

LESSON 5: WHY ALL THE WIGGLING ON THE WAY UP?

Investigating CO₂ Trends

PURPOSE/QUESTION

Students will use carbon dioxide (CO₂), vegetation, and nitrogen dioxide (NO₂) data to examine the seasonal and long-term trends in atmospheric carbon dioxide and some of the factors affecting the trends.

GRADE LEVELS

9-12

TIME TO COMPLETE

2 – 50 minute time periods

STANDARDS

See appendix below-pg. 9

LEARNING OUTCOMES

- Students will discover how seasonal cycles in vegetative cover influence atmospheric CO₂ levels.
- Student will determine the long-term trend caused by fossil fuel burning and deforestation.
- Students will discover that only about half of the carbon we're putting into the atmosphere from fossil fuel burning and deforestation stays in the atmosphere.

STUDENT OBJECTIVES

- Access and collect carbon dioxide (CO₂), vegetation, and nitrogen dioxide (NO₂) data
- Analyze and compare the data sets
- Compute a linear regression of the data
- Draw conclusions from dataset evidence

TEACHER BACKGROUND

Starting in 1958, Charles D. Keeling from the Scripps Institute of Oceanography began measuring the amount of carbon dioxide (CO₂) in the atmosphere in Mauna Loa, Hawaii. He collected air in flasks (or canisters) and made careful measurements that provided some of the first evidence that humans were significantly modifying the atmospheric composition. These measurements are still made today at Mauna Loa and about a dozen stations spanning from the North Pole to the South Pole.

This lesson will give students an opportunity to examine the CO₂ data from Mauna Loa, Alaska, and their home location. They will use this data to explore how the seasonal growth and die-off of vegetation in temperate and colder regions influences CO₂ levels. Then, they will investigate the long-term trend in CO₂ and how it relates to emissions from fossil fuel burning and deforestation.

PREREQUISITES

- [Carbon Cycle interactive animation](#) from the EPA
- From NASA's Earth Observatory, Carbon on the Land and in the Oceans: The Modern Carbon Cycle – found in this lesson's folder
- [Layers of the atmosphere](#)

VOCABULARY

- Importance in Earth System of carbon dioxide (CO₂) and nitrogen dioxide (NO₂)
- [NDVI](#)-Normalized Difference Vegetation Index
- [Charles Keeling](#)
- [Linear regression](#)

LESSON LINKS

[Live Access Server](#)
[Opening My NASA Data in Excel](#)

MATERIALS & TOOLS

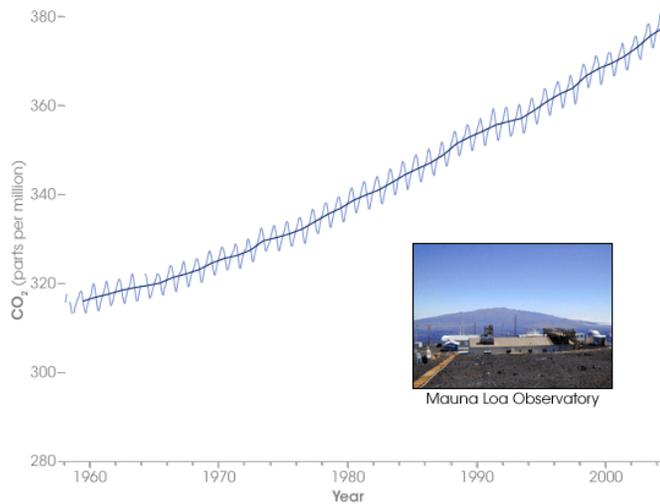
- Computer with internet access
- CCC Tip Sheet – found on pg. 7
- [Carbon Cycle diagram](#)
- Keeling Curve plot - separate jpg. with this lesson
- Monthly NDVI – Monthly – separate jpg. with this lesson
- Tropospheric Total Column NO₂ - separate jpg. with this lesson



PART 1 – Examine CO₂ data for three locations

ESSENTIAL QUESTIONS

1. What do you notice for both Alaska and Hawaii on a single chart?
2. What do you notice about how CO₂ changes through an individual year in Alaska? What factors explain these patterns?
3. What do you notice about the long-term trend of CO₂ at these two locations? What factors might explain this trend?
4. ANSWER BEFORE plotting CO₂ time series. What do you think the CO₂ time series will look like for your locations?
5. ANSWER AFTER plotting CO₂ time series. Describe the time series plot for your location. Does its pattern make sense in terms of what you would expect based on the plots for Hawaii and Alaska? Why or why not?



PROCEDURE

1. Access CO₂ time series data for two locations: Alaska (64°N, 158°W) and Hawaii (20°N, 157°W)
 - a. In the Live Access Server (Advanced Edition), click on the **Choose Dataset** button. Then choose, **Atmosphere > Air Quality > Monthly Carbon Dioxide in Troposphere (AIRS or AQUA)**. A map will automatically appear.
 - b. Under “LINE PLOTS”, select: **Time Series**
 - c. Enter the latitude and longitude for Alaska into the appropriate boxes just below the small grey map on the left of the screen.
 - d. Set the time settings in **Data Range** to be January 2003 to December 2009.
 - e. Click **Update Plot** and a time series plot will appear.
 - f. We want to access the data used to create this plot, so that we can do our own calculations. Click the **Show Values** button and then click **OK** to accept the defaults. The data will appear in the second window.
 - g. Follow the instructions in the Eco-Schools CCC Tech Tips Sheet to import the data into the Microsoft Excel worksheet for this lesson. Put the raw data in the tab titled “Raw Data – Temperature”
 - h. Repeat steps b-g for Hawaii.
 - i. Copy and paste the CO₂ data for both locations into the tab titled “3 sites” in the appropriate columns.

2. Click on the tab labeled “Chart HI + AK”. The time series data plot for both Alaska and Hawaii have been automatically done for you based on the data you input.

3. After analyzing your chart for Alaska and Hawaii answer the Essential Questions above through number 4.

4. Access and upload “your location” data to the tab labeled “Raw – Your location”. Then copy the data to the appropriate column in the “3 Sites” tab. All three columns should now be input and automatic calculations have been made to the right. Now answer Essential Question number 5.

Part 2 - Examine seasonal variation in vegetation

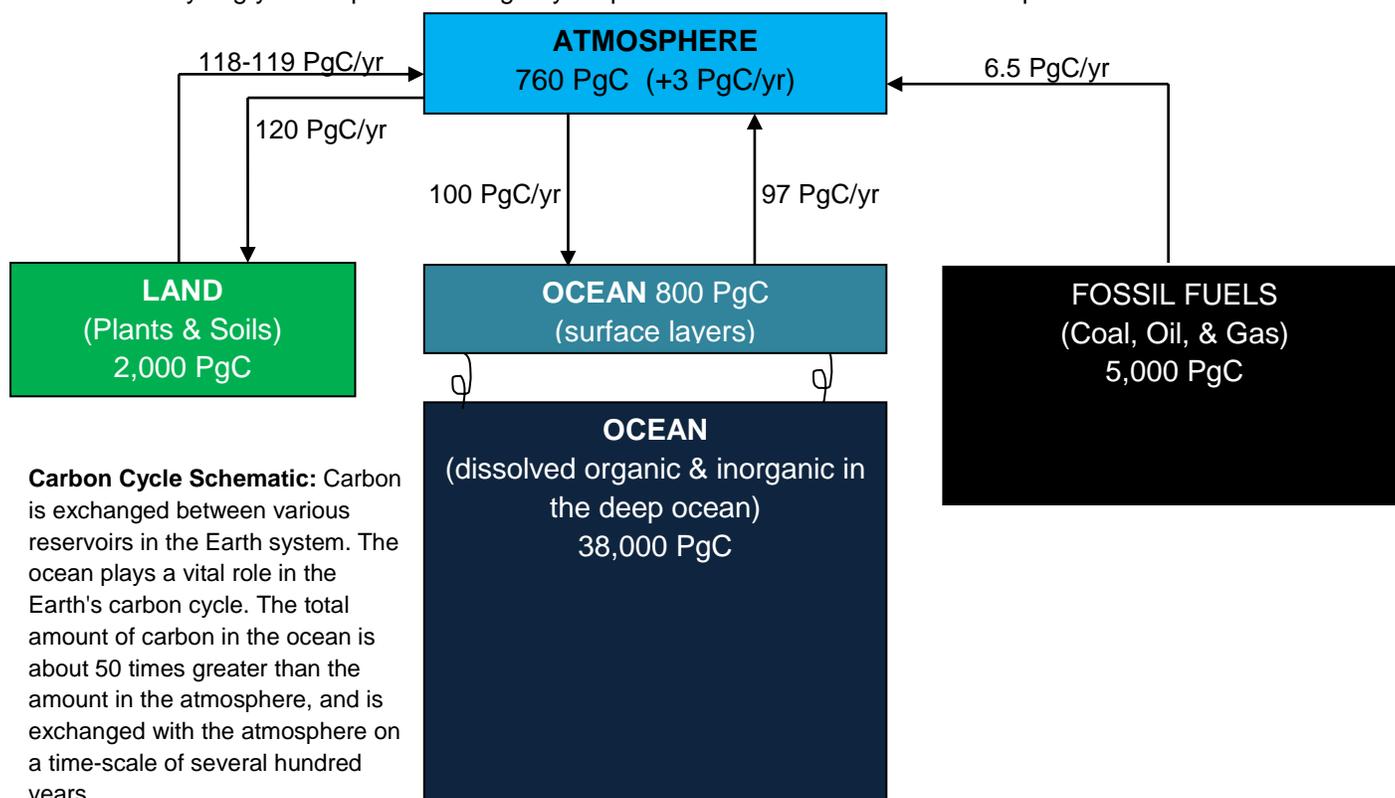
ESSENTIAL QUESTIONS

1. How does NDVI in Alaska, your location, and in the Northern Hemisphere generally change during the year? Explain and elaborate.
2. Revisit your answers to the questions in part 1 in the light of these plots. Does the distribution of vegetation confirm your hypothesis or do you need to revise your hypothesis based on this new information?

PROCEDURE

We will examine how seasonal variation in vegetation is related to the seasonal CO₂ cycle using the Normalized Difference Vegetation Index (NDVI). NDVI provides a measure of how much vegetation is growing at each location.

1. Plot NDVI for January and August 2009
 - a. In the Live Access Server (Advanced Edition), click on the **Choose Dataset** button. Then choose, **Biosphere > Monthly Normalized Difference Vegetation Index (MISR)**.
 - b. Under "MAPS", select: **Latitude-Longitude**
 - c. Set the **Date** to be January 2009.
 - d. Click **Update Plot** and a map will appear. Save or print your map.
 - e. Now, set the **Date** to be August 2009. Click **Update Plot** and a map will appear. Save or print your map.
 - f. NOTE: You may also wish to print out a map of North America for a more detailed view.
2. After analyzing your maps and talking to your peers answer the above essential questions.



[NASA Science: Earth](#)

PART 3 - Examine the long-term trend in the CO₂ time series data

ESSENTIAL QUESTIONS

1. Is the long-term trend quantified by the slope similar or different at your three locations? What can you conclude about how long CO₂ remains in the atmosphere relative to how long it takes for air from different regions to become well-mixed?
2. How does the trend calculated from your three locations over the short record compare to the average long-term trend estimated from the Keeling Curve?
3. How does your estimate in Gtons C compare to the emissions from fossil fuel burning and deforestation? What might be the reason for any differences between these numbers?
4. What does your map of NO₂ indicate about where major sources of combustion are located worldwide?
5. Do you think the long-term CO₂ trend will be similar or different in the Southern Hemisphere? Explain and elaborate.

PROCEDURE

1. A linear regression for each of the three locations has been conducted in the Excel spreadsheet. This slope corresponds to the average CO₂ increase in parts per million (ppm) per month over the 7-year period. These slopes have been multiplied by 12 (to convert the **slope** to the average annual increase in CO₂) averaged across your three locations to get a number representative of the Northern Hemisphere annual average increase.
2. Using the Keeling Curve plot on p. 5-2, estimate the average annual slope over the entire 51 year record.
3. The average annual slope has been converted to Gtons Carbon (using the following conversion: 2.1 Gtons C = 1 ppm CO₂) to calculate how much CO₂ is added to the atmosphere each year. Note that the average annual emissions of CO₂ from fossil fuel burning worldwide is 7.8 Gtons C, and the average annual emissions of CO₂ from deforestation is 1.6 Gtons C.
4. Next, we investigate the locations of major sources of fossil fuel and biomass burning emissions using a map of nitrogen dioxide (NO₂). **NO₂ and CO₂ are both byproducts of combustion and therefore have similar source regions. NO₂ has a much shorter lifetime in the atmosphere than CO₂, making it easier to identify the source regions.**
 - a. In the Live Access Server (Advanced Edition), click on the **Choose Dataset** button. Then choose, **Atmosphere > Air Quality > Monthly Tropospheric Total Column NO₂ (OMI)**. A map will automatically appear.
 - a. Select date **August 2007**. Then click **Update Plot**.
 - b. Save or print your map.
5. After analyzing the data and talking to your peers answer the essential questions at the top of the page.

TOOLS FOR ASSESSMENT

- Concept Quiz – found on pg. 14
- Essay – found on pg. 17
- Science Notebook and Student Reading Assessment Tools – found in **Rubrics** folder
- [Foldables®](#)

WEBSITES FOR FURTHER LEARNING

- [More on the Keeling Curve](#)
- [Intergovernmental Panel on Climate Change 2007 report](#)
- [Mauna Loa Observatory](#)

STUDENT READING RESOURCES

- [Annual US Carbon Emissions](#)
- [The Mystery of the Missing Carbon](#)
- [Changing Global Land Surface: The Carbon Cycle](#)
- [Correct Timing is Everything - Also for CO₂ in the Air](#)



LESSON 5-APPENDIX

WEB ADDRESSES FOR HYPER LINKS

PREREQUISTE KNOWLEDGE AND SKILLS

- Carbon Cycle interactive animation
<http://www.epa.gov/climatechange/kids/basics/today/carbon-dioxide.html>
- Layers of the Atmosphere
<http://www.vtaide.com/png/atmosphere.htm>

VOCABULARY

- CO₂
http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=C
- NO₂
http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=N
- NDVI – Normalized Difference Vegetation Index
http://mynasadata.larc.nasa.gov/science-glossary/?page_id=672?&letter=N
- Charles Keeling
http://en.wikipedia.org/wiki/Charles_David_Keeling#Work_with_Scripps_Institution_of_Oceanography.2C_1958-2005
- Linear Regression
<http://www.statisticssolutions.com/resources/directory-of-statistical-analyses/what-is-linear-regression>

MATERIALS AND TOOLS

- Carbon Cycle
<http://www.teachersdomain.org/resource/tdc02.sci.life.eco.ccycle/>

LESSON LINKS

- Live Access Server, LAS
<http://mynasadata.larc.nasa.gov/live-access-server/>
- Opening My NASA Data in Excel
<http://mynasadata.larc.nasa.gov/opening-my-nasa-data-microsets-in-excel/>

WEBSITES FOR FURTHER LEARNING

- **More on the Keeling Curve** – A website dedicated to Dave Keeling, the first person to make high precision continuous measurements of carbon dioxide levels in the atmosphere.
<http://scrippsco2.ucsd.edu/home/index.php>
- **Intergovernmental Panel on CC 2007 Report** – This report was written by scientist at the request of many governments. Its mission is to provide comprehensive scientific assessments of current scientific, technical and socio-economic information worldwide about the risk of climate change caused by human activity, its potential environmental and socio-economic consequences, and possible options for adapting to these consequences or mitigating the effects.
http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
- **Mauna Loa Observatory** – A page from the NASA's Earth Observatory that details the site for students where Keeling performed his observations
<http://earthobservatory.nasa.gov/IOTD/view.php?id=43182>



STUDENT READING RESOURCES

- **Annual US Carbon Emissions**
<http://earthobservatory.nasa.gov/IOTD/view.php?id=8903>
- **The Mystery of the Missing Carbon**
http://earthobservatory.nasa.gov/Features/BOREASCarbon/missing_carbon_4.php
- **Changing Global Land Surface: The Carbon Cycle**
<http://earthobservatory.nasa.gov/Features/LandSurface/landsurface2.php>
- **Correct Timing is Everything – Also for CO₂ in the Air**
<http://www.co2science.org/articles/V12/N31/EDIT.php>



Tech Tips for Eco-Schools USA Climate Change Connections Curriculum

How do I import data into an Excel spreadsheet?

1. Access data from My NASA Data:
 - a. Once you have all the parameters set for your desired data set (and have clicked “Update Plot” to have your preferences processed), click the “Show Values” button. A new window will pop up with a Table of Values.
 - b. The first several lines of the Table will provide information that describes the data set, often called “metadata”, such as the name of the variable, what subset of the data is included in the file, and what time range. Make sure to keep this metadata with the rest of the data when you copy it into Excel. This way you’ll be able to easily keep track of which data you have!
2. Copy the data from the browser (note that these instructions are for Internet Explorer running on a PC, and may need to be modified for other platforms):
 - a. In this new window, select all. You can do this by clicking anywhere in the window and then typing “Ctrl-A”. Or you can right-click in the window, which will pop up a menu, and then choosing “Select All” from the options.
 - b. Next, copy this data. Again there are two options. You can use the keyboard shortcuts, and type “Ctrl-C”. Or you can right-click and choose “Copy” from the pop-up menu.
3. Paste the data into Excel:
 - a. Now open your Excel worksheet and go to the tab where you want to put the raw data. Click in the A1 cell.
 - b. Paste the data, either by typing “Ctrl-V”, by clicking “Paste” (located at the left under the “Home” tab), or by right-clicking in the A1 cell and choosing “Paste”.
4. Convert the data from text to columns:
 - a. Now, we have the data in Excel, but we can’t manipulate it very well because all the data for each row is lumped into one cell. We want to split out each data value into its own cell.
 - b. Starting at the row where the column headers are located (probably around row 7), highlight the A column down to the end of the data.
 - c. Click on the Data tab at the top of the window, and then choose the “Text to Columns” wizard (located a little to the right of center).
 - d. A dialogue box will pop up to help you through the process.
 - e. The first page of the wizard asks you to identify whether the data is “Delimited” or “Fixed width”. In most cases, the My NASA Data data will be “Fixed Width”, so select that option and click “Next”.
 - f. The next page of the wizard gives you a chance to check whether the column breaks make sense and to adjust them as necessary. Make any changes that are needed. Or, go back and switch to “Delimited” on page 1 if you notice that the columns are not lining up as you expected. Once you are satisfied with the columns, click “Next”.
 - g. The final page of the wizard allows you to designate what kind of data values are in each column and a destination for the data. For the purposes of the CCC curriculum, we’ll just accept the defaults and click “Finish”.
 - h. Now your data should be in beautiful columns and the values should make sense. It’s always a good idea to double check that nothing crazy happened!



My NASA Data isn't working! What should I do?

1. Double check that you entered everything correctly. Especially check that you have the right data set and that you have entered dates and latitude/longitude values within the range of available data. Usually the user interface will prevent you from entering invalid data ranges, but sometimes there are glitches.
2. Refresh the browser and/or restart the browser. Occasionally, a fresh start is the easiest way to clear out any mistakes or glitches.
3. Update your browser and/or JAVA. If you have older versions of the software, then you might find that some functionality is lost.
4. If you're still struggling, consider whether problem might be at the My NASA Data website. It might be a temporary problem, in which case taking a break and returning to the site at a later time could be a good choice. Or it could be a more significant problem, in which case you'll want to explore the "help" resources provided by My NASA Data (link in upper right hand corner of page).
5. Ask your Eco-Schools contact for help or email eco-schoolsusa@nwf.org!

How do I print or save a map or graph?

1. Use the "Print" button to generate a version of your map or graph that is suitable for saving or printing. Once you click on the "Print" button, a new window will pop up with your map or graph.
2. Print a map or graph by using the print option on your browser.
3. Save a map or graph in one of two ways:
 - a. By choosing "Save as" in the browser. Use the defaults to save as a "Web Archive, single file (*.mht)".
 - b. By right clicking and choosing "Save picture as..." Use the defaults to save as a *.png file.
4. When saving, make sure to give your new file a descriptive name and put it somewhere that you'll remember!

How do I find my latitude and longitude?

A number of sites help you find your latitude and longitude. For example:

1. <http://itouchmap.com/latlong.html>
2. <http://www.findlatitudeandlongitude.com/>



LESSON 5-STANDARDS**National Science Education Standards****Unifying Concepts and Processes**

- Systems, Order, and Organization
- Evidence, Models, and Explanations
- Change, Constancy, and Measurement

Standard A – Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Standard B – Physical Science

- Conservation of energy
- Interactions of energy and matter

Standard D – Earth and Space Science

- Energy in the earth system
- Geochemical cycles

Standard E – Science and Technology

- Abilities of technological design
- Understandings about science and technology

Standard F – Science in Personal and Social Perspectives

- Natural resources
- Environmental quality
- Natural and human induced hazards
- Science and technology in local, national, and global challenges

Standard G – History and Nature of Science

- Nature of scientific knowledge
- Historical perspectives

National Education Technology Standards**Standard 1: Creativity and Innovation**

- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

Standard 3: Research and Information Fluency

- Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
- Process data and report results



Standard 4: Critical Thinking, Problem Solving, and Decision Making

- Collect and analyze data to identify solutions and/or make informed decisions.

Standard 5: Digital Citizenship

- Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.

Standard 6: Technology Operations and Concepts

- Understand and use technology concepts
- Select and use applications effectively and productively
- Troubleshoot systems and applications
- Transfer current knowledge to learning of new technologies

National Council of Teachers of Mathematics Education Standards

Measurement

- Understand measurable attributes

Data Analysis and Probability

- Develop and evaluate inferences and predictions that are based on data

Process

- Connections
 - Recognize and apply mathematics in contexts outside of mathematics
- Representation
 - Use representations to model and interpret physical, social, and mathematical phenomena

Climate Literacy Principles

Principle 1: The sun is the primary source of energy for earth's climate system.

Principle 2: Climate is regulated by complex interactions among components of the Earth system.

Principle 4: Climate varies over space and time through both natural and man-made processes.

Principle 5: Our understanding of the climate system is improved through observations, theoretical studies, and modeling

Principle 6: Human activities are impacting the climate system.



Energy Literacy Principles

Principle 1: Energy is a measurable quantity that follows physical laws.

Principle 2: Physical Earth processes are the result of energy flow through the earth system.

Principle 4: Various sources of energy can be used to power human activities, and often this energy must be transferred from source to destination.

Principle 5: Individuals and communities make energy decisions every day.

Principle 6: The amount of energy human society uses depends on many factors and can be reduced in many ways.

LESSON 5-ESSENTIAL QUESTIONS ANSWER KEY

Essential Questions-1

1. What do you notice about how CO₂ changes through an individual year in Hawaii? What factors might explain these patterns?
[In Hawaii, CO₂ is highest during the spring and lowest during the early fall. This variation is caused by the rapid growth of the biosphere during the summer months, which draws down atmospheric CO₂ levels as plants photosynthesize. During the fall and winter months, plants are not growing but plant and animal respiration continues, releasing CO₂ into the atmosphere and allowing CO₂ levels to build up again.]
2. What do you notice about how CO₂ changes through an individual year in Alaska? What factors might explain these patterns?
[The amplitude of seasonal change is much greater in Alaska than in Hawaii. Alaska has more pronounced seasonality of vegetation growth and dormancy. Also, several years appear to have a secondary peak in early fall, perhaps from the enhancement of respiration in melting peat or from wildfires. (need to check on this and/or change location).]
3. What do you notice about the long-term trend of CO₂ at these two locations? What factors might explain this trend?
[CO₂ is steadily increasing in both places. Emissions of CO₂ to the atmosphere from burning fossil fuels are the primary cause of this increase. Deforestation is another significant contributor.]
4. What do you think the CO₂ time series will look like for your location?
[CO₂ will be increasing in all locations. The amplitude of the seasonal cycle will depend on how vigorous a seasonal vegetation cycle is present in the chosen location.]

Essential Questions-2

1. How does NDVI in Alaska, your location, and in the Northern Hemisphere generally change during the year? Why?
[There is significantly more vegetation in Alaska, locations in North America, and the Northern Hemisphere generally during August than during February. This reflects the fact that August is at the end of the growing season, while February is at the end of Northern Hemisphere winter. The large growth of the biosphere during the summer corresponds to the annual minimum in atmospheric CO₂ levels at each of the 3 locations, because the CO₂ has been used by plants to grow. The opposite is true during winter, when much of the mid- and upper-latitude biosphere is



largely dormant. During this time, plants and soils are decaying, releasing CO₂ to the atmosphere. That's why CO₂ reaches its annual maximum around the end of winter.]

2. Revisit your answers to the questions in part 1 in light of these plots. Does the distribution of vegetation confirm your hypothesis or do you need to revise your hypothesis based on this new information?

[Answers will vary]

Essential Questions-3

1. Is the long-term trend, quantified by the slope, similar or different at your three locations? What can you conclude about how long CO₂ remains in the atmosphere relative to how long it takes for air from different regions to become well-mixed?

[Students should find that the trend is similar at all the locations, about 2 ppm/year. The lack of geographic variation in the long-term trend indicates that CO₂ is a long-lived gas that remains in the atmosphere longer than it takes for air to be well-mixed]

2. How does the trend calculated from your three locations over the short record compare to the average long-term trend estimated from the Keeling Curve?

[The two trend calculations should be quite similar. The rate might be slightly larger for recent years than for the average over the entire 51-year range because CO₂ emissions have increased over that time period.]

3. How does your estimate of average annual increase of CO₂ in the atmosphere in Gtons C compare to the emissions from fossil fuel burning and deforestation? What might be the reason for any differences between these numbers?

[The annual emissions of CO₂ are about twice as high as the annual increase in atmospheric CO₂. This indicates that some of the CO₂ emitted by fossil fuel burning and deforestation is quickly removed from the atmosphere. This CO₂ is being stored elsewhere in the Earth system, namely in the oceans and in the terrestrial biosphere, which has shown net growth in recent decades. Without these natural sinks for the CO₂ that humans are adding to the atmosphere, we would have even more global warming underway!]

4. What does your map of NO₂ indicate about where major sources of combustion are located worldwide?

[Major sources of combustion in the Northern Hemisphere are centered in the highly urbanized parts of North America, Europe, and Eastern Asia. Major sources in South America and Africa correspond to locations of seasonal biomass burning. NO₂ is very low over the oceans, consistent with its short lifetime. Some NO₂ appears to be transported over the oceans at higher latitudes, because the chemical break down of NO₂ is slower in colder locations. NO₂ levels appear to be much greater in the Northern Hemisphere than the Southern Hemisphere, indicating that more CO₂ is emitted in the Northern Hemisphere.]

5. Formulate a hypothesis. Do you think the long-term CO₂ trend will be similar or different in the Southern Hemisphere? Why?

[The Southern Hemisphere trend should be similar to the Northern Hemisphere trend. The rate of increase is the same because fossil fuel CO₂ remains in the atmosphere for decades to centuries, which is much longer than the average time it takes for air in the lower part of the atmosphere (troposphere) to become well-mixed (about 1-2 years). The absolute amount of CO₂ might be slightly less in the Southern Hemisphere because more CO₂ sources are located in the



Northern Hemisphere, and it can take 1-2 years for CO₂ emitted in the Northern Hemisphere to mix into the Southern Hemisphere.

NOTE: If time allows, students could test their hypothesis by conducting the same analysis for one or more locations in the Southern Hemisphere.]



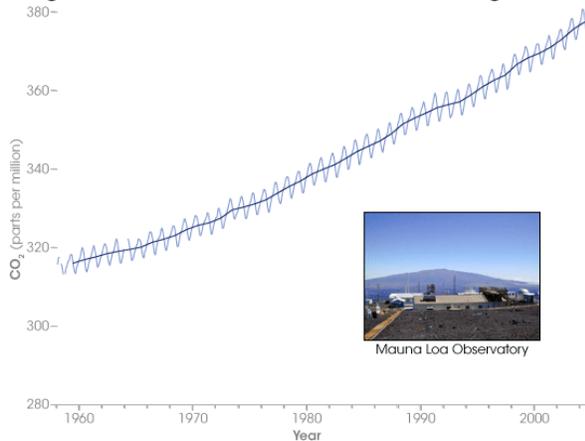
Name: _____ Date: _____

Science Concept Quiz

Lesson 5: Why All the Wiggling on the Way Up?

Investigating CO₂ Trends

The carbon cycle includes many important processes that impact the earth system. The famous diagram from Mauna Loa, The Keeling Curve, depicts the rise of CO₂ from 1958 to 2008.



Which groupings would be considered carbon sinks, having the ability to absorb large amounts of carbon, and would therefore be disadvantageous to destroy?

- A. parking lots and buildings
- B. trees and oceans
- C. coal beds and natural gas reserves
- D. farmland and factories

_____ points out of 20

I. Answer

- A.
- B.
- C.
- D.

_____ points out of 15

II. What is the main concept behind the question?

- A. Natural resources
- B. Renewable energy
- C. Change over time
- D. Carbon cycle

_____ points out of 25

III. Provide the reasoning behind your answer.

_____points out of 40

IV. Why are the other responses not the best answer chose?

- 1.
- 2.
- 3.
- 4.

Use the rest of this page if more room is needed to fully communicate your thoughts.



Teacher Answer Key

1. B
2. 4
3. Answers will vary. The carbon cycle is made up of places where carbon is stored, where it is giving off and how it is transferred. This knowledge will allow me to best answer the question.
4. Answers will vary.
 - A) Parking lots and buildings contribute to higher temperatures and do not absorb carbon.
 - B) This is the correct answer. Trees and oceans are places where carbon can be absorbed if trees are cut down then carbon cannot be absorbed. As oceans warm they are unable to store as much carbon and therefore it stays in the atmosphere.
 - C) Coral reefs and natural gas reserves produce carbon in different ways.
 - D) Farmland and factories also produce carbon. Even though farmland produces crops of various kinds they cannot absorb the tons of carbon released into the atmosphere like large areas of trees are able to do.



Student Name
Teacher/Class
Date

Lesson 5: Why All the Wiggling On the Way Up? Investigating CO₂ Trends

Based on your analyses, collaborations, and writings provide evidence of understanding for how CO₂ varies seasonally and regionally within the northern hemisphere.

What Is the Expectation?

Accurate science relating to trends in CO₂

Evidence supporting your claims

Visual representations

Key vocabulary

Evidence of on grade level spelling and grammar usage

