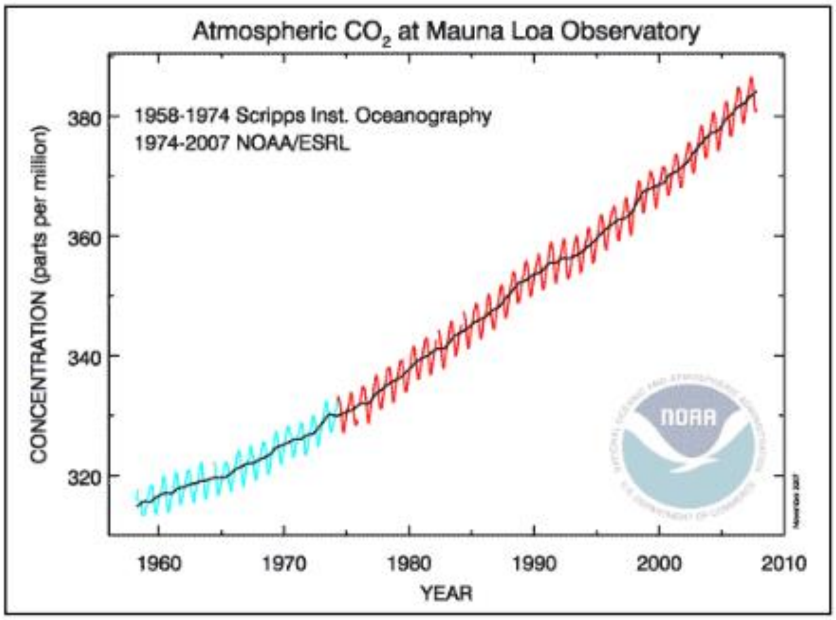
Data: Keeling Curve of CO2 concentration in the atmosphere since 1960



Source: This data is from the NASA Algebra 2 With Space Science Applications e-textbook, (citation at end of this document).

The data shows the Keeling Curve which models the level of CO2 in the atmosphere. The table below shows years since 1960 and the measured level of CO2.

The portion of the data shown can be modeled with a quadratic function.

Year	0	10	20	30	40	50
CO2	317	326	338	354	369	390

How does the data serve as an engaging context for the math concept?

Quadratic functions are a staple of the Algebra 2 curriculum. However, genuine real-world applications are often overlooked when teaching the quadratic function unit. This data creates context for using quadratic function in understanding a real-world phenomenon. Global warming is a topic that has been often discusses and very politicize in this day and age. The data presented here is an objective representation of CO2 levels in the atmosphere over a span of time.

From a math perspective it allows students the opportunity to observe how a quadratic function can represent a data set. It allows multiple representations of data such as a table, graph, and equation. Students can develop a deeper insight as to how the coefficients in the standard form of a quadratic equation are derived using the data points. Furthermore, this data creates a fantastic cross-curricular connection to different areas of science. In modeling and reflecting on the data questions naturally arise such as; what is causing the level to go up, what is its effect on the planet, and how will it shape the future?

Measurable objectives:

Students will –

- Identify and describe properties of a quadratic function
- Graph data points in a quadratic function
- Calculate a quadratic function that best describes the data
- Draw conclusions from the data about the level of CO2 in the atmosphere over time
- Extrapolate data from the graph to draw conclusions about what future CO2 levels will be like (what if scenarios)

CCSS Math Practice Standards:

- **CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them.**
- **CCSS.Math.Practice.MP2 Reason abstractly and quantitatively.**
- **CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others.**
- **CCSS.Math.Practice.MP4 Model with mathematics.**
- **CCSS.Math.Practice.MP5 Use appropriate tools strategically.**
- **CCSS.Math.Practice.MP7 Look for and make use of structure.**
- **CCSS.Math.Practice.MP8 Look for and express regularity in repeated reasoning.**

CCSS Math Content Standards:

- **CCSS.Math.Content.HSA.REI.B.4- Solve quadratic equations in one variable.**
- **CCSS.Math.Content.HSF.IF.C.7.a - Graph linear and quadratic functions and show intercepts, maxima, and minima.**
- **CCSS.Math.Content.HSF.IF.C.8.a - Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.**
- **CCSS.Math.Content.HSF.IF.C.9 - Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions)**

Collecting Evidence of learning:

Though I have never done this type of data project before, I have done a few different data collections projects in my Algebra 2 class. One of the projects I have done is have students look at data of the population growth of a rich country and a poor country over time. Students then analyzed the data to support or refute the claim that developing countries have larger population growth then developed countries. The end result was a poster where students presented their data, graphs, and reflections, on a creative medium. Using the data on the Keeling Curve from the Nasa website, students could create something similar. Students could plot the data, generate a line of best fit with a quadratic equation, then use their data to make an estimate of future results. Students can use their representation to create a poster that discusses the reasons the data might look the way it does and some repercussions for the planet if the trend continues.

Another format I have used for collecting evidence of learning is a guided lesson. In the guided lesson, the teacher presents the data, what the data represents, and its significance. This can be done through a discussion, a YouTube video, or both. The teacher then walks students though the data analyses, alternating between whole group support and small group collaboration. The underlying goal is to help students develop a connection between quadratic functions, modeling, and data analysis. The following questions would assess the students understanding of the modeling.

1) Graph the data for the points indicated

2) Use technology to create a line of best fit that is linear and another that is quadratic, which one is a better fit?

3) Use your model to predict the CO2 concentration in the year 2050 and 2075.

4) Do you think that prediction is accurate or will something happen that will change the prediction? Explain your reasoning.

Function transformations are also a key area of study in Algebra 2. The data for the Keeling Curve and its corresponding graph could be used as a basis for reflecting on function transformations. The following questions will encourage students to think about the connection between function transformations and the data:

1) What would happen to the graph of the function if all the data points were 50 PPM less/more then they currently are?

2) What would happen to the data set if there was a larger increase in C02 from year to year/ smaller increase?

3) If year zero is 1960, what does the negative domain of the graph represent? What is a reasonable domain for the data set to be realistic?

Another Important skill in Algebra 2 is representing quadratic equations in standard form as well as vertex form. As an exercise or exit ticket, students can be asked to convert their equation for the Keeling curve into vertex form, then describe the vertex of the parabola and the line of symmetry.

Sources:

1) Odenwald, S. (2011, May). *Algebra 2 With Space Science Applications* [PDF]. NASA Goddard Spaceflight Center.

2) Common Core Standards for Mathematical Practice. (n.d.). Retrieved June 2, 2019, http://www.corestandards.org/Math/Practice/