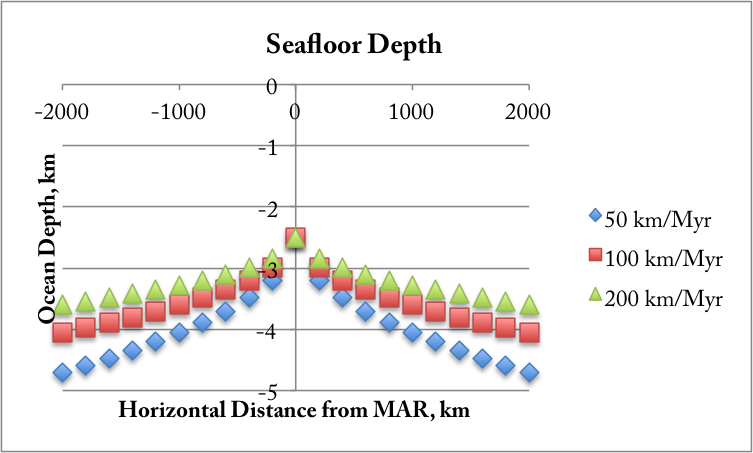
**Example 1**

Treatment 1 – Activity A[[1]](#footnote-1)

The PowerPoint presentation projected figures that should match what the students created in their homework.

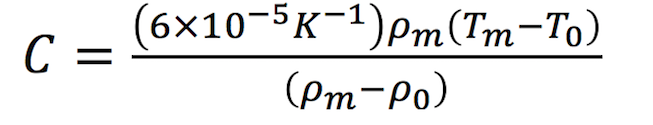
Pair up and discuss figure 1 and answer the following questions. Please turn in your answers.

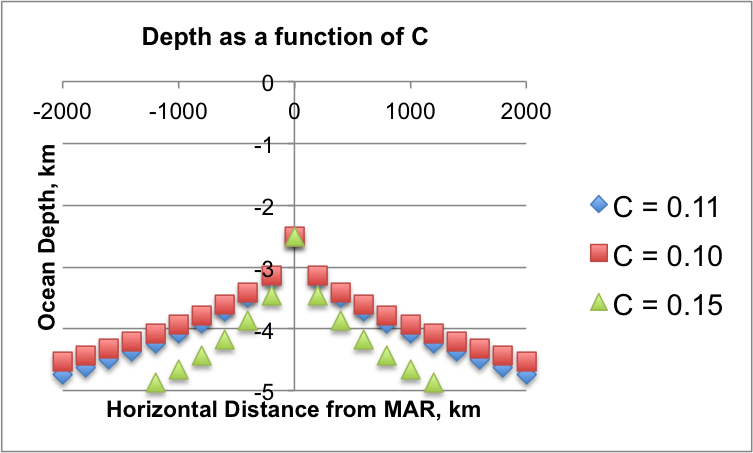


From power point the students respond to the following questions in a “Think Pair Share”:

* How does an increase in seafloor spreading rate U influence the steepness of the MAR walls?
* How does an increase in spreading rate influence the depth of the ocean far from the ridge?
* Hypothesize how these profiles make sense in the context of the physical processes linked to MAR formations.

Pair up and discuss figure 2 and answer the following questions. Please turn in your answers.





From power point the students respond to the following questions in a “Think Pair Share”:

* + Using Figure 2 and the mathematical formula for *C*; How does the height of the ridge change when mantle density increases?
  + How does the height of the ridge change when mantle temperature increases?
  + Is the ocean depth profile strongly dependent on assumed mantle temperature?
  + Is the ocean depth profile strongly dependent on assumed mantle density?
  + Hypothesize how these processes make sense in the context of the physical processes linked to MAR formation.

Treatment 2 – Activity A

Pair up and use the computer terminals and the Excel files you created in your homework to discuss and answer the following questions. Please turn in your answers.

Questions for turn in from EX2

1. Spreading rate
   1. Using graph one; How does an increase in sea floor spreading rate **U** influence the steepness of the MAR walls?
   2. How does an increase in sea floor spreading rate U influence the depth of the ocean, far from the ridge (or the height of the ridge above the background ocean)?
   3. Hypothesize how these profiles make sense in context of the physical processes linked to MAR formation.
2. Density and temperature
   1. Using graph 2 and the mathematical formula for ***C***; How does the height of the ridge change when mantle density increases?
   2. How does the height of the ridge change when mantle temperature increases?
   3. Is the ocean depth profile strongly dependent on assumed mantle density?
   4. Is the ocean depth profile strongly dependent on assumed mantle temperature?
   5. Hypothesize how these processes make sense in the context of the physical processes linked to MAR formation.

**Example 2**

Treatment 1: Activity A.

*In both treatments we start with a slide presentation that reviews the various causes for global temperature change and the basics of linear regression. After this review the students are asked to make a prediction:*

1. What slope would indicate a warming Earth? What slope would indicate Earth’s average global temperature was not changing? What slope would indicate a cooling Earth? Sketch lines in the axes below to show what the expected slopes would be in these different scenarios.

oC

oC

oC

time

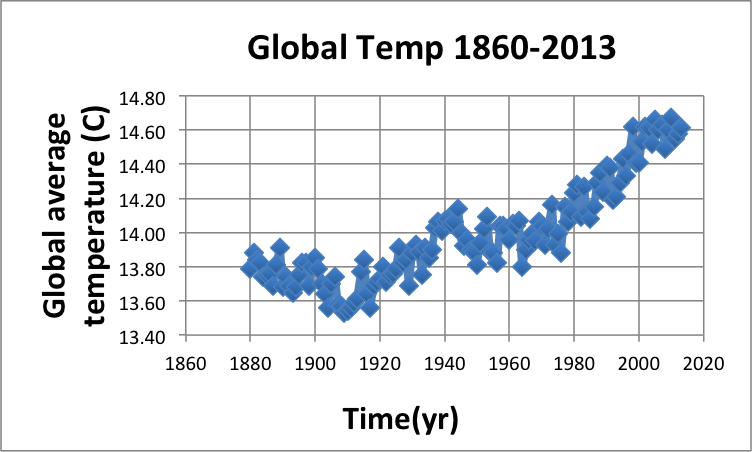
time

time

cooling warming no change

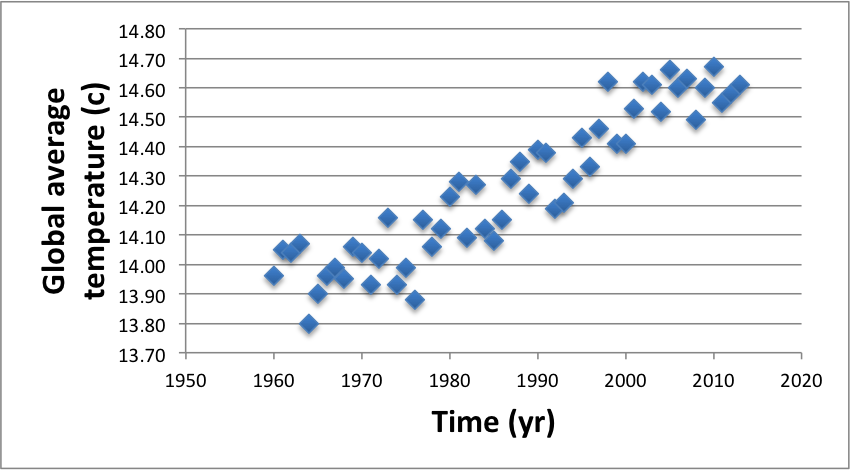
*Here the two lesson plans diverge. The treatment 1 students are provided with figures that plot temperature data from weather stations all over the world compiled by the Goddard Institute for Space Studies, NASA, for the years 1860 to 2013.*

1. Now that you have your predictions, you are ready to conduct your analysis. Below we have plotted the global average temperature records from 1860 to 2016. Work with a partner to estimate a trend line through the data. What is the slope of your line?



1. Many scientists claim that drastic changes in global temperature began in the mid-1900s when fossil-fuel-powered transportation became a mainstay for most families. Test this hypothesis by adjusting your trend line so that it only looks at the most recent decades, after personal transportation became common.

Below is a plot of the global average temperatures from 1960 to 2013. Estimate a trend line through the data from 1960-2013. What is the slope of your line?



1. Considering both of these graphs, which trend has the higher r2 value and what does that indicate?

Treatment 2; Climate change

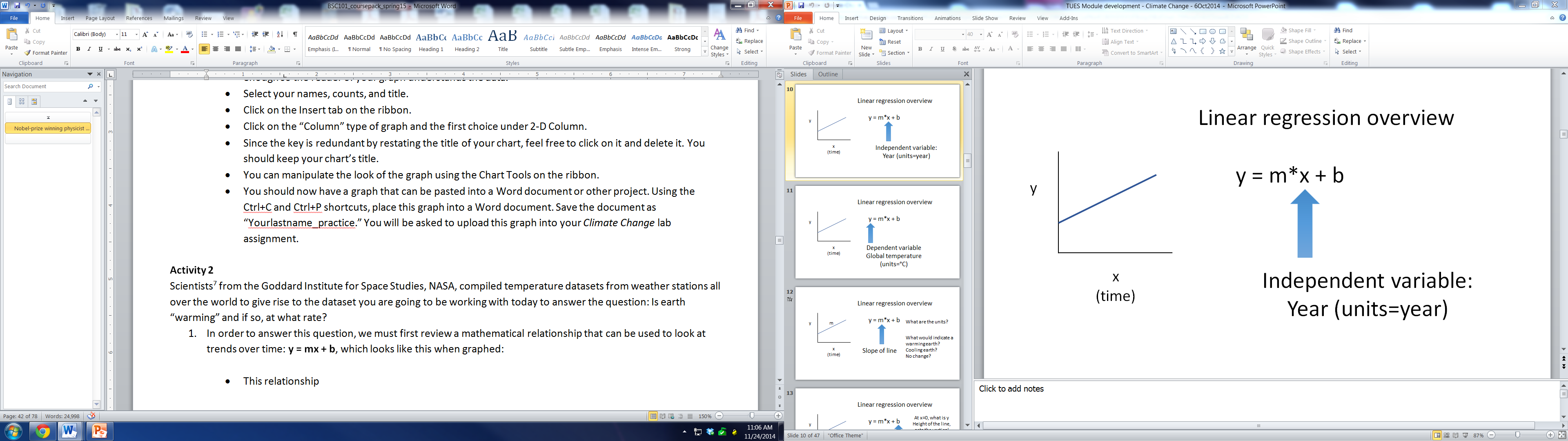
Introduction

A planet’s climate can influence many important processes. Scientists have studied climate on many planets to understand what factors influence climate and atmospheric temperature. The 3 main things that influence a planet’s atmospheric temperature are 1) the distance to the sun, 2) the amount of energy from the sun that is absorbed by the planet’s surface (some sunlight is reflected by shiny surfaces like ice, whereas darker surfaces tend to absorb sunlight and convert it to heat), and 3) the amount of heat that is trapped by the planet’s atmosphere. The most data for understanding changes in climate over time are available for Earth, since in addition to modern data measurements there are historical and pre-historical indicators of temperature and atmospheric composition.

Activity A

Scientists[[2]](#footnote-2) from the Goddard Institute for Space Studies, NASA, compiled temperature datasets from weather stations all over the world to create the dataset you are going to be working with today to answer the question: Is earth “warming”? The data you will use are from years 1880-2013.

1. In order to answer this question, we must first review a mathematical relationship that can be used to look at trends over time: **y = mx + b**.
   * Recall from high school introductory algebra that:
     + x = the independent variable, which is in this case, time (years)
     + y = the dependent variable, which is in this case average global temperature (oC)
     + m = the slope of the line, in this case this indicates the rate of change over time as the units for the slope are oC/year.
     + b = the intercept of the line on the y axis
     + Graphed, these variables look like this:



m

b

1. Before you conduct your analysis, you should first make your predictions. What slope would indicate a warming Earth? What slope would indicate Earth’s average global temperature was not changing? What slope would indicate a cooling Earth? Sketch lines in the axes below to show what the expected slopes would be in these different scenarios.

oC

oC

oC

time

time

time

cooling warming no change

1. Now that you have your predictions, you are ready to conduct your analysis. Open the ClimateChange.xls file from your lab computer’s desktop. This file is also available in Resources & Materials.
2. First, select all the data, including column headings, from 1880 to 2013.
3. Click on Insert from the ribbon. This time, choose Scatter as the type of graph because both of your variables are quantitative. Then choose “Scatter with only Markers” as your type of Scatter plot.
4. You will notice that “Temperature (oC)” was put as your graph title. Click on the title once and rename your graph to something that is more descriptive of your graph (e.g., “Changes in Earth’s Temperature since 1880”). Avoid using the term “versus” or “vs.” in your title because this does not describe the graph, only what is on the axes.
5. Next, right-click on the data points in the graph. Then choose “Add Trendline.”
6. A window will open that allows you to choose Trendline Options. Check the boxes for “Display Equation on Chart” and “Display R-squared value on chart.”
   * Equation for the line: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   * Rate of air temperature change (include units) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

* + Recall that the **slope (m in y = mx + b)** of the line tells you the direction of the relationship. Compare the slope from your analysis to your predictions for the different scenarios above.

Which scenario best describes what your analysis indicates is happening to Earth (warming, cooling, or no change)?

* + **R-squared (r2)** is a statistic resulting from a **linear regression analysis**. It describes the proportion of variation in the dependent variable explained by the independent variable. When r2 ~1, the data form a perfectly straight line. As the data become more scattered from the line, r2 decreases toward 0. Higher r-squared values indicate a stronger relationship between the two variables.

R2 =

* + Create Figure 1. Copy and paste your graph, with both your equation and r2 value on the graph, into a Word document. Underneath the graph, add a figure legend that describes what the figures show. The figure legend should not just say what data are in the figure (because that is obvious from the axis labels), but also state what the pattern or ‘take home message’ is from the graph. Save the document after doing so.

1. Many scientists claim that drastic changes in global temperature began in the mid-1900s when fossil-fuel-powered transportation became a mainstay for most families. Test this hypothesis by adjusting your trendline so that it only looks at the most recent decades, after personal transportation became common. You can do this by:
   * Decide on the year in the mid-1900s that you want to begin the trendline. Scroll to that year and select the data (year and temperature) from that year all the way to 2013. Using the Shift+click shortcut, also select the column headings.
   * Create a Scatter graph just as you did before and add a trendline with the R2.
   * Rename the graph to a more appropriate title that indicates the year your analysis begins.
   * Equation for the line: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   * Rate of air temperature change (include units) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Something to think about:** Compare the rate of change and the r2 for this analysis with the one you performed before. Does this data support or reject the hypothesis that the rate of global average temperature is greater since the 1950s than between 1880 and the 1950s because of personal transportation?

Create Figure 2. Copy and paste your graph, with both your equation and r2 value on the graph, into the Word document you started earlier, add a figure legend, and save.

|  |  |  |
| --- | --- | --- |
| **Module Name** | **Learning Goals** | **Homework** |
| Climate Change | 1. Improve quantitative literacy, develop data manipulation and analysis skills, construct scientific knowledge about natural phenomena,  highlight the inherent variability in real data,  develop informed views about the Nature of Science (NOS) | 1. Determine the rate of change of CO2 concentration using Mauna Loa data and quantify its relationship to rising temperatures 2. Compare this relationship between increasing temperature and CO2 concentration to historical data from ice core samples.  3. Compare modern and historical rates of change |
| Stream Discharge | 1. Students will download, organize and analyze streamflow data. 2. Students will use data to compare short-term and long-term discharge variability, and quantify climate change impacts on water quantity in their region. 3. Students will calculate flood frequency from peak discharge data, and will calculate the effects of urbanization and flood control on flood frequency. 4. Students will develop an understanding of the following scientific concepts:  Stream discharge  Variability and trends in time series data  Peak flow and flood events  Flood probability and recurrence interval  Effects of urbanization on discharge events 5. Students will develop an understanding of the following statistical concepts:  Detecting variation and trends on short and long timescales  R-squared  Peak event probability | 1. Use a coin toss experiment to compare geometric probability distribution in modeled and emperical results  2. Use recurance intervals to calculate the 100 year flood hazard. 3. Compare flood recurance intervals through time in pristive and urban enviroments |
| Nutrient Loading | 1. Evaluate factors related to concentration versus discharge that control the load of nitrogen exported downstream.  2. Discuss causes of variability and covariability in nitrate-N and discharge data, and propose a strategy that allows data to be used with a high level of confidence. 3. Explore how to look at correlations of two variables 4. Understand the effect of sample frequency on developing a robust estimate of a variable | 1. Compare nitrate concentratoins in upstream tributaries to what we measure down stream in the Missippi River.  2. Examine the effect of sample frequency on the emperical results. |
| Spectral Seismology | 1. The vocabulary needed to describe signals in the time and frequency domain 2. The ability to conceptualize a waveform as the sum of separate frequency components  3. The ability to relate a signal presented in the time domain to its conjugate in the frequency domain 4. The ability to use a signal presented in either the time or frequency domain to develop an analysis plan and choose an appropriate filter. | 1. Examine and describe the wave forms from recent teleseismic earthquakes on the IRIS data portal  2. Apply the Fast Fourier Transform (FFT) to earthquake records to analyze frequency content 3. Construct a synthetic waveform of individual frequency components  4. Utilize a smartphone app to examine how a seismometers measure ground motion.  5. Use Seismic Canvas to analize both to explore and process the seismic records from earthquakes and fin whales |

1. Dax Soule 2015 adapted from @ R. MacKay 2003 [↑](#footnote-ref-1)
2. Hansen, J., Ruedy, R., Sato, M., & Lo, K. (2010). Global surface temperature change. *Reviews of Geophysics, 48*, 1-29. [↑](#footnote-ref-2)