

Investigating Climate Change around the World

A laboratory experiment from the
Little Shop of Physics at
Colorado State University



Overview

Human-caused climate change is often called “global warming,” but the changes are much more complicated than uniform warming. We will examine temperature trends at 5 U.S. sites and 7 international sites representing varying climates. From this experiment, students will learn where warming is more extreme; that year-to-year variability is different from long-term trends; and that changes in extreme temperature events are also occurring.

Necessary materials:

- Computer with Microsoft Excel or some other spreadsheet software
- Temperature data of 12 sites are provided

This experiment is set up to have up to 12 groups. Three students per group would be an ideal number.

Doing the Experiment

Students should divide into groups of about three, each choosing a site to focus on. Each site has a dataset of monthly mean temperatures, and monthly min/max temperature from at least 1943 to present. However, there is missing data in all but one of the datasets, so students will get a feel for how missing data affects the robustness of temperature trends. Using the provided datasets, students will calculate the trends and create plots. Finally, all of the groups will present their results to the rest of the class. If computers are limited, this will work with larger groups, or as a presentation by the teacher with a projector attached to the main computer.

The following U.S. sites are available from 1943:

- Anchorage, Alaska - 61.2°N, 149.8°W; marine/subpolar climate
- Honolulu, HI - 21.3°N, 157.8°W; moist tropical climate
- Detroit, MI - 42.2°N, 82.9°W; humid continental
- Pueblo, CO - 38.3°N, 104.6°W; semi-arid climate
- Sioux Falls, SD - 43.5°N, 96.7°W; humid continental climate

And the following international sites are available (see next page for map):

- Im. M.v. Popova, Russia (from 1937) - 73.3°N, 70.0°E; polar tundra climate
- Oxford, England (from 1853, only minimum and maximum temperatures) - 51.8°N, 1.3°W; marine climate
- Halley Research Station, Antarctica (from 1956) - 75.6°S, 26.6°W; polar ice cap climate
- Atar, Mauritania (Africa) (from 1943) - 17.8°N, 8.6°W; arid desert climate
- Natal, Brazil (from 1943) - 5.9°S, 35.1°W; tropical seasonal wet climate
- Sydney, Australia (from 1943) - 33.9°S, 151°E; humid subtropical climate
- Cagliari, Sardinia, Italy (from 1943) - 39.2°N, 9.1°E; Mediterranean climate



Instructions for handling the data in Excel

1. Each of the data sets contain annual mean temperatures for January, July, and the year, as well as the minimum and maximum temperatures for each year's January and July.

2. You will have your students calculate the mean for each dataset, and the trend to see how the temperature is changing over time.

3. To calculate the mean value, type: `"=average(start:finish)"`. *Start* is the cell where the list of temperatures begins, and *finish* is the cell where it ends. For example, the mean of a 68-year list that starts in Column B would

be computed as `"=average(b1:b68)"`.

4. You can calculate the slope of the array by entering: `"=slope(ystart:yfinish,xstart:xfinish)"`. *ystart* and *yfinish* are the beginning and end of the list of temperatures. *xstart* and *xfinish* is just a list from 1 to how many years of data you have.
5. Now you are almost ready to plot the trend of the temperatures. You just have to calculate a y-intercept. Remember the geometry formula: $y = mx + b$? In this case, x is your numbered list from 1 to number of years. m is the slope. b is the y intercept. So you can calculate b by changing the formula around to: $b = y - mx$. Use the average as your y , and assume that the trend passes through the average value half-way through the data record. So for a 68-year record, x would be 34.
6. Now create a list of the predicted temperatures based on the calculated linear trend. This list will just be $mx + b$, where x is the list of years (starting at 1).
7. Plot the actual list of temperatures and overlay the calculated linear trend so you can visualize the increase or decrease in temperature over the course of the data record.
8. All of these steps are already done in the excel spreadsheets you will receive. Depending on the level of the students, you can have them do as much or as little of this experiment as you see fit.

Summing Up

Here are some of the topics students should discuss and think about during this experiment:

- Which sites have the most extreme warming? Do any sites have cooling?
- What does the average temperature for an individual year have to do with long-term trends? (The answer here is not much - one particularly warm or cold year neither proves nor disproves global warming.)
- Are there trends in the extreme temperatures? What are the implications? For example, agriculture will benefit from increasing minimum temperature, while increasing maximum temperatures are harmful to crops.
- Some sites have sparse data at the beginning of the record. Would the trend be affected by looking at a shorter record? For example, Cagliari only has one temperature value before 1952, so what if we calculate the average and trend from 1952-2007 instead of from 1943-2007?
- If the trends you calculated continue, what do you expect the temperatures to be in 2050? In 2100?
- Does the general pattern of trends you see correspond to predictions by IPCC climate models?

For More Information

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: <http://cmmmap.colostate.edu>

Little Shop of Physics: <http://littleshop.physics.colostate.edu>