**Unit 7: Investigation 6 (2 Days)**

**EXPONENTIAL FUNCTIONS AND CLIMATE CHANGE**

CCSS: F LE-1, F LE-1c, F-LE 2, F-LE 5

**Overview**

Students model the increasing concentration of carbon dioxide in the earth’s atmosphere with an exponential equation of the form$ y=ab^{x}$. Students analyze global temperature data and model the increasing trend with a linear model of the form y = *mx* + *b*. They then use their use their models to make future projections for the earth’s carbon dioxide concentration and temperature. They also examine the growth of alternative energy sources that can reduce the concentration of carbon dioxide in the atmosphere.

**Assessment Activities**

**Evidence of Success: What students will be able to do.**

* Represent climate data with tables, graphs, and equations.
* Explore graphs of data and determine which type of function (linear, exponential, or piecewise) to use as a model
* Interpret the parameters of functions in terms of context.
* Use linear and exponential models to predict future values.

**Assessment strategies: How they will show what they know.**

* **Exit Slip 7.6** requires students to interpret parameters, make predictions, and compare linear and exponential models.
* **Journal Entry** asks students to consider the implications of climate change.

**Launch Notes**

The activity begins with an introduction to global warming. You may want to initiate the discussion by discussing recent extreme weather events (such as the draught of 2012 and Hurricane Sandy) that have been attributed to long-term changes in the earth’s climate. During the introduction, video clips from the movie documentary, *An Inconvenient Truth* (by Al Gore), can be shown to enhance the presentation. In this documentary, Gore explains the phenomena of global warming and discusses the importance of a collective effort to halt climate change.

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| **Closure Notes** |

You may end this investigation by informing students that the end-of-unit project will be based on this activity and our analyses of the CO2 and global temperature data. Our attention will turn to the consequences of global warming. If possible, a science teacher may be able to facilitate a summary of the phenomena of global warming.

**Learning Activities**

1. After the launch students, in **Activity 7.6.1 The Mathematics of Global Warming**, students are introduced to the scientific data showing carbon dioxide levels and global temperature over the past 400,000 or so years. The level of CO2 has been cyclic on our earth, rising and falling with the warm spells and the ice ages. After gaining familiarity with the data leading up to the modern day, a second clip from the movie can be shown to examine what is happening with CO2 presently. In this clip, Gore examines the global CO2 data and temperature data over a 650,000-year time period. For 650,000 years, the CO2 level never exceeded 300 parts per million by volume (ppmv). Gore shows in a dramatic fashion how the projected level of CO2 increases over the next 50 years.

Make certain to obtain this movie prior to the lesson. The video clips will help to initiate the task and motivate students to study these phenomena further. You may ask students to discuss the video clip and summarize their thoughts.

Next challenge the students to model the CO2 data since 1960. Students will read ordered pairs from a graph of the rising CO2 levels, represent the data with a table, and then input the data into their graphing calculators. Some groups may initially decide to use a linear function, but an exponential function is a better choice.

To create an exponential model, students will likely use the graphing technique of defining a value for parameter “*a*” and then using trial-and-error to find an estimate for *b*, as demonstrated in **Activity 7.3.4.** After defining their model, ask students to interpret the real world meaning of the values for their parameters. They then may use their models to project future levels of CO2.

**Group Activity**

**Activity 7.6.1** lends itself to work in small groups. Each group will determine whether to use a linear or exponential function to model the CO2 and temperature data. They may then defend their choice in discussion with the entire class.

**Differentiated Instructions (For Learners who Need More Help)**

The differentiation for this activity will be in the degree to which the teacher provides support to the groups. In the end, however, all students need to be successful in finding an equation to model this relationship.

Students now turn to examine the global temperature data for the past century (questions 8–12). The data in the activity are presented in tabular form. The students are directed to plot the data and to determine which type of function will best model the relationship. Note that neither a linear function nor an exponential function appears to be a good fit for the global temperature data. The temperature rises during the first third of the century, then levels off, and begins to rise again around 1970. Students should recall their study of piecewise functions from Unit 5. A good fit to these data is this piecewise function:

$$f\left(x\right)=\left\{\begin{array}{c}0.0192x+56.5 when 0\leq x\leq 40\\57.15 when 40<x<70\\0.031x+55 when 70\leq x\leq 100\end{array}\right.$$

**Differentiated Instructions (Enrichment)**

Have students research various methods of determining the average global temperature. These web sites are a good place to start:

<http://data.giss.nasa.gov/gistemp/>

[www.wikipedia.org/wiki/Temperature\_record\_since\_1880](http://www.wikipedia.org/wiki/Temperature_record_since_1880).

Questions 12–16 deal with another set of data that are possibly indicative of global warming: the shrinking of the ice cap on Mount Kilimanjaro in Tanzania. In this case students are asked to fit both a linear and an exponential model to the data.

**Exit Slip 7.6** has students interpret linear and exponential models for temperature data since 1975.

1. Following the analysis of climate change data, students may want to learn about and examine solutions to global warming. In **Activity 7.6.2 Countering Global Warming** alternatives to burning fossil fuels are presented: wind power, solar energy, and geothermal energy. The growth of each of these energy sources over the past three decades can be modeled with an exponential function. In many was this activity serves as a review of the Unit since multiple representations are used to present the data: first a table, then a graph, and finally an equation. The concept of percent rate of change is revisited in question 12.

**Journal Prompt**

Now that we have examined the CO2 and global temperature data and made our projections, we can explore the impact global warming is having on our earth and its inhabitants. Suggest some real-world relationships that you believe have been or may be impacted by global warming.

**Resources and Materials**

* **Activity 7.6.1 The Mathematics of Global Warming**
* **Activity 7.6.2 Countering Global Warming**
* **Exit Slip 7.6 Earth’s Average Surface Temperature**
* Graphing Calculators
* An Inconvenient Truth website: [www.climatecrisis.com](http://www.climatecrisis.com)
* An Inconvenient Truth website: <http://www.takepart.com/an-inconvenient-truth>
* Up-to-date CO2 levels: [www.co2now.org](http://www.co2now.org)
* Up-to-date Global Temperatures: <http://www.cpc.ncep.noaa.gov/>
* National Wildlife Federation website – Global Warming Link
* [www.worldclimatereport.com](http://www.worldclimatereport.com)