Time Series Analysis of Lehigh Valley Climate Records

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Goals of the lab exercise:

1. to review some basic methods of data analysis and visual data presentation;
2. to appreciate how some basic climate parameters are calculated from instrumental weather measurements; and
3. to get familiar with the local/regional climate pattern in preparing for analysis of tree-ring data in the forthcoming labs.

Summary Activities:

We will make some time series plots, compute seasonal means and compare temperature and precipitation series over the last century. We will look at general features of instrumental climate records for our region.

All we will need for plotting and calculating is a spreadsheet program (e.g., Excel). If you are familiar with spreadsheets, then you should be able to do all these exercises quickly. If you are not familiar with them, hopefully you will be after this lab. Some tricks and tips can help you manipulate large data sets more efficiently.

Data Sets:

We will need two data files:

1. monthly maximum, minimum and mean temperatures and monthly precipitation from Allentown (Lehigh Valley Airport) Climate Station for the period of 1925-1990/1996. Each column shows the temperature or precipitation for a particular month (or annual values) over the period.
2. annual temperatures and precipitation from Pennsylvania Climate Division 2 (East Central Mountains).

These data sets can be downloaded from NCDC Climate Visualization web site (http://www.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgr.html), which contains Climate Division Precipitation, Temperature, and Drought Data/Graphics **(http://www.ncdc.noaa.gov/oa/climate/onlineprod/drought/main.html)** and Global Historical Climatological Network Data/Graphics **(http://www.ncdc.noaa.gov/oa/climate/ghcn/ghcn.SELECT.html)**. Or from the United States Historical Climatology Network (http://www.ncdc.noaa.gov/oa/climate/research/ushcn/ushcn.html#INTRO).

Report/Assignment:

You need to prepare a report of 1-2 pages in length, with appropriate graphs attached. The report should provide concise answers to the following questions (with one or a few sentences for each question).

Detailed Activities and Assignments:

1. Time series plots of temperatures

Time series plot is a straightforward and fundamental way to present climate data. A climate variable (e.g., temperature, or precipitation) is plotted against time to illustrate trends and patterns in the data.

a. Plot monthly mean, maximum and minimum temperatures as a function of time (year). For each of temperature parameters (max, min, and mean), plot the three months of each season (winter=D,J,F; spring=M,A,M; summer=J,J,A; fall=S,O,N) on the same graph (e.g., D, J, F mean temperatures on 1 graph), and plot all four graphs (4 seasons) on the same page. You should end up with three pages, one page for each temperature parameter.
b. Plot annual means of max, min and mean temperatures for the entire period on a separate single graph.
c. Calculate and plot deviations of mean annual temperatures from the long-term mean of the entire period. (deviation = temperature of a particular year – average temperature of the period).

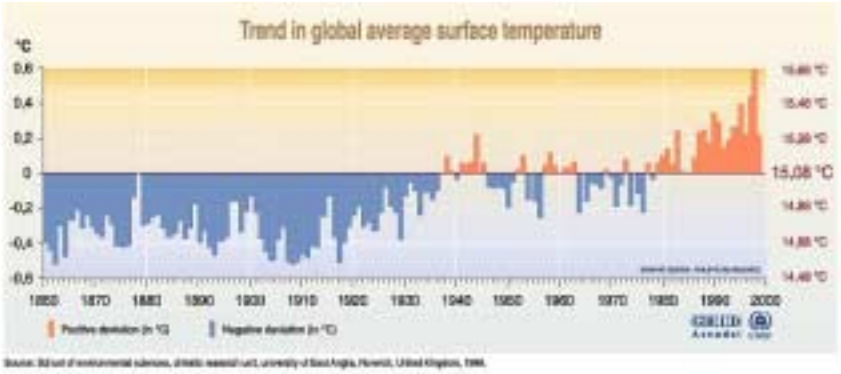
Question 1.

A. Is there a long-term trend in the Allentown temperature data over the ~70-year period? If yes, in what parameter (e.g., max, min) and in what month (e.g., January, or July) is the trend most apparent? What does this mean in terms of climate change?

B. Are there any periods (a few years, a decade) that are particularly warm or cold? In which months mostly? For what parameter (max, or min temperatures)?

C. How does the plot from (c) above differ from the global mean temperature trend as shown below? Discuss possible reasons of difference based on what you have learned about climate controls.

D. Can this simple exercise be used in the global warming debate? Can additional statistical analysis and data manipulation, e.g., moving average and regression analysis with significance testing, help address the global warming debate?



(Figure from: http://www.grida.no/climate/vital/17.htm)

2. Plot annual cycle of temperatures
For each month (from January to December), calculate the means of the mean monthly temperatures over the entire period. Make a graph of the annual cycle of temperatures over 12 months.

Question 2. What is the nature of the annual cycle (seasonality) of temperature in Allentown? What are the warmest month and coldest month? Based on above analysis and answers (Question 1 on apparent season of long-term trend), if the trend continues into the future, would you expect stronger (larger difference in summer and winter temperatures) or weaker seasonality in temperature?

3. Time series plots of precipitation

a. Plot monthly precipitation, with each season on the same graph and all 4 seasons on the same page, as a function of time (year).
b. Compute and plot annual total precipitation over the entire period.

Question 3.
A. Is there a long-term trend in the precipitation data?

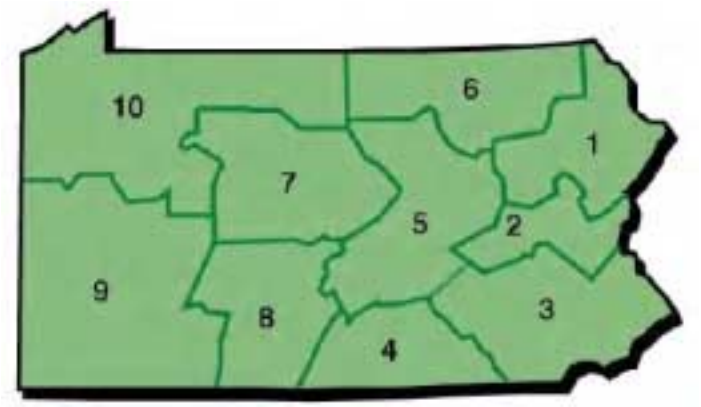
B. Is there evidence of multiple year dry or wet periods? Are these related to temperature values above? Would different combinations of warmth and moisture (e.g., warm-dry, cold-dry connections) tell us anything about the causes of the climate anomalies?

4. Plot annual cycle of precipitation

Plot the annual cycle of the average monthly precipitation over the period of the record. *Note: although a line graph or an x-y graph worked well for the temperature, **a bar graph** may be more appropriate for precipitation, as done conventionally.*

Question 4. What is the nature of the annual cycle of precipitation in Allentown? How does it compare to temperature? Precipitation has stronger or weaker seasonality? Why?

5. Comparison with regional climate records.
A climate division is a region that has a relatively uniform climate pattern. U.S. National Weather Service divides Pennsylvania into 10 divisions (see sketch map below). Lehigh Valley (Allentown) is in Division 2 (East Central Mountains). The data from this division are derived from 44 climate stations, including Allentown (ABE).



Plot the annual mean temperature and annual precipitation time series for Division 2.

Question 5.

A. What are the similarity and difference between Division 2 data sets and Allentown data sets in temperature and precipitation patterns?

B. Was there an extended dry period for the region? How do temperature and precipitation correlate during that dry period?

Background Information about Allentown (from National Weather Service):
Allentown is located in the east central section of the state and in the Lehigh River valley. Twelve miles to the north is Blue Mountain, a ridge from l,000 to l,800 feet in height. The South Mountain, 500 to l,000 feet high, fringes the southern edge of the city. Otherwise the country is generally rolling with numerous small streams. Temperatures are usually moderate and precipitation generally ample and dependable with the largest amounts occurring during the summer months when precipitation is generally showery. General climatological features of the area are slightly modified by the mountain ranges so that at times during the winter there is a temperature difference of l0 to l5 degrees between Allentown and Philadelphia, only 50 miles to the south.

The growing season averages l77 days, and generally ranges from l70 to l85 days. It begins late in April and ends late in October. The average occurrence of the last temperature of 32 degrees in the spring is late April, and the average first fall minimum of 32 degrees is mid-October.