Atmospheric Carbon Dioxide and the Greening of the Planet

A Carolina Essentials™ Activity

Overview

Atmospheric carbon dioxide (CO_2) levels have been changing globally since about 1785. Ice core samples indicate that prior to the late 1700s, CO_2 levels were around 280 parts per million (ppm). In 1885, CO_2 levels peaked at 293 ppm as a direct result of the Industrial Revolution, a period powered by coal combustion. As industrialization continued worldwide to include fossil fuel cars and electric power plants, CO_2 levels rose to 349 ppm. In 2014, CO_2 levels reached 400 ppm, and today, atmospheric levels are hovering around 416 ppm.

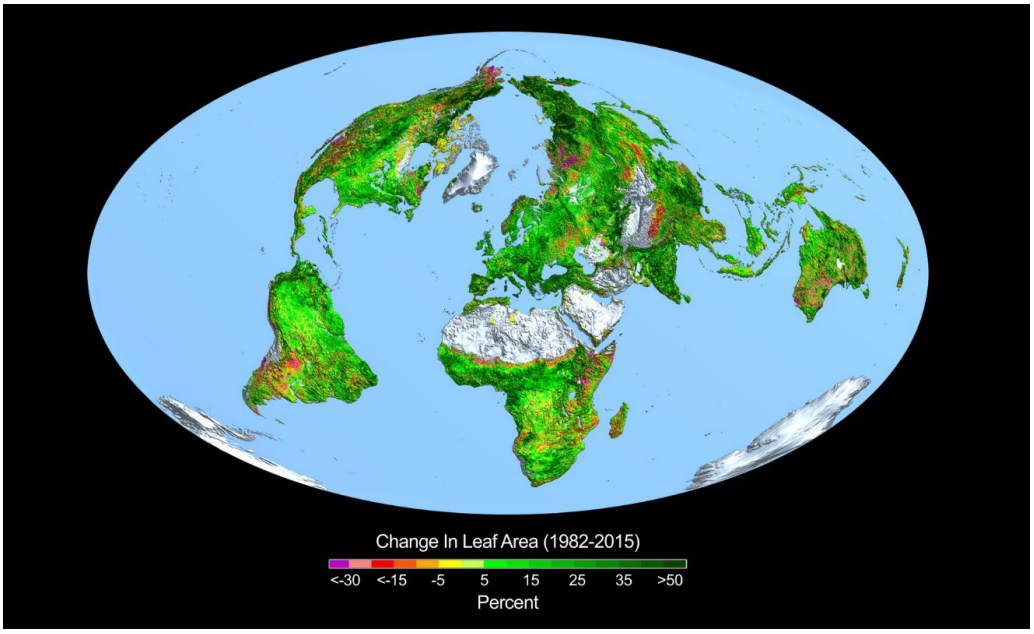
Carbon dioxide levels are often associated with climate change, but this is just one piece of the puzzle. How are changing atmospheric CO_2 levels impacting the cycling of carbon in the hydrosphere, geosphere, and biosphere? One method used to examine the interactions between atmospheric carbon dioxide and the biosphere is to measure global leaf cover. Since plants absorb CO_2 from the atmosphere during photosynthesis, it can be hypothesized that as CO_2 levels increase, leaf cover should increase. Using satellite imagery, scientists can study the relationship between atmospheric carbon dioxide and global leaf cover (as seen in the map below).

In this activity, students use data from 2015 through 2020 to build on the model shown in the map below. They are asked to modify the model presented for 2015 to explain predicted leaf cover for 2016, 2018, and 2020 after calculating percent change in atmospheric carbon dioxide levels.

Earth and Space Science
Grades: 9–12

Phenomenon

Look at the image below. The scale indicates percent change in the amount of leaf area worldwide from 1982 to 2015. What patterns do you notice?



Boston University/R. Myneni

Continued on the next page.

TIME REQUIREMENTS

PREP	ACTIVITY
15 min	30-45 min

Teacher Prep: 15 min
Student Activity: 30-45 min

SAFETY REQUIREMENTS

No PPE is required for the activity.

MATERIALS

Colored pencils or pens

Graph paper or graphing program

HELPFUL LINKS

Photosynthesis

Phenology: Spring Leaf Index

REFERENCE KITS

Analyzing Patterns in Climate Change

Modeling the Carbon Cycle

REFERENCES

CO_2 Virtual Science Data Environment. 2020. OCO-2 Data Set. https://co2.jpl.nasa.gov/#mission=OCO-2.

Global Climate Change: Vital Signs of the Planet. 2020. "Carbon Dioxide." https://climate.nasa.gov/vital-signs/carbon-dioxide/.

International Energy Agency. 2020. "Global CO_2 Emissions in 2019." IEA, Paris. https://www.iea.org/articles/global-co2-emissions-in-2019

Reiny, Samson. 2016. "Carbon Dioxide Fertilization Greening Earth, Study Finds." NASA, April 26, 2016. https://www.nasa.gov/feature/goddard/2016/carbon-dioxide-fertilization-greening-earth.

©2020 Carolina Biological Supply Company

CAROLINA®
www.carolina.com

Atmospheric Carbon Dioxide and the Greening of the Planet

A Carolina Essentials™ Activity

Essential Question

How can global leaf cover and atmospheric carbon dioxide levels model interactions between the atmosphere and biosphere within the carbon cycle?

Activity Objectives

1. Use data to establish a relationship between global leaf cover and atmospheric carbon dioxide levels.
2. Using atmospheric carbon dioxide levels and the global leaf cover map as a starting point, predict global leaf cover for 2020.

Next Generation Science Standards* (NGSS)

PE HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

PE HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. **Using Mathematics and Computational Thinking** • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect the climate. • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved. **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Safety Procedures and Precautions

No PPE is required for the activity.

Continued on the next page.

©2020 Carolina Biological Supply Company

CAROLINA®
www.carolina.com

Atmospheric Carbon Dioxide and the Greening of the Planet

A Carolina Essentials™ Activity

Teacher Preparation and Disposal

Copy or upload the student activity sheets.

Student Procedure

1. Based on the global CO_2 levels from 2015 to present, construct a graph of CO_2 levels in parts per million (ppm).

January and July CO_2 Levels (ppm)

Year	January	July
2015	400.36	402.24
2016	402.25	403.07
2017	405.98	407.35
2018	407.70	408.29
2019	408.96	410.10
2020	413.65	414.04

2. Calculate annual average and percent change for each year from 2015 to 2020.

Year	Annual Average	Percent Change
2015	*avg. = 401.30 ppm*	
2016	*avg. = 402.66 ppm*	*% change = 0.34%*
2017	*avg. = 406.66 ppm*	*% change = 0.99%*
2018	*avg. = 407.99 ppm*	*% change = 0.33%*
2019	*avg. = 409.53 ppm*	*% change = 0.38%*
2020	*avg. = 413.85 ppm*	*% change = 1.05%*

3. Using your data for percent global CO_2 change in parts per million since 2015 and the global leaf cover map for 2015 as a starting point, construct a global leaf cover model for 2016, 2018, and 2020.

Each year, CO_2 increases, so the shade of green should darken indicating more leaf area. What were shades of yellow, students may change to green.

Teacher Preparation and Tips

If you would like for students to have more CO_2 data, please go to the Atmospheric CO_2 Levels Graph maintained by the 2 Degrees Institute.

Remind students to average the January and July CO_2 values before calculating percent change.

Students need to begin illustrating their model with the current values shown in the phenomenon map. This model assumes that the global average is applicable in each location even though that may not be the case.

Students may use one of several different methods to complete question 3 based on whether they are doing the assignment digitally or on paper, and what tools they have at their disposal.

Continued on the next page.

©2020 Carolina Biological Supply Company

CAROLINA®
www.carolina.com

Atmospheric Carbon Dioxide and the Greening of the Planet

A Carolina Essentials™ Activity

Analysis and Discussion

1. Use the historical and current data to propose a model for the cycling of carbon through changes in atmospheric CO_2 levels and global leaf cover. Your model may be a graphic, flow chart, or written explanation.

   Student answers may vary, but key points include the following: as atmospheric CO_2 increases, more CO_2 is available to plants for photosynthesis, more photosynthesis means more leaf production, and more leaf production means more global leaf area, which means a greener planet.

2. Compare your model to the one described in the 2016 article "Carbon Dioxide Fertilization Greening Earth, Study Finds," which represents changes from 1982 to 2015. Are the models consistent for explaining the phenomenon of leaf cover change? Explain.

   Student answers will vary, but student models should show darker shades of green as CO_2 levels increase.

TEACHER NOTES

*Next Generation Science Standards® is a registered trademark of Achieve/WestEd. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of, and do not endorse, these products.

©2020 Carolina Biological Supply Company

CAROLINA®
www.carolina.com