Climate Change, long-term data and noise: Changes in Lake Ice on Lake Mendota, WI

Introduction

One challenge to our understanding of environmental effects due to global warming is lack of data collected over long periods of time. Almost any environmental variable will exhibit **variation** over the short term. If we try to interpret trends or patterns from short-term data sets, we might come to a wrong conclusion. Can you think of an **example** to illustrate this point?

In most areas of science, it is rare to have a long-term data set. Few studies are funded for more than a few years. In this lab you will work with an unusually valuable data set in that it spans over150 years (1855-2006).

Plotting the lake ice records for Lake Mendota

The data for this lab come from Wisconsin's Lake Mendota, which is part of the North Temperate Lakes Long-Term Ecological Research (LTER) sites. The scientists recorded several variables that we could use:

- The date of "ice on" in the fall or winter (first day ice covers the lake)
- The date of "ice off" in the spring (when ice breaks up)
- The duration (number of days) of complete ice cover

1. How would you predict <u>each</u> of these measures to change in response to global warming? Why?

2. Why might these measures be more useful than periodically recording air temperature directly?

<u>Examine the spreadsheet of data in Excel</u>.

Download the data from Course Documents on Blackboard. This spreadsheet includes the original ice data collected at Lake Mendota over a 150-year period.

- Look at the headings at the top of the columns to make sure you understand each variable.
- Take a look at the first row of data, for the winter of 1855-56. In this winter, the ice froze on December 18 and melted on April 14. So the "Ice Duration" was from Dec. 18 to April 14, a total of 118 days.
- Some years the "ice duration" is less than the difference in these two dates because the ice broke up temporarily between "ice on" and "ice off" dates.

<u>Make a graph by hand to look for 20-year trends.</u>

Suppose that you are a scientist living in some period between 1855 and 2006. You are relatively fortunate to have 20 years of data on ice cover from Lake Mendota. Pairs of students will be assigned a 20-year period to look for trends in ice duration. For now, look ONLY at your 20 year period.

You will be given scrap paper to ROUGHLY plot your 20 years of data. Discuss what should go on the x-axis and y-axis. This is just a quick sketch to look for general trends; do not worry about precise values. This exercise will help you think about how to set up your graph in Excel.

Make a scatter plot in Excel.

- As done in the population growth lab, first highlight the x-axis variable and its values.
- While holding the control key (or apple key on a Mac), highlight the y-axis variable and its values.
- Insert a chart, and choose a scatter-plot format (called "XY Scatter").
- Adjust the graph to your tastes. Should you connect all the dots? (See handout on making scatterplots).

Interpret your Excel graph:

3. A. Do you see a trend in the duration of lake ice cover? That is, as time elapses, does the value tend to increase, decrease, fluctuate more, fluctuate less, stay the same, etc.?
   B. What is the average duration of lake ice cover over your 20-year interval? (Use a formula in Excel to calculate this: "=average()" and then select the cells to be averaged.)
   - Before proceeding, each group will show their screen to the class and note any trends.

Plot the entire data set of 150 yrs.

- Selecting whole columns is faster than selecting individual cells!

4. A. Do you see a trend in the duration of lake ice cover for the whole data set of 150 years?
   B. What are some of the longest and some of the shortest periods of ice duration in the entire data set? In what years do they occur?
   C. Calculate the average ice duration for the entire data set. In what time periods is the ice duration typically above that average? When is it typically below the average? .

Insert a trendline:

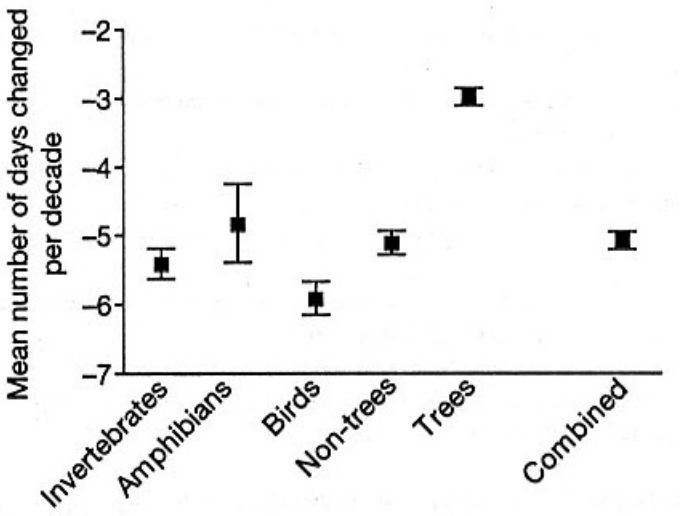
Choose *Chart* from the main menu, then *Add trendline*. The default *linear* trendline is fine.
Choose *Options* → *Display equation on chart*.

5. A. What is the equation for the line from the whole data set?
   B. What does this equation mean (in words)? For example, how much does the duration of lake ice change every 100 yrs?
   C. Summarize the 150 year trend with a hand-drawn sketch, and simply plot the average line (not every point!). Now sketch what a line would look like for a much smaller lake, and a much larger lake. Label each.

The big picture.

6. A. Look again at the Excel chart of the entire data series. By themselves, are these data on lake ice compelling evidence of global climate change? Why or why not? Are there any **alternative explanations** for the trends here?
   B. What other **evidence** would you seek to determine whether the trends here are truly a result of global climate change?
   C. If we have a cold wet summer, then does that mean global warming is not happening as fast as climate experts suggest? Explain
   D. The year 2005 had a record number of hurricanes, including the infamous Katrina. Does that mean severe global warming is already upon us? Explain.

Responses in biota to climate change
This graph is a "meta-analysis" of 143 studies of almost 1500 different species (Root et al 2003, *Nature* **421**:57-60. © 2003 Nature Publishing Group). For each species, scientists recorded the "phenology," or timing when important events happened in each species' life cycle such as date of egg laying, migration, flowering, etc. These events were examined for over 30 years in most studies. The graph presents whether there have been any significant changes over time. A negative change means the events (*e.g*,. migration) were happening earlier in the spring *or* later in the fall.

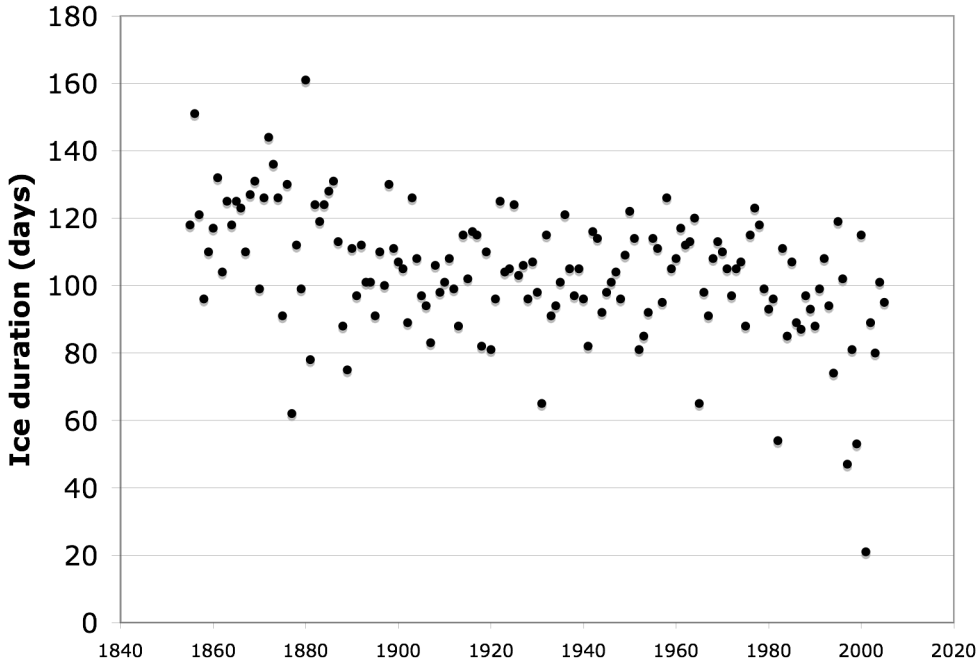


7A. Is the basic message of this graph consistent with the data on duration of lake ice? Why or why not?

7B. How do the **rates of change** in biota compare to the rate of change from lake ice data **over the same time period** (1970-2003)? Explain the difference: speculate why one changes much faster,

7C. What could be some implications of the changes in this figure of changes to the biota? How might communities of species be affected?

Instructors' Notes:



Number of days of lake ice on Lake Mendota, WI over the last 150 years. Students produce this graph from the LTER data available at http://lterquery.limnology.wisc.edu/abstract_new.jsp?id=PHYS. The raw data may be difficult for students to access directly; the instructor should prepare a file with the data ahead of time.

This exercise is effective at helping students understand that annual variation is the norm in ecology, and that long-term trends are more important than short-term fluctuations. This exercise also helps students learn and apply the concept of slope in a scatterplot.