

Global Climate Change Lab: Analysis of Historical Temperature and Precipitation Data: Is Global Warming Real?

Note: This is the 2nd lab I have my Global Climate Change class do. We will not do all the exercises in the lab but just give a flavor for the kinds of things that can be done with web-based data sets, in this case data from the NASA-GISS site.

In this lab exercise you will use your new skills with Excel to analyze temperature and precipitation data from a variety of cities around the nation and the world. By “variety” we mean cities that are in the northern and southern hemispheres, at high, middle and equatorial latitudes, near the coast and in the middle of continents, and so forth. By doing this analysis you will see how geographic position on earth affects climate and understand some of the factors that contribute to large or small extremes in climate for a particular city over a long time span.

We will also assess the skepticism about the reality of global warming. Despite recent events in the press there is considerable lack of awareness of the problem because of the complexity of the issue, more immediate concerns, apathy, or even outright disbelief. While all climate scientists believe global warming is occurring, a survey of the mass media found that about 50% of the articles in the mass market publications argued against global warming or that humans were changing the climate in any perceptible way.

Climate change deals with the long-term variation in temperature, rainfall, vegetation, storminess, and so forth on Earth. By long-term we can mean many orders of magnitude of time from billions to hundreds of years. Climate change can be quite spectacular changing from a very hot climate to a very cold one or more subtle depending on the time frame. The period between 1400 and 1700 is known as the Little Ice Age though the global temperature decreased by less than one degree centigrade. During the ice ages of the last million years or so the temperature change was about 6-8°C colder than today (15°C), each lasting for several thousand years.

Because the instrumental (thermometers) measurement of temperature is relatively recent the temperature records for many cities start in the late 1800's. This should be enough time to see a temperature trend especially since we think the Industrial Revolution (1850-present) has provided most of the greenhouse gases.

Think about this: Would you expect the climate data in the late 1800's to be more, less, or as accurate and precise as the data in the 21st century? Why?

Think about this: Under what circumstances might you want to use daily data rather than monthly averages and vice versa?

We want to look at two temperature data sets to help us answer some questions about Global Warming: Is it occurring? If so, is it occurring globally? Can we use long-term records to predict future temperature change?

Let's look at two specific locales, one a large city and the other a small town in different parts of the US. One thing we need to take into consideration is that large cities have lots of pavement, buildings, and general lack of vegetation, cause the large city to absorb more the incoming solar radiation during the day and re-radiate the back radiation of heat at night. We call this the "urban heat island effect". For now we will ignore the effect but will return to it later.

Modeling Temperature Data Sets

1. How Hot is Los Angeles?

Log on to the website: http://data.giss.nasa.gov/gistemp/station_data/. This is the data site of the Goddard Institute for Space Studies (GISS) at Columbia University in New York City.

1. Under the header **Download Station Data**, type **Los Angeles** in the box labeled **"enter here a station name to search for"**
2. Click **Search**
3. In the new open window, click Los Angeles, California. You will see a graph of the annual average temperatures in LA for the period 1880-2008.

Q: Is there a discernible increase or decrease in the temperature through time?

Q: What process(es) might be responsible for the observed changes in temperature over time?

Let's explore this data set further with EXCEL.

4. Click **Download monthly data as text**.
5. After new web page opens, click **File> Save as...**
6. In the **Save in** window, navigate to save your file on the desktop
7. In the **File Name**, type **LA_Station**
8. Click **Save**
9. Open EXCEL
10. Click **File>Open**
11. In the **Look In** window, point to the desktop
12. In the **Files of type**, point to the all files (*.*) . Then in the name window scroll to find your **LA_Station.txt** file and double click it.
13. A new window, **Text Import Wizard**, will appear. This happens because our file is in a

format not recognized by EXCEL.

14. Click **Next** twice and then **Finish**.

Name your new EXCEL file, LA_station. As you look at it you may notice some strange temperature or 999.9. This is a common way to indicate NO DATA not that global warming is really out of control and we didn't know how bad it really was.

Think about this: Why would there be data missing in a record?

In order to get rid of the 999.9's, do the following:

Press **Ctrl+F** keys together and the **Find and Replace** box will appear.

Click **Replace** tab.

In the **Find What** box, type 999.9

Leave the **Replace with** box empty

Click **Replace all**

Click **OK**, then **Close**

In the EXCEL files you will notice each row is a year of record and that the first 12 columns represent Jan-Dec, then the next four columns are three month period (D-J-F, M-A-M, J-J-A, S-O-N), the last column is the Annual average temperature for the year.

Do This:

1. Make a Scatter plot with connect data points for all the annual average temperature for all years of record.
2. Change the vertical axis to better show the data
3. Now add a linear trend line to the graph including displaying the equation and R^2 value of the data set. Move the graph to Chart 1 (right click, Move Chart)
4. Calculate the mean annual temperature and standard deviation for LA for the
5. Period 1880-2008 at the bottom of the Annual Temp column in the spreadsheet

Questions:

Considering the magnitude of the mean, is this a large standard deviation?
What does this say about the variability of temperature in LA over the time period?
What might be an explanation for the variability?

2. How Hot is it down in Texas?

Go back to the GISS website and **find the dataset for Albany, Texas.**

Extract the dataset in the same way as you did for LA (**type Albany into the selection box and click on the first Albany that comes up in the list**), copy the entire dataset to the existing LA_Station EXCEL file, make a graph with a trend line, equation of the trend line and R^2 value, and calculate the mean temperature and standard deviation for this dataset. Move the Albany graph to Chart 2.

Compare the two dataset graphs.

Q: What is the most obvious difference between the two sets of data?

Q: What does this tell us about Global Warming?

Let's look at the data in another way.

On each graph add another trend line, this time adding a polynomial trend with the degree at 6.

Q: Does the polynomial R^2 value improve any over the linear trend?

Notice that as opposed to the linear trend there appear to be slight increases and decreases in annual temperature over time. It is generally cooler before 1920, warmer from 1920-1950, cooler from 1950-1990 and then warmer since about 1993 in both datasets.

Q: With the polynomial trend, could there be any other explanations for the changes in climate over time?

Q: Which model (linear or polynomial) would be best for explaining the datasets?

3. The Urban Heat Island Effect

We now return to the Urban Heat island effect to see if land development in a large city could be an explanation for the rise in temperature overtime or if global warming in some places is occurring because of forces outside the city itself. We will compare the LA record to one from Ojai, CA, a small town far enough outside LA to not be effected by the heat island phenomenon.

Do This: Return to the GISS website main page and type into the place selector **OJAI**. Click on the selection and collect the data as before including placing the data into a new EXCEL spreadsheet.

Copy the column for Annual temp for all the years of record and Paste it to the right of the Annual temp on the LA_Station spreadsheet.

Make a graph of LA and Ojai temperature versus time and place linear trend lines through each graph.

Q: From the trend lines of the two graphs, is the rise in temperature due to the heat island effect?

Q: What would the Ojai graph look like if the heat island effect were solely responsible for the rise in temperature of time?

The Homework Exercise:

We have seen that the effects of Global Warming are not universally apparent in every part of the US. Is the same true for the World as a whole? To test to see if Global warming is truly global do the following to be submitted to Moodle drop box for a grade by Sep 15-16 per your lab day:

1) Produce a graph of historical temperature for your home town or a locale near to your hometown. Include a trend line with slope equation and R^2 value. Include the latitude, longitude, altitude, distance from the nearest ocean and any other pertinent geographical information (e.g., near mountains, a large lake, inland sea, desert, etc.)

2) Produce a graph of historical temperature for one the 26 largest cities in the world OUTSIDE the US similar to your hometown graph. In some cases you may have to merge 2 or more records to get the longest time period.

The largest non-US cities by population are:

Tokyo, Japan - 28,025,000	Ôsaka, Japan - 10,609,000
Mexico (City), Mexico - 18,131,000	Rio de Janeiro, Brazil - 10,556,000
Mumbai, India - 18,042,000	Tianjin, China - 10,239,000
São Paulo, Brazil - 17,711,000	Jakarta, Indonesia - 9,815,000
Shanghai, China - 14,173,000	Paris, France - 9,638,000
Calcutta, India - 12,900,000	Istanbul, Turkey - 9,413,000
Buenos Aires, Argentina - 12,431,000	Moskva (Moscow), Russian Fed. - 9,299,000
Seoul, South Korea - 12,215,000	London, United Kingdom - 7,640,000
Beijing, China - 12,033,000	Lima-Callao, Peru - 7,443,000
Karachi, Pakistan - 11,774,000	Tehrān, Iran - 7,380,000
New Delhi, India - 11,680,000	Bangkok, Thailand - 7,221,000
Dhaka, Bangladesh - 10,979,000	Bogotá, Colombia - 6,834,000
Manila, Philippines - 10,818,000	
Cairo, Egypt - 10,772,000	

3) Choose any third city that is as far away from your hometown and the large city you chose in part 2. If you chose a large city in the northern hemisphere then find one in the southern hemisphere. If your first two cities are similar in latitude or altitude or closeness to the ocean pick one that is radically different in these respects. Choose a city with as long a climate record as possible. Repeat the process of graphing, statistical analysis, and geographic information gathering as above.

- 4) Place all three datasets in one EXCEL file with all the graphs as CHARTS in the same file.
- 5) Analyze the data sets and the ancillary data (looking at a world map may help with the geographic context).
- 6) Write a 500-word essay comparing and contrasting the climates of the three cities over time and in their geographic context and from this data set determine if global warming is real, not real or equivocal and why you think so.
- 7) Submit the EXCEL file and essay as a WORD document to Blackboard drop box. Make sure the file names include your last name.

DATA SHEET FOR TEMPERATURE AND PRECIPITATION EXERCISE

City #1 _____ (Your Hometown)

Longitude: _____

Latitude: _____

Elevation (meters): _____

Distance from coast (km): _____

of years of record: _____

Other geographically interesting facts about this city:

City #2 _____ (one of the top 25 Cities in the World- see list)

Longitude: _____

Latitude: _____

Elevation (meters): _____

Distance from coast (km): _____

of years of record: _____

Other geographically interesting facts about this city:

City #3 _____ (any other city as far from the first two as possible)

Longitude: _____

Latitude: _____

Elevation (meters): _____

Distance from coast (km): _____

of years of record: _____

Other geographically interesting facts about this city.