Name: Date: Class:

CO_2 Activity Worksheet Answer Key

For this activity, you need the *CO2-case-study-data.xls* file, which is available from your teacher. Begin by opening this document in Excel or Google Sheets. Then work either individually or in groups to complete this worksheet. Remember to use the *Excel Reference Sheet* for help.

Background Information: This data was collected in Paonia, CO, one data set from January and one from April. Both data sets include four days of minute-averaged data—in other words, each data point is the average of all data recorded during that minute.

1. Develop a **hypothesis** that explains how you expect the CO_2 data to differ in the two months, and why. *(For example, do you expect one month to be higher?)* Record your hypothesis below.
   (Hint: Think about different sources and sinks of carbon dioxide and how the time of year might affect these.)

   Expect student responses to include both a prediction and an explanation.

Data Statistics

1. Calculate the following using Excel (*use Table 1 on the Excel sheet*):

	January	April
Mean (ppm)	437.1	430.0
Median (ppm)	447.9	427.5
Standard deviation (ppm)	25.1	14.2

2. Create a ***bar graph*** of the data from Table 1. *(Hint: Highlight the entire table, then click "insert," then choose the "column chart.")* Place the chart in the allocated space; label the axes and chart title.

3. Below, list two observations regarding these statistics.
   Examples responses:
   - The January mean is higher than the mean for April.
   - The median is higher in January than April.
   - The standard deviation is larger for January than April.

Visualizing the Data in Time

1. Make a ***time series*** of the data. Use the "Index Minute" values for the x-axis values and the CO_2 data from the y-axis data, which lets you overlay both data sets on one graph. Also, choose the "scatter with smooth lines" option. Place the chart in the allocated space; label the axes and chart title.

2. List one similarity between the two data sets. *(Hint: Are there any patterns?)*
   Both data sets display a similar daily trend; during both months, CO_2 is higher at night and lower during the day.

3. List one difference between the two data sets.

The periods of elevated CO_2 at night last longer in January, resulting in higher CO_2 in general. There is also more variation in the data (the maximums are higher, and the minimums are lower).

Examining Relationships in the Data

1. Make 2 *scatter plots* of temperature vs. CO_2, one for the January data and one for the April data. Plot temperature on the x-axis and CO_2 on the y-axis. Place the charts in the allocated space; label the axes and chart titles.

2. Do you see a relationship between CO_2 concentrations and temperature? Is the relationship stronger for one month or the other? If so, which one?

   A negative correlation exists between temperature and CO_2 concentrations. In other words, CO_2 is higher at lower temperatures and CO_2 is lower at higher temperatures. This relationship appears to be stronger in January.

3. Fit a linear relationship to each scatterplot and find the R^2 value. Do the R^2 values confirm your answer to the previous question? ❑ YES ❑ No If not, check your values.

   R^2 for January = .98 R^2 for April = .57

Final Conclusions

1. *Complete the following*: CO_2 concentrations in January are generally higher than April.

   This means that CO_2 appears to be greater in the winter season.

2. Based on your analysis, was your hypothesis correct? If not, explain where your analysis and your hypothesis conflict.

   Answers will vary, depending on students' original hypotheses.

3. **Putting it all together:** Temperature does not control CO_2, so why do we see a correlation? Give two explanations for seasonal differences in CO_2 concentrations *(Hint: Again, think about CO_2 sources and sinks, how these vary seasonally, and how they explain your analysis.)*

   The daily fluctuation we see in CO_2 in both months is driven by the planetary boundary layer. The boundary layer lowers at night and rises during the day. When the boundary layer lowers, there is a smaller volume for the CO_2 to fit into, resulting in higher concentrations. This is why we see a correlation between temperature and CO_2.

   The seasonal differences are driven by several factors including winter-time temperature inversions (which trap pollutants at night), less vegetation performing photosynthesis and acting as a sink, and increased burning for home heating (many homes in Paonia use wood or coal stoves). All of these factors work together and result in greater variance and higher CO_2 on average in the winter.