temperature trend obvious, so we can predict with confidence? Are trends in towns around the Great Lakes similar to those for the globe?

**OBJECTIVE**

In this investigation, you will graph data on temperature anomalies over a short period in the recorded climate history of the world or in one Great Lakes town (Cloquet, Minnesota). With limited data, what do you conclude about temperatures in the future? How does your prediction improve with more data?

**PROCEDURE**

**Graphing temperature anomalies**

From the average yearly temperatures reported by thousands of weather centers, scientists have calculated an average temperature for the 20th Century. Then the National Oceanic and Atmospheric Administration (NOAA, home of the National Weather Service) calculated how each year's average temperature differed from the average for all 100 years. That number is the *temperature anomaly* for the year. If the average temperature for a year was below the century average, the anomaly is negative. If the average for a year is above the century average, the anomaly is positive.

1. You will receive a set of data to plot on a new kind of graph. The data will be either GLOBAL or CLOQUET-GREAT LAKES temperature anomalies for some past years. Use the graph paper provided to plot the data.
    a. Look at the darker lines that cross near the center of the graph. The horizontal line [left to right] represents the global average temperature in the 20th Century. The vertical line [top to bottom] divides the ACTUAL anomalies, the ones on your list, from some PREDICTIONS you make based on what the temperature is doing on your graph.
    b. Count how many years you are graphing, then count backward from the vertical center line so your last year lines up next to the center line. You may have some blank parts of the graph on the left.
    c. This will be a BAR GRAPH, with each year's bar going either up or down from the average line. Do not connect the tops of the bars as if the numbers are on a line graph.

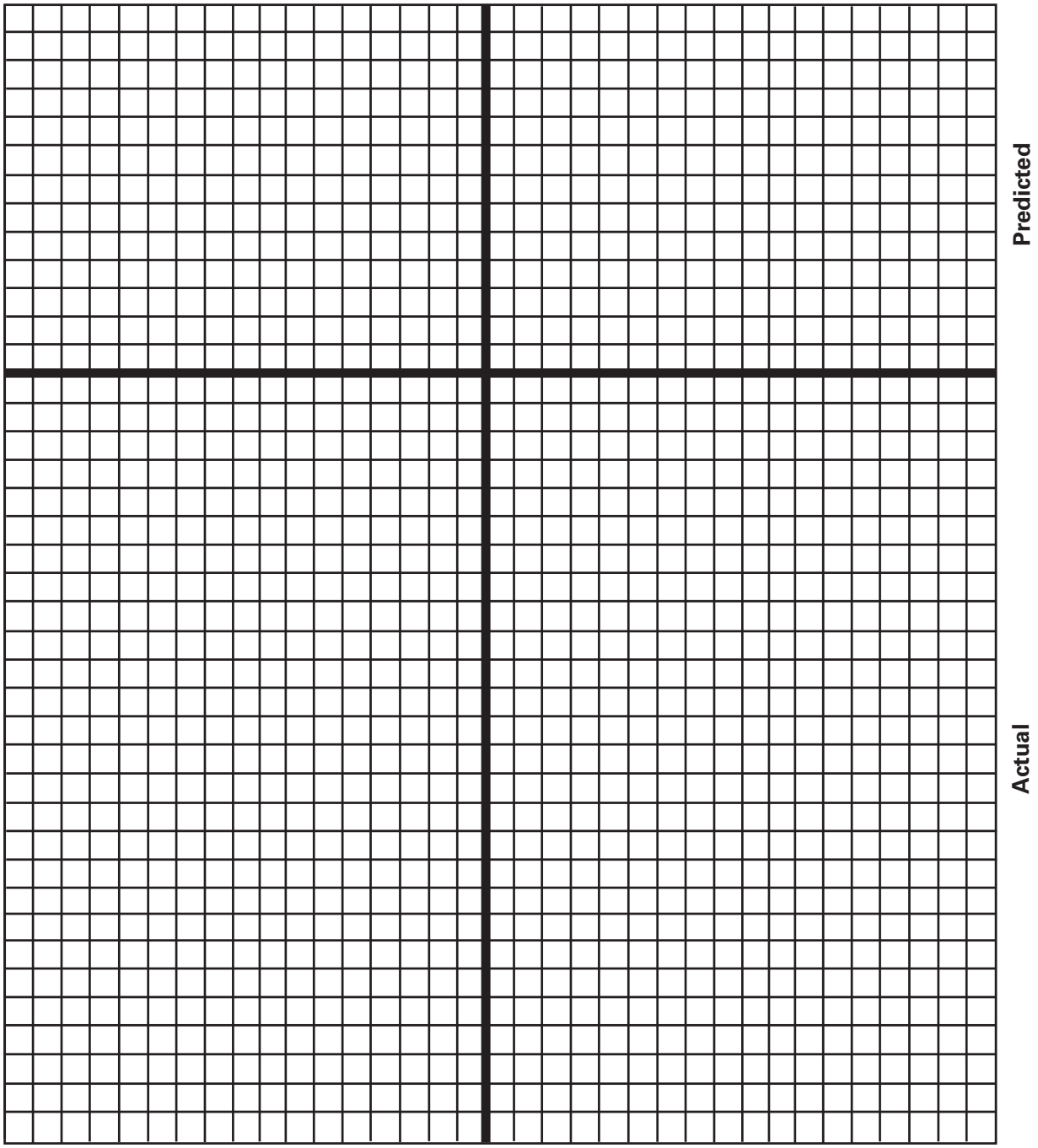
2. After you have made a bar graph of your years of anomalies, look at how the numbers are changing from the first bar to the last one you plotted. Are the numbers going up, down, or what for the period you plotted? Try to identify a *trend* in the data.

3. To the right of the center line, predict how the anomalies will look over the next 25 years, and fill in a sample of how that graph might look.

4. The class will look at each graph in order by years and discuss how predictions were made. Be ready by answering the worksheet questions.

Name _____ Period _____

**Graph of Temperature Anomalies  Check one: ____GLOBAL  ____ GREAT LAKES**



Name _____ Period _____

**Answer the following questions on this worksheet:**

1. Based on the class GLOBAL graphs and predictions, answer the following:
    a. Describe the global temperature anomalies in the early half of the class graph.

    b. Based on the graph, how would you define "global warming"?

    c. Which prediction gives you more confidence – one based on a small amount of data, or one based on more data? Why?

2. Look at the CLOQUET - GREAT LAKES graphs. Describe how the local graph compares to the global graph:
    a. Is global warming occurring in Cloquet, an example of the Great Lakes region? _____ Discuss how the data led to your conclusion.

    b. Assume one of your classmates holds a different opinion of 2a. How will you use data to defend your position?

    c. Consider the geographic area over which the annual averages are collected. Which graph is based on more data, global or Cloquet? _____

    d. If your class graphed both global and Cloquet anomalies on the same Y-axis scale, why does the local graph have anomalies that are so much different?

Name _____ Period _____

3. If time permits, use the U.S. Historical Climatology Network at ***http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn_map_interface.html*** to find the mean annual temperatures of other locations in the Great Lakes. Use the software at the web site to plot a graph of annual mean temperatures.
    a. What location did you choose for data from the U.S. Historical Climatology Network? _____

    b. Does it appear that global warming is occurring there? Describe the graph – does it look more like the global data or the Cloquet data graph?

    c. What factors might affect whether the temperature in a local area is related to global trends?

4. If time permits, watch NASA's animation of global temperature anomalies at ***http://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php***.
    a. What do the red and blue colors represent?

    b. Based on the animation, what is the overall trend in global temperature change?

    c. Click on the dots to see the average temperature anomaly for each decade. Why does it appear that there are few to no global temperature anomalies in the 1950s, 1960s and 1970s?

    d. Describe the temperature anomalies for the Arctic region in the 1880s, 1970s, and 2000s. What do you notice about temperature anomalies in the Arctic compared to other parts of Earth?

    e. What do the gray patches represent? Why does the area of the gray patches decrease throughout the decades?