

## 3.1 Millions of Flasks of Air Reading



Small lake at 12,500' on Mauna Kea in Hawaii. 1958  
Credit: Scripps Institute of Oceanography

Shhhhtttthhhleep! That's the sound of air rushing into a round bowling ball sized flask being held up to the wind by a scientist in 1958. The air was an oncoming oceanic breeze whooshing by a tall mountain in Hawaii called Mauna Loa. Once the whooshing air was inside the flask, the scientists sent the air sample to an analyzer to figure out the carbon dioxide ( $\text{CO}_2$ ) concentration in the air. Measurements of  $\text{CO}_2$  concentration on Mauna Loa are now made every ten minutes (now this is done with an automatic gas analyzer, instead of someone holding up a flask millions of times). This record of data from Mauna Loa, which began in 1958,

is considered the longest continuous record of atmospheric carbon dioxide concentration in the world.

### What does this information tell us?

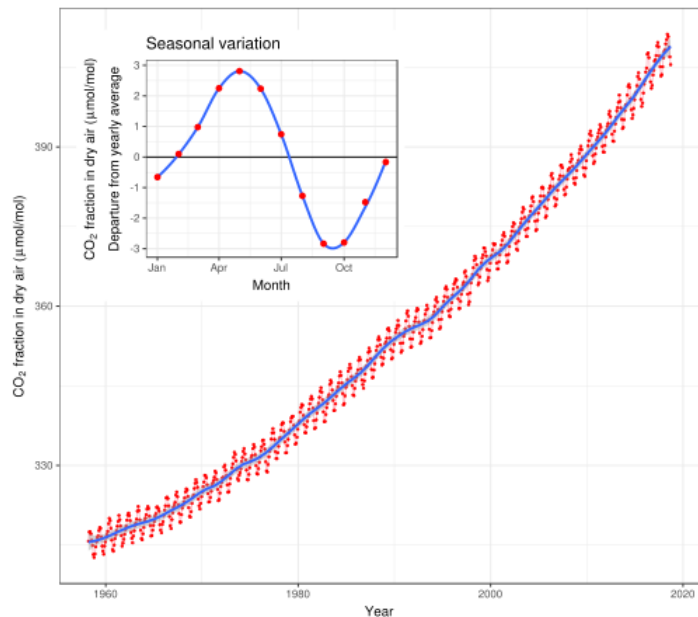
These millions of measurements of carbon dioxide are used to make a famous scientific graph: The Keeling Curve. This graph shows us two important things. The first is that in the northern hemisphere each year,  $\text{CO}_2$  levels fall in the spring and summer, and rise in the autumn and winter. On the graph this change is shown by the line that goes up and then down again each year. The second thing this graph shows us is that  $\text{CO}_2$  is gradually accumulating in the atmosphere. On the graph this change is shown by the line that goes upward over



Credit: Joe Strauch

many years. It is this steady rise in  $\text{CO}_2$  that is considered one of the most important scientific discoveries of the 20<sup>th</sup> century.

Monthly mean  $\text{CO}_2$  concentration  
Mauna Loa 1958 - 2018



Credit: NOAA

Data : Dr. Peter Tans, NOAA/ESRL ([www.esrl.noaa.gov/gmd/ccgg/hendri/](http://www.esrl.noaa.gov/gmd/ccgg/hendri/)) and Dr. Ralph Keeling, Scripps Institution of Oceanography ([scrippsco2.ucsd.edu](http://scrippsco2.ucsd.edu/)). Accessed 2018-10-21

### Who was Charles David Keeling and why do we credit this discovery to him?

These data began being recorded several decades ago when, as a young scientist, Keeling wondered if  $\text{CO}_2$  concentrations in the atmosphere were changing. Dr. Charles Keeling, as a young researcher, became the first person in the world to develop an accurate technique for measuring carbon dioxide in the air. Once he

perfected his instrument, he measured CO<sub>2</sub> all over the place, even on camping trips with his new wife! Keeling was a meticulous person who worked hard to be sure that his measurements were precise and accurate. He had a drive for perfection in everything he did—from playing the piano to gardening. Keeling required that the measurements be taken in exactly the same way for 40 years: measurements were taken by the same person using the same equipment to ensure that the data were high quality.



Credit: Scripps Institute of Oceanography

## Why did Keeling go to Hawaii to take measurements of CO<sub>2</sub>?

During the 1950s some scientists began to suspect that human activities like burning fossil fuels and deforestation might be increasing the amount of CO<sub>2</sub> in the atmosphere. But, no one knew the best way to measure *global* atmospheric CO<sub>2</sub>. This is because it's difficult to get global measurements. In a city, CO<sub>2</sub> released from cars or factories increases the concentration of CO<sub>2</sub> in the air. In natural areas, trees lower CO<sub>2</sub> levels by performing photosynthesis. Areas with lots of decaying things, like compost piles, release lots of CO<sub>2</sub>. Wind patterns move and mix around these high and low concentrations of CO<sub>2</sub>, making it difficult to see overall changes each year. What was his solution? Keeling realized that Mauna Loa was high enough to be removed from these local sources and sinks of CO<sub>2</sub>. The top of the mountain is bare with very few plants, and in the middle of the Pacific Ocean, Keeling could sample well-mixed air that had CO<sub>2</sub> from sources across the entire northern hemisphere.



Credit: Scripps Institute of Oceanography

## Why do we care that CO<sub>2</sub> concentrations in the atmosphere are increasing?

When Keeling began his measurements on Mauna Loa, he measured 315 ppmv (parts per million by volume). Imagine a giant jar with a million marbles in it; 315 of the marbles would be made of CO<sub>2</sub> molecules. Just two years after his first measurement, he was amazed to learn that the concentration of CO<sub>2</sub> was increasing by just a little bit each year. In 2013, for the first time, the concentration of CO<sub>2</sub> passed 400 ppmv when the annual cycle was at its peak in the spring—and the numbers continue to rise each year. It is incredible that today we still use the same methods for data collection as Keeling developed in 1958! Now scientists understand that this increase in CO<sub>2</sub> in the atmosphere will cause the entire planet to warm. This is because increasing the concentration of greenhouse gases (like CO<sub>2</sub>) in the atmosphere amplifies the greenhouse effect. The big question that many scientists are now asking is: how will increases in global temperature impact climate systems, ecosystems, and human systems on Earth?