Today I Learned About Removing CO_2 from the Atmosphere

Description

Carbon dioxide is increasing in Earth's atmosphere as we burn fossil fuels like coal, oil, and natural gas. While technology that can remove CO_2 from the air is growing, it is an engineering challenge. Students model the challenge of carbon capture and graph the historic rise in carbon dioxide as observed at Mauna Loa, Hawai'i.

Skills & Objectives

SWBAT:

- Briefly explain some reasons for increases in atmospheric carbon dioxide
- Understand that carbon capture technology is difficult to develop in part because the concentration of atmospheric carbon dioxide is very low.
- Demonstrate that carbon dioxide has been rising in Earth's atmosphere since at least the 1950s.

Skills

- Create and/or interpret data via a line graph
- Communicate scientific information

Students Should Already Know That:

- Carbon dioxide in the atmosphere acts like a heat-trapping blanket.
- Burning fossil fuels releases excess carbon dioxide into the atmosphere.

Standards Alignment:
HS-ETS1-3 Evaluate a solution to a complex real-world problem.
CCSS.ELA-LITERACY.SL Speaking & Listening
CCSS.ELA-LITERACY.RST Science & Technical Subjects
CCSS.MATH.CONTENT.HSS.ID.A Summarize, represent, and interpret data
Disciplinary Core Ideas:
ESS2.D Weather and Climate
ESS3.C Human Impacts on Earth Systems
ETS1.A Defining and Delimiting an Engineering Problem

TILclimate Guide for Educators

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How to Use These Activities

Pages with the circular "TILclimate Guide for Educators" logo are intended for educators. Simpler pages without the dark band across the top are meant for students.

A detailed table of contents on the next page describes what students will do during each activity. All activities are designed to be done as standalones, in sequence, or as part of a larger curriculum effort.

The podcast episode, bead model (p. 1-2) and graphing activity (p. 4) all take similar amounts of time. They could be set up as rotating stations.

Projects for the "Each One Teach One" activity can be as simple or as complex as is appropriate for your class.

A Note About Materials

- Standard pony beads come in a variety of colors. A 1lb bag costs around $12 or less from various online suppliers.
- For this model, one could use a mixed-color bag and decide on a single color that represents carbon dioxide, or a single-color bag with a very small number of a contrasting color representing carbon dioxide.
- Dry beans, dry rice, or other small items could also be used.
- Students who have challenges differentiating colors can take the "Input" or "Timer" role. However, they may be able to agree with their teammates on a bead color that they are able to easily discern.

Podcasts in the Classroom: Throughout these Guides for Educators, we invite students to think about how they would share their learning with family and friends. Student-created podcasts are shareable, creative, and have multiple options for embedded assessment. We would love to hear any podcasts or see any other projects you or your students create! Email us at tilclimate@mit.edu, Tweet us @tilclimate, or tag us on Facebook @climateMIT.

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Detailed Table of Contents

Today I Learned About Removing CO_2 from the Atmosphere

Removing CO_2 from the Atmosphere

This Educator Guide includes a demonstration, discussion, math extensions, graphing activity, and a creative communication project. Educators may pick and choose among the pieces of the Guide, as suits their class needs.

Parts of this Guide may align with the following topics:

- Mathematics: Graphing datasets with a single line (annual mean data) or with multiple lines (monthly mean data.) Interpreting graphs. Arithmetic with scientific notation.
- Physical science: Atmospheric composition and changes over time. Measuring very small concentrations.
- Life/environmental science: History of the development of Earth's atmosphere. Carbon cycle changes.
- History/social science: Choices about technology use. The Industrial Revolution.
- ELA/literature: Science fiction or other texts with future technology.
- ELA/nonfiction: Interpreting and communicating scientific information.
- Extension: Print or otherwise represent 1 million of something (there are documents available online to print 1 million dots) and color them to represent the atmosphere and/or to demonstrate change in CO_2 concentration over time.

MIT Resources

We recommend the following as resources for your own better understanding of climate change or as depth for student investigations. Specific sections are listed below:

- Climate Science, Risk & Solutions, an interactive introduction to the basics of climate change. https://climateprimer.mit.edu/
  - 02: The greenhouse effect and us
  - 05: How much of the CO_2 increase is natural?
  - 09: How long can we wait to act?
  - 10: What can we do?
- MIT Climate Portal Explainers are one-page articles describing a variety of climate topics. https://climate.mit.edu/explainers
  - Greenhouse Gases
  - Carbon Capture
  - Renewable Energy

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Discussion Questions

- We measure carbon dioxide at very low levels, hundreds of parts per million. What are some other important things that might be measured at this level? (Examples: lead in drinking water should not rise above 15 parts per billion (ppb); ground-level ozone affects air quality at 70 ppb.)
- Do you think engineers and inventors should keep developing carbon capture technology? Why or why not?
- What other ways do we know of to reduce the carbon dioxide in the atmosphere?
- We are adding carbon dioxide to the atmosphere every day. A metaphor some people use is that the atmosphere is a bathtub, being filled from a faucet of carbon dioxide. If a bathtub is close to overflowing, you should turn the faucet off before you start emptying the tub. How are communities, governments, and organizations reducing the amount of carbon dioxide we release into the atmosphere?

Climate Solutions

Climate solutions can be thought of as falling into four co-equal categories. Across all categories, a focus on community-level solutions leads to more effective action. Community-level solutions change decision-making so that the default option for individuals is the one that has the best result for the climate. For example, policies that increase the solar and wind mix in the electric grid, instead of asking homeowners to install solar panels. For more on talking about climate change in the classroom, see “How to Use This Guide”

- **Energy Shift**
  How do decision-makers make the switch from carbon-producing energy to carbon-neutral and carbon-negative energy?
- **Energy Efficiency**
  What products and technologies exist to increase energy efficiency, especially in heating and cooling buildings?
- **Adaptation**
  How can we adapt buildings to keep people safe from heat and cold?
- **Talk About It**
  Talking about climate change with friends and family can feel overwhelming. What is one thing you have learned that you could share to start a conversation?

What solutions are the most exciting in your classes? We would love to hear from you or your students! Images, video, or audio of student projects or questions are always welcome. Email us at tilclimate@mit.edu, Tweet us @tilclimate, or tag us on Facebook @climateMIT.

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Math Challenge Answer

According to NASA, Earth's atmosphere weighs 5.1×10^{15} metric tons (MT).

As of June 2021, carbon dioxide measured 417ppm in the atmosphere.

For most of human history, we have had between 250-350ppm CO_2 in the atmosphere.

1. How many metric tons (MT) of CO_2 is in the atmosphere now? (417 ppm is .000417)

$$\mathbf{0.000417 \cdot (5.1 \times 10^{15}) = 2{,}127{,}600{,}000{,}000 = (2.1267 \times 10^{12})}$$

If we wanted to lower CO_2 to 350ppm, how many MT CO_2 would we have to remove?

$$\mathbf{0.00035 \cdot (5.1 \times 10^{15}) = 1{,}785{,}000{,}000{,}000 = (1.785 \times 10^{12})}$$

$$\mathbf{(2.1267 \times 10^{12}) - (1.785 \times 10^{12}) = 341{,}700{,}000{,}000 = (3.417 \times 10^{11})}$$

Mount Everest is estimated to weigh 1.619×10^{11} metric tons. How many Mount Everests would it take to make up the number of metric tons of CO_2 we would have to remove to get back to 350ppm?

$$\mathbf{(3.417 \times 10^{11}) / (1.619 \times 10^{11}) = 2.11}$$

We would have to remove more than two Mount Everests' worth of

CO_2 from the atmosphere to reduce from 417ppm to 350ppm.

Unfamiliar with scientific notation? These calculations can be done on Wolfram Alpha https://www.wolframalpha.com/. 5.1×10^{15} is written 5.1x10^15.

Bead Weighing Example

1. Count out and weigh 100 beads in grams.	A: **25** grams	Taking a sample is easier than counting all the beads.
2. Weigh all beads in grams.	B: **454** grams	Make sure to zero the scale (tare) with your container on it first.
3. Divide B / A	C: **18**	How many sets of 100 beads do you have?
4. Multiply C * 100	D: **1,800** beads	How many beads do you have?

For this example, we rounded all answers to estimate the number of beads.

1,800 (number of beads total) x **0.0004** (400 parts per million) = **.72** (carbon dioxide beads)

A perfectly accurate model would have less than one CO_2 bead.

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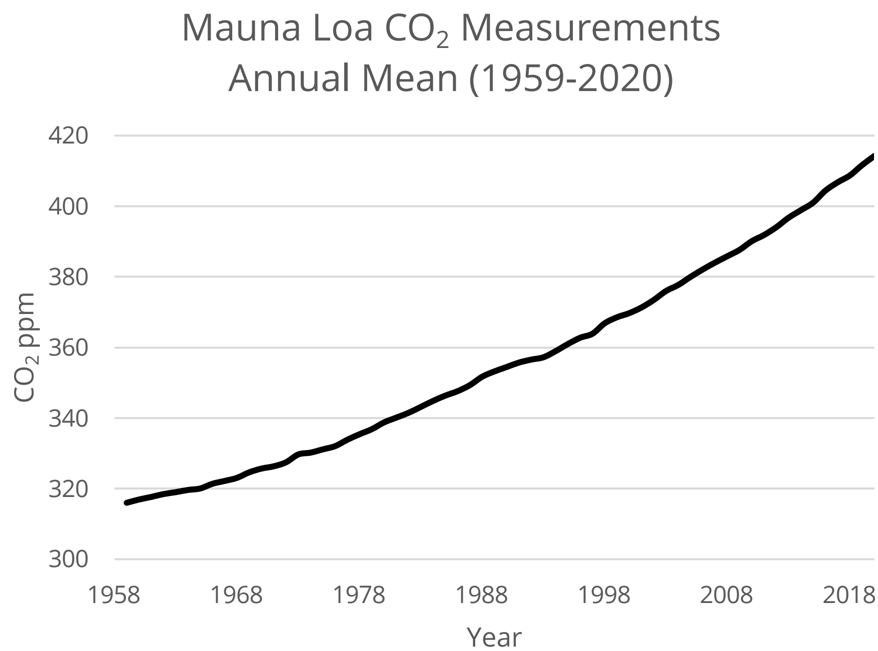
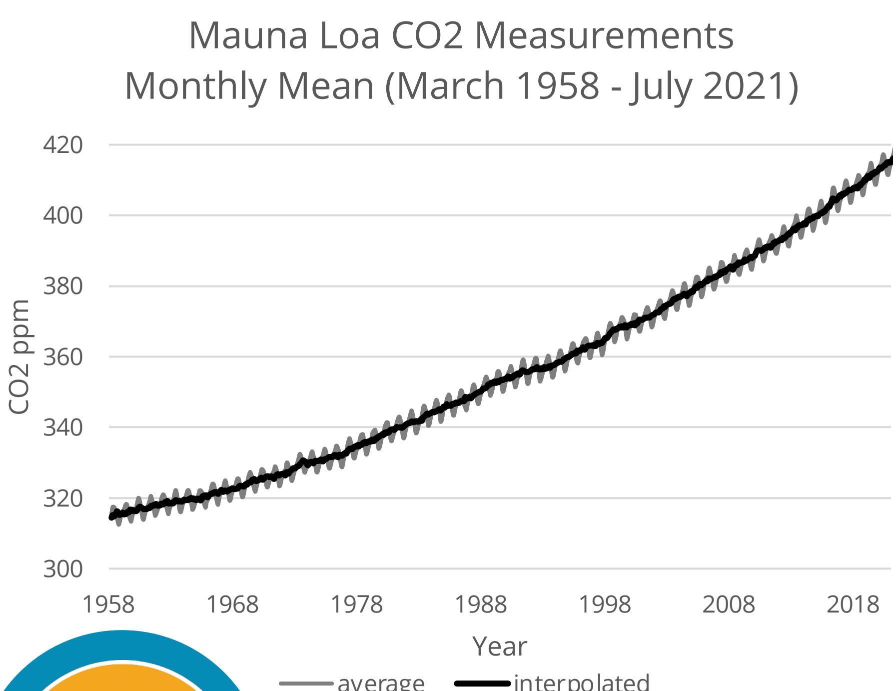
Mauna Loa Annual Mean Graph Example

This example graph was created in Microsoft Excel. Other graphing programs such as Google Sheets or OpenOffice will produce similar, if slightly different, results. For this smaller dataset, students could also plot data points by hand on graph paper. In this case, the chart type is XY Scatter with Smooth Lines.



Mauna Loa Monthly Mean Graph Example



This example graph was also created in Microsoft Excel as an XY Scatter with Smooth Lines chart. The Interpolated line is smoothed to erase seasonal variability, and is almost identical to the Annual Mean line, above. In the interactive graph on NOAA's website, this is called the trend line. Atmospheric CO_2 rises during the Northern Hemisphere's winter when trees are dormant and falls when they are active.

https://gml.noaa.gov/ccgg/trends/data.html

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