**Temperature Over Time - Investigation 2**

<http://www.ces.fau.edu/nasa/module-3/temperature-change-industrial/investigation-4.2.php>

**How Has Temperature Changed Since the Industrial Revolution?**

**Exploration 1: Temperature Anomalies for the Past 125 Years**

In this exploration, you will study the past 125 years of instrumental temperature data to identify the changes in temperature anomalies since the industrial revolution.

**Use the interactive, time series graphing tool** **to answer the following questions.**

1. What general temperature anomaly trend do you observe during the following time spans?

A. The past 125 years

 B. 1910 and the mid-1940s

C. The mid-1940s and the mid-1970s

D. The mid-1970s and 2010

1. How does the variation of decade-long (such as between 2000 and 2010) temperature anomalies compare to the longer time span (such as between the mid-1970s and 2010) temperature anomalies?
2. What year did temperature anomalies begin to remain above normal?

**Exploration 2: Estimating and Using Linear Regression to Calculate Temperature Trends**

**Part A - Estimating the Temperature Trend For the Past 125 Years**

**Use the interactive, time series graphing tool to answer the following questions.**

1. Click on the *Show Slope* button.
2. Adjust the slope and the y-intercept by moving the sliders below the graph. Make your best estimate of the slope and location of the trend line.
3. Click on the Take Snapshot button. An image of the graph with your trend line will appear.
4. Right click on the image and save the image to your computer.
5. Insert the image (Insert>Picture) into the student worksheet.
6. What is the slope of this line? (The slope is shown in the bottom left corner.) Round to the nearest one thousandth. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
7. Based on your estimated slope, what is the average rate of change in temperature anomalies over 100 years? (Hint: Multiply your slope by 100.)

**Part B - Determining the Temperature Trend For the Past 125 Years Using Linear Regression**

You will calculate the slope of the line for different time periods using a simple regression analysis in Microsoft Excel. **(NOTE: You will need the separate set of instructions for this activity.) Open the instructions and download the data now. Throughout the instructions, you will be asked to enter your results in the table in your student worksheet.**

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| --- | --- | --- |
| **Time Interval (Years)** | **Corresponding Number in Instructions** | **Slope of the Trend Line/Rate of Change**Calculated by Excel Formula for Regression – SLOPE(See Instructions 1-5.) |
| 125-Year (1885-2010) | 1.k |  |
| 100-Year (1910-2010) | 2.d |  |
| 75-Year (1935-2010) | 3.d |  |
| 50-Year (1960-2010) | 4.d |  |
| 25-Year (1985-2010) | 5.d |  |

**Analysis of Findings**

1. How does the slope of the recent 25-year trend line generally compare to the slope of the past trend lines?

2. During which time interval was the rate of change in temperature anomaly the highest?

**Exploration 3: A Comparison of Temperature Trends**

**Part A – Temperature Trends over Recent Decades Compared to the Past 125 Years**

In the previous exploration, you estimated the trend line for the past 125 years. You also used linear regression to calculate the slope for the past 125, 100, 75, 50 and 25 years, and you graphed the trend lines for 125 years and 25 years. Now you use the interactive time-series graphing tool to view the trend lines for these same time periods.

**Use the interactive, time-series graphing tool to answer the following questions.**

1. Click on the button for 125 years. How much does this slope differ from the one that you estimated in Part B of Exploration 2.
2. Click on the buttons for the 100-, 75-, 50-, and 25-year time intervals. How do your observations compare to the slopes of the trend lines that you calculated using linear regression in the previous exploration?
3. What do you observe about the slopes of the trend lines for each time interval?

**Part B – Calculating the Rate of Change (Slope) of Temperature**

The interactive time-series graphing tool just showed trend lines and slopes using a calculation in the program. However, it is possible to calculate the slope of a line if you know two points on the line. To do this, you calculate the change in the y value or the temperature anomaly over the change in the x value or time in years. Follow the directions below to calculate the approximate slope of each trend line for the 100-, 75-, 50-and 25-year time intervals. Remember that the slope is the rate of change.

**Use the interactive, time series graphing tool to answer the following questions.**

1. Click on the trend line for 100 years. Choose a data point near the beginning (left side of graph) that is ***on the line*** or ***as close to the line as possible***. Enter the beginning year and the beginning temperature anomaly in the table.
2. Choose an ending year that is ***on the line*** or ***as close to the line as possible***. Enter the ending year and the ending temperature anomaly in the table.
3. Calculate the change between beginning and ending years AND the change between beginning and ending temperature anomalies. Enter these values in the table.
4. Use the equation above to calculate the slope of the line between the two points you chose.

 Slope = vertical change (rise) = y2 – y1

 horizontal change (run) x2– x1

1. Repeat steps 1-4 to complete the table.

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| **Time****Interval****(Years)** | **Beginning Year** | **Ending** **Year** | **Change****In****Years** | **Beginning Temperature Anomaly** | **Ending****Temperature****Anomaly** | **Change in Temperature****Anomalies**  | **Slope** **(Rate of Change)** |
| **125-Year** (1885-2010) | **1894** | **2000** | **106** | **-0.31** | **0.3** | **0.61** | **0.006** |
| **100-Year** (1910-2010) |  |  |  |  |  |  |  |
| **75-Year** (1935-2010) |  |  |  |  |  |  |  |
| **50-Year** (1960-2010) |  |  |  |  |  |  |  |
| **25-Year** (1985-2010) |  |  |  |  |  |  |  |

1. How similar is this slope using two points on the line to the one calculated under the graph on the website? If there is a difference, why do you think that is?

**Part C - A Comparison of Very Recent and Past Warming Trends**

You have just seen that the rate of change for increasing temperature anomalies is greater over the more recent decades than over the span of time since the industrial revolution in the 1880s. But how does this recent rate of change compare to rate of change determined from the ice core data?

You will need to review your response to Temperature Over Time - Investigation 1, Exploration 1, Question 7 (Antarctica) **and** Investigation 1, Exploration 2, Question 8 (Greenland). Fill in these rates of change and the 125-Year and 25-Year rates of change in the table.

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| **Time Intervals for Different Ice Cores** **and Instrumental Data** | **Rates of Change for Temperature Anomalies**(per 100 years) |
| Antarctica Glacial-Interglacial Periods |  |
| Greenland Glacial-Interglacial Periods |  |
| 125-Year (1885-2010) |  |
| 25-Year (1985-2010) |  |

Compare the average rate of increase of temperature anomalies for the glacial-interglacial periods to the rates of change over the last 125 and 25 years to answer the following questions.

1. How many times greater is the rate of temperature change for 1885-2010 (since the industrial revolution) than the average for the three Antarctica glacial-­interglacial cycles?

1. How many times greater is the rate of temperature change for 1985-2010 than the average for the three Antarctica glacial-interglacial cycles?
2. How does the rate of temperature change for 1985-2010 compare to the average for the three Greenland glacial-interglacial periods?

1. How many times greater is the rate of temperature change for 1985-2010 than the average of the last 125 years?