Global Warming and the Dust Bowl: Two Successful Applications of NDP-041 Data in Classroom Learning

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PURPOSE

The purpose of this project is to teach students what types of climatological data are available and what possible applications for this data exist. From this exercise, students use the NDP-041 Historical Climatological Network data set to solve a problem. Students manipulate and interpret this data using EXCEL spreadsheets to calculate means and moving averages of temperature and precipitation.

DATA SET

The data (NDP-041) used in this exercise are from the Historical Climatology Network at the Carbon Dioxide Information Analysis Center based in Oak Ridge National Laboratories, Tennessee. The main CDIAC site is: http://cdiac.esd.ornl.gov/ These data are available on the CDIAC ftp web site: ftp://cdiac.esd.ornl.gov/ndp041 For information regarding data sources, see the readme file. Temperature and precipitation data are located in "precip.data.Z" and "temp.data.Z". These files contain total monthly precipitation in tenths of millimeters for 7533 stations worldwide and mean monthly temperature in tenths of degrees Celsius for 6039 stations worldwide. These data span the period from 1693 (1701 for pressure) to 1990. Corresponding station inventories, including station number, name, location, dates of record, and percent data missing, are in precip.statinv and temp.statinv. These files are also available and easier to use in CD-ROM format from the CDIAC. Because the data files are so large, users should open them in Word and then select and paste the data sets from particular stations into Excel. The "text to columns" command readies the data for analysis. We have found it most convenient to replace the -999 code for missing data with blank cells. We do these steps for introductory geoscience students to allow them to focus on statistical analysis and graph interpretation. Advanced students work directly with the original files.

DATA SET AVAILABILITY

Temperature and precipitation data on NDP-041 is not available after 1990. Internet-based sources, such as the National Climatic Data Center, have been used as a means of completing the later stages of this record with little success. Record lengths are variable from station to station with the longest records from western Europe. The availability of data outside of western Europe has increased during the past 300 years due to European colonization. Significant gaps in data exist in sparsely-populated areas of northern North America, central South America, northern Africa, the Tibetan plateau, the East Indies, and Antarctica (NDP041.DES).

PROBLEM #1: GLOBAL WARMING

Students evaluate the following questions:

1) Has the earth been warming?
2) If so, is the warming rate steady through time?
3) Is warming uniform over the globe?

In order to answer these questions, students work in groups to analyze data from a wide distribution of climate stations, including those located at high latitudes. Students analyze data for stations that have long, complete records.

Students use Excel to calculate and plot the yearly mean temperatures for individual stations. They also create plots of the 5-year moving average of temperature (Figs. 1 and 2). These plots enable them to analyze short- and long-term variations in temperature.

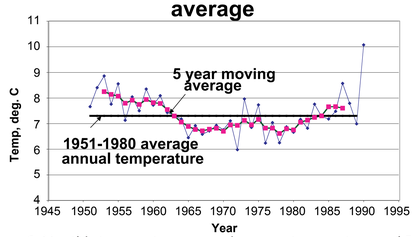

Figure 1. Monthly temperatures, annual average temperature, and 5-year moving average of monthly temperatures for Toronto, Canada from 1951 to 1990. Graph shows temperature decline during first years of record (1950s), stable temperatures in 1960s and 1980s, and rising temperatures in 1980s, and 1990 high is spurious.

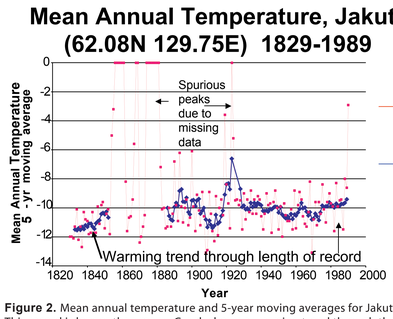

Figure 2. Mean annual temperature and 5-year moving averages for Jakutsk from 1829-1989. This record is longer than many. Graph shows a warming trend through the entire period of the record. Spurious peaks in the mean annual temperature plot occur due to missing data.

PROBLEM #2: THE DUST BOWL

Three questions are posed about climate change during the Dust Bowl:

1) What happened climatologically during the Dust Bowl years?
2) Were heat and dryness confined to the classic "Dust Bowl" area of the High Plains?

For this exercise, students look at monthly and annual precipitation and temperature data from 1890 to 1950 at stations across North America. Time permitting, they also use monthly precipitation data to investigate the possibility that the frequency of high intensity rainfall, which would not be absorbed, changed during the Dust Bowl years and may affect analysis of mean annual precipitation.

Students plot the mean annual precipitation, 5-year and 10-year moving averages of annual precipitation and monthly precipitation to compare long-term and short-term precipitation trends (Fig. 2). Students plot the 10-year moving average of annual temperature and the 5-year moving average of annual precipitation in order to examine the combined effects of these factors in creating drought conditions (Fig. 3). In attempting to analyze the short-term intensity of precipitation, students plot the 5- and 10-year moving averages of summer precipitation (Fig. 4).

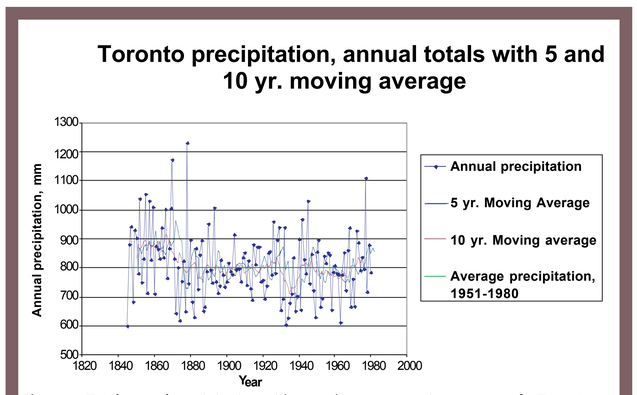

Figure 2. Total annual precipitation with 5- and 10- year moving averages for Toronto, Canada from 1951-1980. Graph shows generally higher precipitations at the beginning of record (1845-1865) and an abrupt precipitation decline (almost 10 cm in 10 yr. moving averages) from 1928-1941.

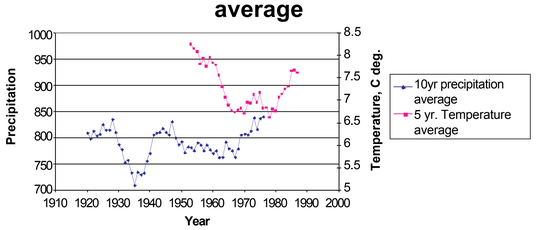

Figure 3. 10-year moving average of annual precipitation and 5-year moving average of average annual temperature in Toronto, Canada from 1920 to 1990. Graph shows high temperatures and moderate precipitation in 1950s, lower temperatures and higher precipitation in 1970s, and possible higher temperatures accompanied by definitely lower precipitation in 1930s.

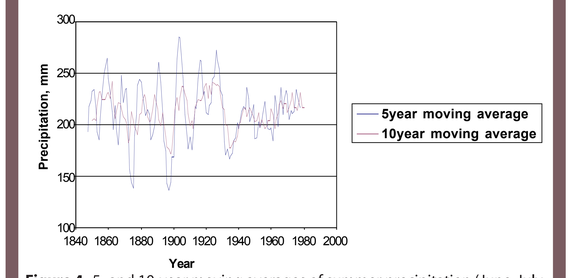

Figure 4. 5- and 10-year moving averages of summer precipitation (June, July, and August) in Toronto, Canada from 1840-2000. This graph shows significant precipitation lows in 1870s, 1890s, and 1910s on 5 yr. moving average, precipitation lows in 1930s and 1890s on 10 yr. moving average, and much less variability post 1944.

CONCLUSIONS

Each pair of students prepares a short power point presentation with graphs and interpretation from their analyses. These presentations are stored on a course server and used by all students for study for papers and exam.

By presenting analyses of precipitation and temperature data from individual stations worldwide, students are able to interpret climate trends related to global warming and the Dust Bowl. In examining these important questions about climate, students also learn about the geographic and temporal availability of data, as well as tools in Excel that can be used for doing simple statistics and preparing graphs. They learn to interpret graphical data and to combine their work with that of other students.

References

Boden, T. and Nelson, T., 1993, CDIAC's numberic data package collection: Selected data sets relevant to studies of greenhouse gases and climate.