

## How Have Humans Changed the Earth?

### Student Handout

Scientists have proposed that we have entered a new era – the Anthropocene. They have named it as such because this era is defined by how humans have affected the Earth. In this activity, you will explore the ways in which human activities have shaped the Earth.

#### ***The Greenhouse Effect***

1. Visit the web page <http://climate.nasa.gov/causes/> and read about the greenhouse gas effect. Explain how the greenhouse gas effect contributes to climate change.
  
  
  
  
  
  
  
  
  
  
2. List the gases that contribute to the greenhouse effect and describe their sources.

#### ***Carbon Dioxide***

3. Go to NASA's Climate Time Machine <http://climate.nasa.gov/interactives/climate-time-machine> and open the "Carbon Dioxide" viewer. Play the video or drag the slider to see how the Earth's CO<sub>2</sub> levels have changed between 2002 and 2014. Describe the trend that you observe in CO<sub>2</sub> concentration over time. Also compare and contrast what you observe between the Northern and Southern Hemispheres of the Earth as well as between different seasons.

4. Why do you think there is a difference between the levels of CO<sub>2</sub> between hemispheres during different seasons?

For hints, check out these resources:

- Science Bulletin: “Earth’s Green Carbon Machine” by the American Museum of Natural History: <https://www.youtube.com/watch?v=geR2KsF53y4>
- Earth’s Green Carbon Machine Backgrounder: <http://www.amnh.org/content/download/43544/660599/file/Earth's%20Green%20Carbon%20Machine%20Backgrounder.pdf>
- Article “Why are Seasonal CO<sub>2</sub> Fluctuations the strongest at Northern Latitudes”: <https://scripps.ucsd.edu/programs/keelingcurve/2013/05/07/why-are-seasonal-CO2-fluctuations-strongest-in-northern-latitudes/>

## Mauna Loa CO<sub>2</sub> Measurements

The graph at the right shows a portion of CO<sub>2</sub> data recorded at Mauna Loa Observatory in Hawaii and represents part of the “Keeling Curve”.

Charles Keeling was a scientist famous for his work measuring the amount of CO<sub>2</sub> in the atmosphere. He began taking these measurements in California and later expanded his network of monitoring stations worldwide.

The monitoring station at Mauna Loa Observatory in Hawaii is significant because it has been measuring CO<sub>2</sub> since the 1950's and has the longest continuous record of measurements.

This location is considered to be ideal

for measuring CO<sub>2</sub> because of its distance from large population centers and the prevailing winds on the island blow from land to sea, so the effects from local vegetation are minimized.

The red line on the graph represents the actual measurements and the black line indicates the trend.

5. Relate the data you see in the graph to your observations in questions 3 and 4. Do these data confirm that there are seasonal fluctuations in CO<sub>2</sub>?

6. What does the trend line in the graph above indicate about CO<sub>2</sub> levels?

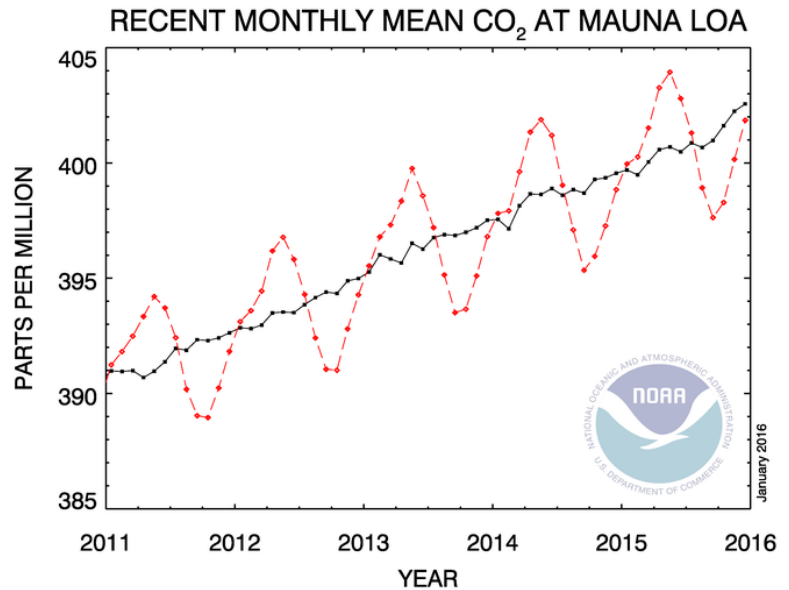
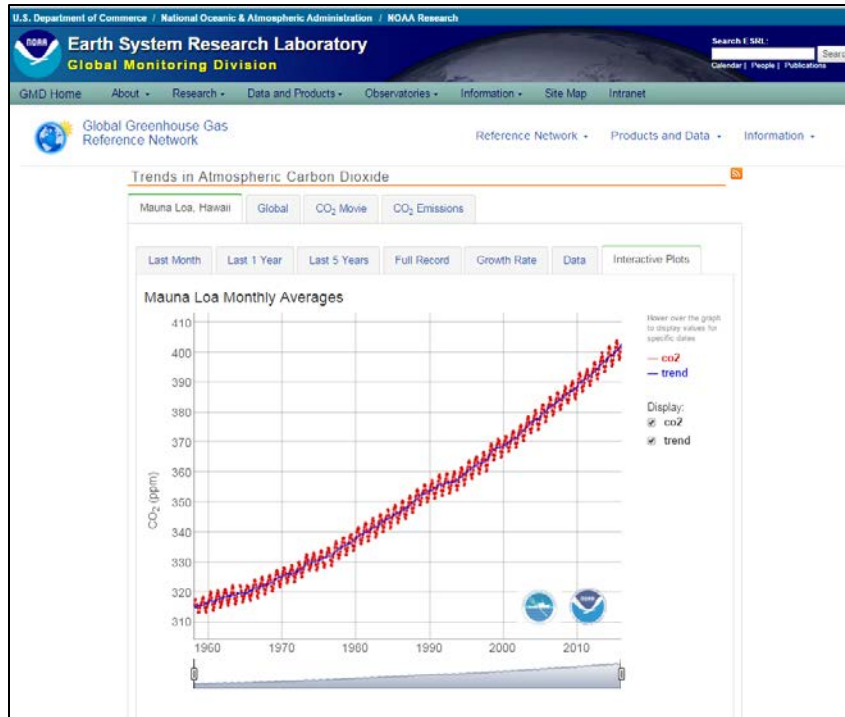


Image credit: [NOAA Earth Systems Research Lab](#)

Go to the interactive version of the Keeling Curve here (screenshot shown below):  
<http://www.esrl.noaa.gov/gmd/ccgg/trends/graph.html>



Use the interactive version to examine the CO<sub>2</sub> month/year data by mousing over the dots on the graph. Make sure you are on the "Mauna Loa, Hawaii" tab and the "Interactive Plots" tab as pictured in the screenshot below. You can also use the slider at the bottom to zoom in on a decade.

7. Describe the trend line from 1960 to present.
8. Now click on the tab "CO<sub>2</sub> Movie" and play the short video (3:44) and answer the questions below.

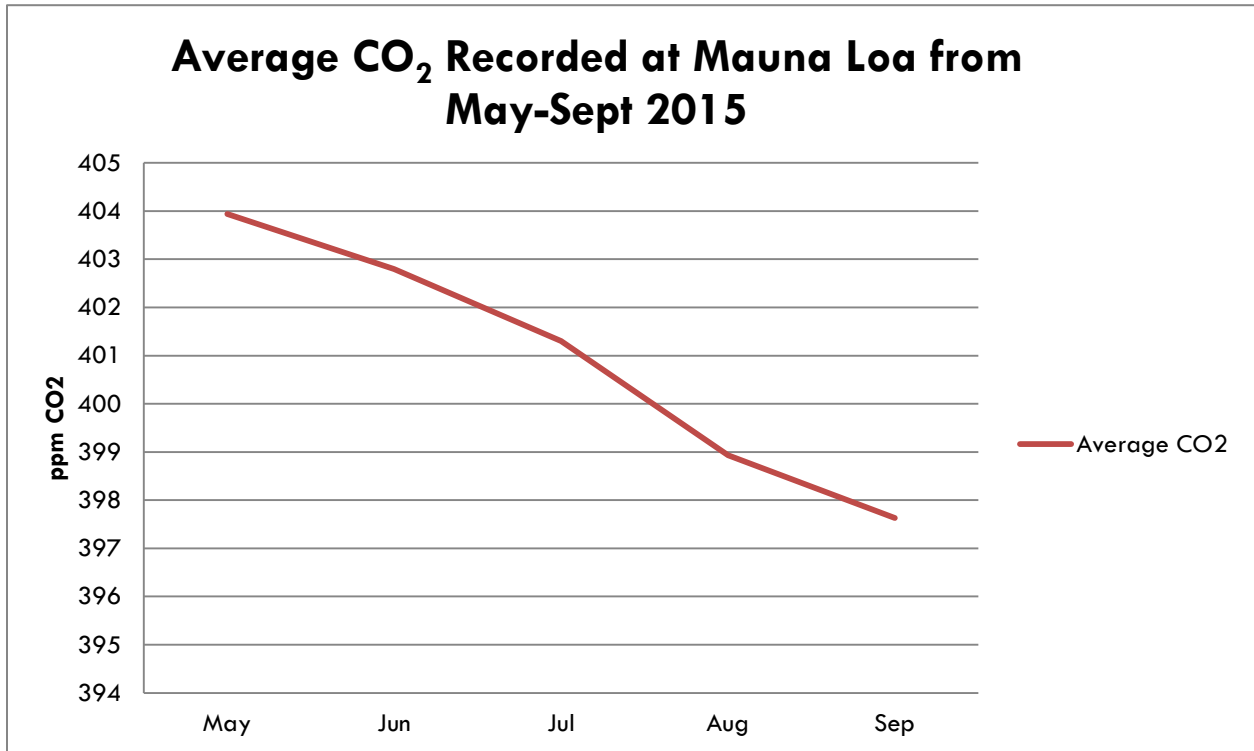
What does this animation depict?

How far back in time does it go?

Where are these ancient measurements obtained?

What is the highest level of CO<sub>2</sub> recorded in ppm? What is the lowest level on record?

9. Why is the information in the CO<sub>2</sub> movie graph important for us to understand?



Graph made from data obtained from [NOAA ESRL](http://noaa.esrl.noaa.gov/gmd/ccgg/trends/)

10. In the graph above, you can see the average CO<sub>2</sub> recorded at Mauna Loa for the months of May-September 2015. Why would it be inappropriate to examine such a short period of time if your goal was to understand a larger trend in CO<sub>2</sub> levels? What kind of biological event does this graph capture?

### NASA's Vital Signs of the Planet and Climate Time Machine

11. Go to NASA's Vital Signs page (<http://climate.nasa.gov/>) and record the carbon dioxide levels for the present day and the global temperature rise since 1880.

12. Go to NASA's Climate Time Machine <http://climate.nasa.gov/interactives/climate-time-machine> and open the "Global Temperature" viewer. On this visualization, what do white, dark blue and dark red areas signify? Describe the general trend in global surface temperature between 1884 and 2014.
13. In question 11, you noted the Earth's average global temperature rise since 1880. It may seem like a small amount – but even a small temperature change can be significant. Visit NASA's Vital Signs page at <http://climate.nasa.gov/effects/> and describe why this small change is significant.
14. What are some of the long-term effects of climate change described by the Vital Signs of the Planet website (<http://climate.nasa.gov/effects/>)?
15. In which part of the US do you live? What are the U.S. regional effects of climate change currently visible for your area (<http://climate.nasa.gov/effects/>)?

## A Changing Planet

16. Go to <http://storymaps.esri.com/stories/2015/atlas-for-a-changing-planet/> and explore the Esri story map called *Atlas for a Changing Planet*. Describe some of the other ways that humans are changing our planet that haven't been discussed previously. Note that you can zoom in, click, and move around the maps on the right hand side.

17. Explore the Modeling Temperature and Precipitation Scenarios in the story map. These models were created by scientists to make projections about what the Earth's climate would be like under different scenarios ranging from "business as usual" models where humans don't try to decrease greenhouse gas emissions to scenarios with aggressive greenhouse gas emissions reductions. The three models in the story map are listed below with the assumptions that the models are based upon:

- 2.6 Greenhouse gas emissions peak between 2010-2020 followed by a steep decline
- 6.0 Greenhouse gas emissions peak around 2080 and then decline
- 8.5 Greenhouse gas emissions continue to increase through the 21<sup>st</sup> century

Zoom into the map and try to find your approximate location and click on it for each of the scenarios. When you click, a box will pop up and indicate the predicted temperature change for that location by 2050. For each scenario write the temperature change for your location in degrees Celsius, convert to Fahrenheit, and include the annual change in precipitation found in the next series of models in the story map.

**Scenario 2.6:**

**Scenario 6.0:**

**Scenario 8.5:**

18. Based on the information you obtained from the models, under which scenario do you think your city will fare the best as we move into the future?

19. Given that climate change affects the entire world, what are some of the ways that countries are cooperating to work towards a better future? Explore the story map some more and note these below.