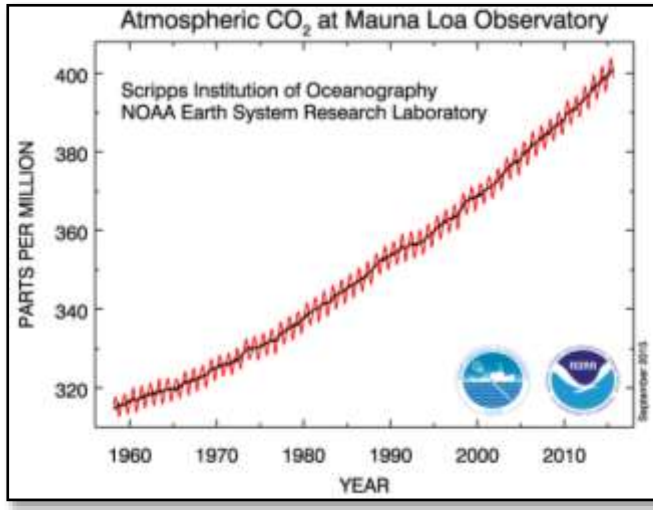
Student Sheet 1

CRITICAL THINKING ACTIVITY: ON THE TRAIL OF CO_2



In 1958, ***Dr.David Keeling*** began measurements of the concentration of carbon dioxide (CO_2) in the atmosphere at the ***Mauna Loa Observatory*** in Hawaii. The Mauna Loa record, now known as the ***Keeling Curve***, continued under Dr. Keeling until 1974 and is continued today by the Scripps Institution of Oceanography in California. It is the longest continuous record of direct measurements of CO_2 and shows a steadily increasing trend from year to year. It is also easy to see the ***saw-tooth effect*** caused by changes in the rate of plant growth through the seasons (lower CO_2 levels in summer, higher in winter.)

In May 1974, ***National Oceanic and Atmospheric Administration (NOAA),*** started a ***global monitoring network*** to add to the work that Keeling started. The Mauna Loa Observatory today is part of the ***Earth System Research Laboratory (ESRL),Global Monitoring Division (GMD***) in Boulder, CO.

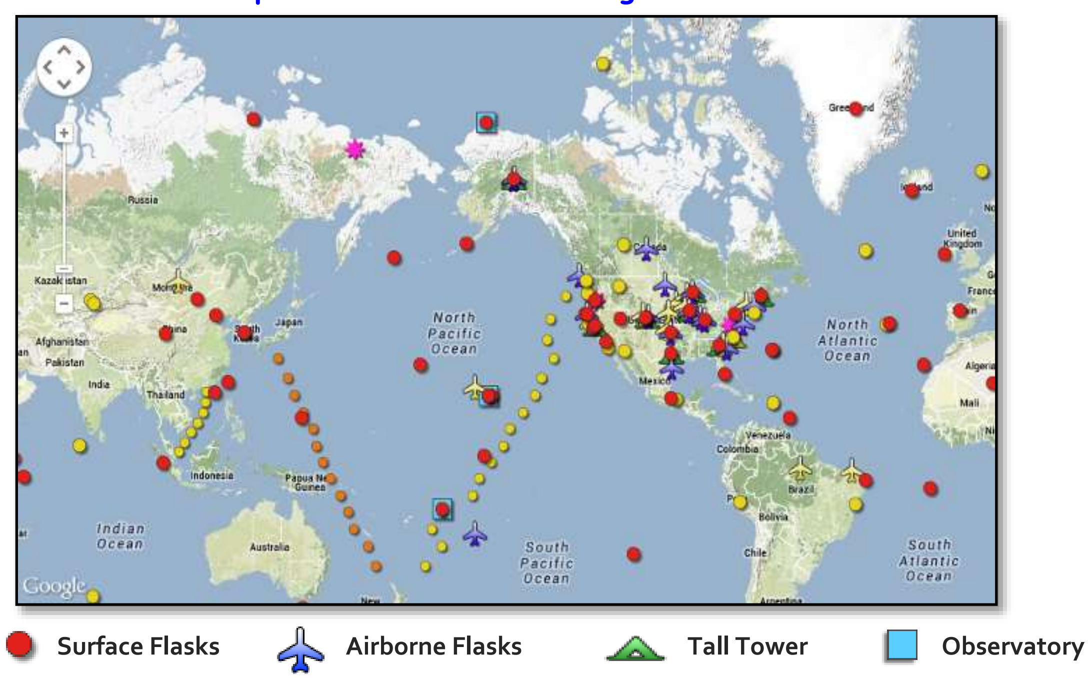
NOAA, Boulder,CO

Student Sheet 2

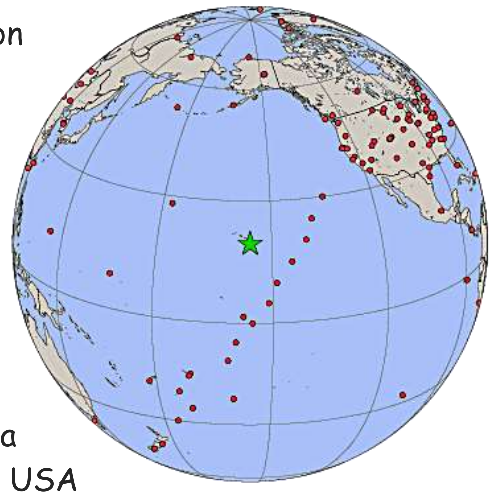
Monthly average CO_2 concentrations are determined from daily averages of the number of CO_2 molecules in every one million molecules of dry air (with water vapor removed). This monthly reading is the most current and thorough indicator of how well we are doing to tackle the root causes of global warming and climate change. There is no single indicator as complete and current as the updates for atmospheric CO_2 from Mauna Loa.

The NOAA program includes around the clock measurements at 6 baseline observatories, 8 tall towers, and air samples collected by volunteers at more than 50 sites and from small aircraft mostly in North America. The air samples are returned to Boulder for analysis and the data is shared with universities and other research groups. NOAA scientists are measuring the atmospheric distribution and trends of the three main long-term drivers of climate change, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), as well as carbon monoxide (CO), which is an important indicator of air pollution. They are compared with measurements made by many other international laboratories, and with regional studies around the world.

Map of the NOAA Monitoring Network

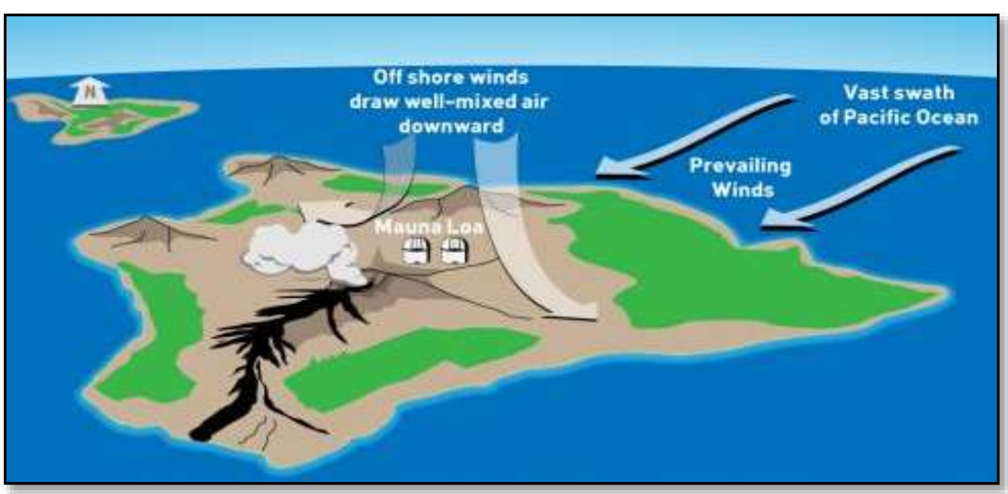


Student Sheet 3

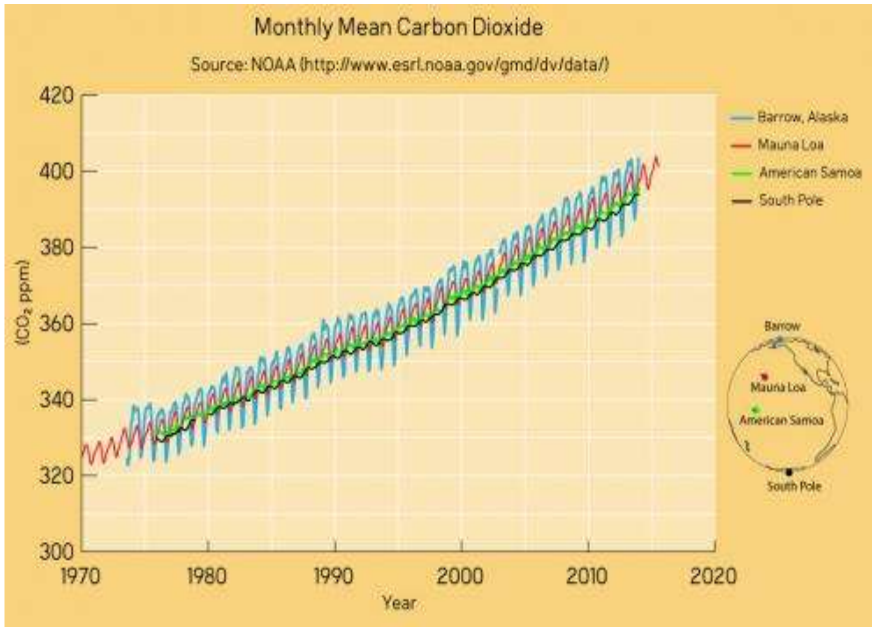


Why Mauna Loa? When buying a piece of land on which to build a house, the location is everything. Distance from a busy street or from the closest town is often the deciding factor. These are also important to consider in deciding where to place air-monitoring sites. The distance from major pollution sites–such as a town, coal plant, or even a busy highway–and the most common wind direction at the site actually determine the area selected. Early attempts to measure CO_2 in the USA and Scandinavia found that the readings differed a lot because of the influence of growing plants and the exhaust from automobiles and industry.

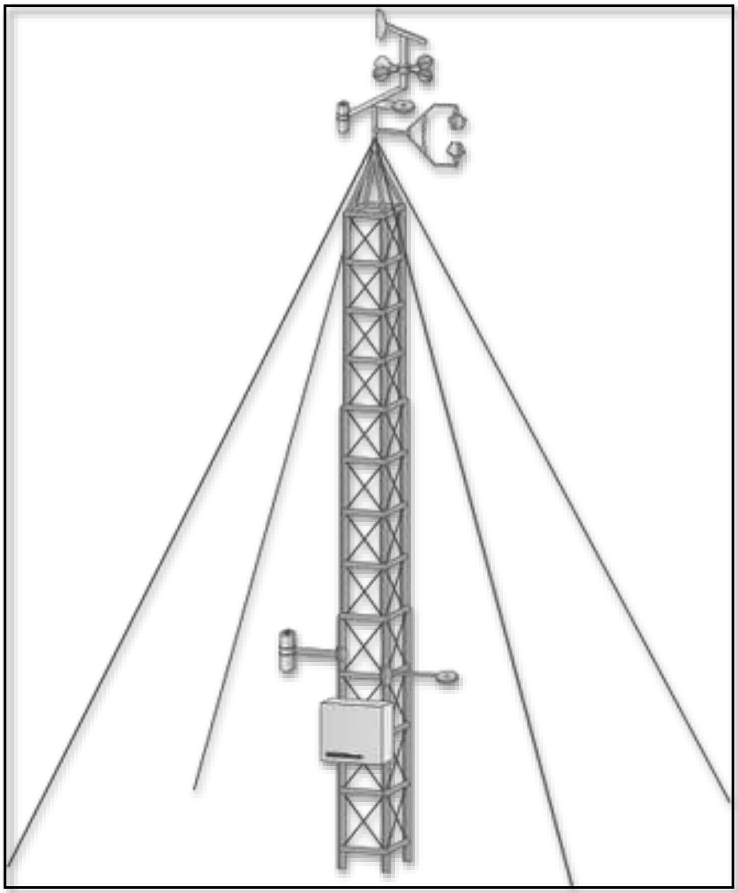
Mauna Loa is ideal because it is so far from large population centers. Also, on tropical islands at night, the winds blow from the land out to sea, which brings clean, well-mixed Pacific air from high in the atmosphere to the observatory, which removes any interference coming from the vegetation lower down on the island. Occasionally, the volcano does release CO_2 that can interfere with the readings, but generally, prevailing winds blow the volcanic gases away from the observatory. If the winds do blow from active volcanic vents toward the observatory, the influence from the volcano is easy to pick out on the normally steady records and any questionable readings can be easily spotted and edited out.



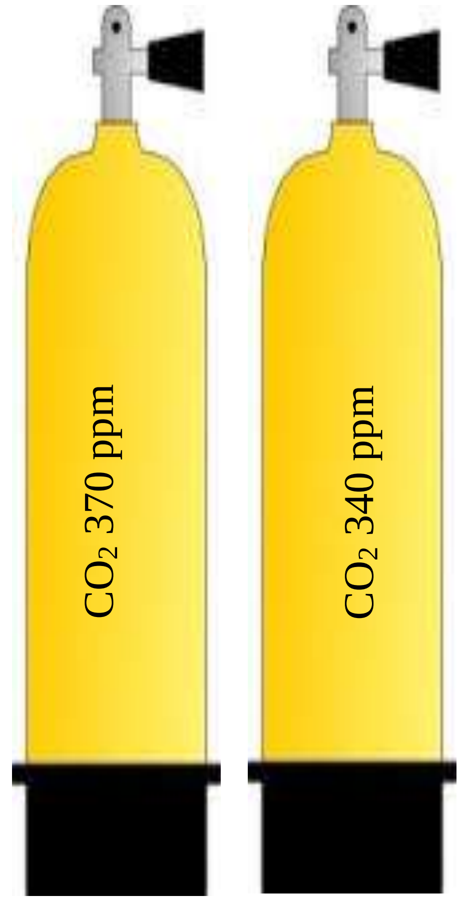
Student Sheet 4



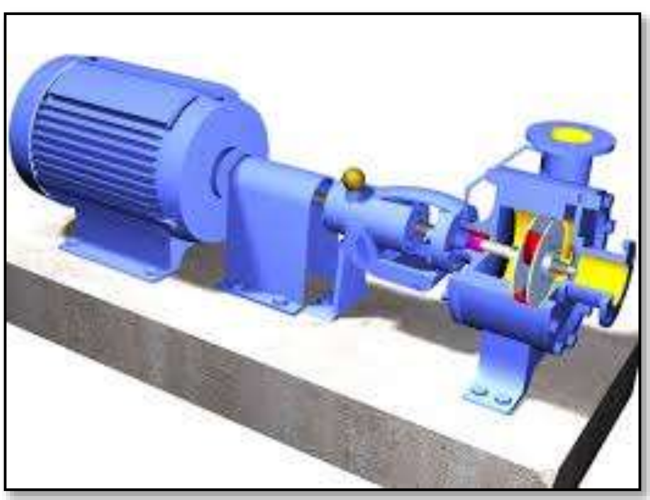
As the NOAA graph shows, other observatories show the same increasing trend. This trend is calculated from hundreds of CO_2 measuring stations and is consistent with independently measurements from satellites. The seasonal saw-tooth varies from place to place, of course, but the background trend continues steadily upwards. The Mauna Loa CO_2 record is considered one of the best records in climate science and the Keeling Curve is one of the best-defined results in climatology.



AIR COLLECTION TOWER



REGULATING TANKS



AIR PUMP

COMPUTER

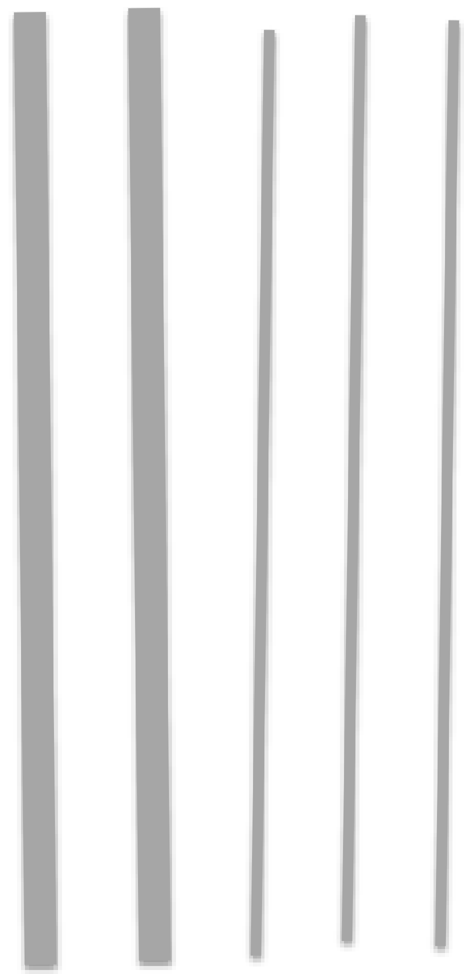
INTERNET

CO_2 ANALYZER

COLD TRAP

THERMOMETER

STAINLESS STEEL TUBING



ANALYSIS AND COMPREHENSION

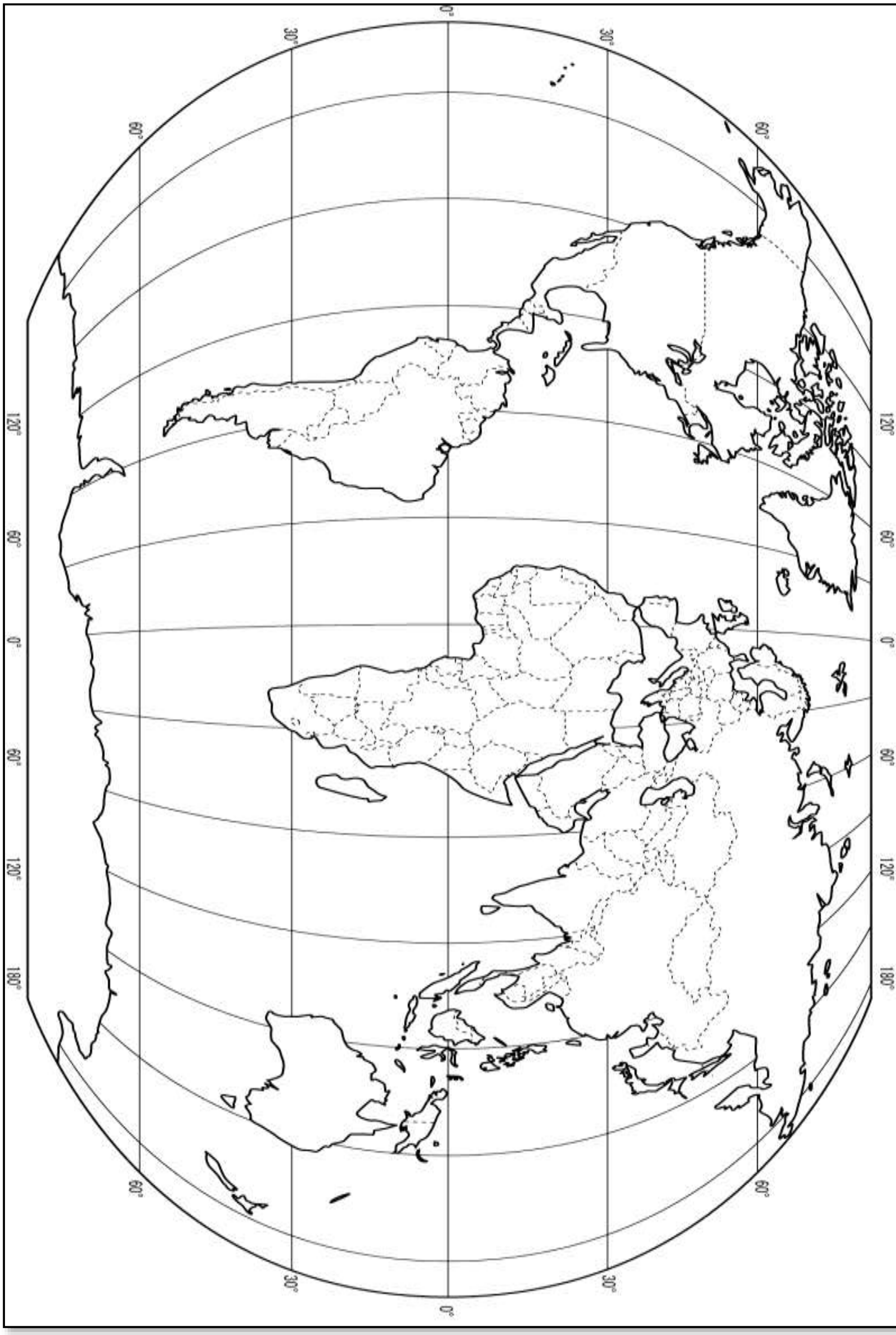
Part 1: The NOAA/ESRL Network

1. Who originally began monitoring the concentrations of CO_2 in the atmosphere and where?
2. Is this program continued today? Where?
3. What does the slope of the graph from Mauna Loa tell scientists?
4. Explain what the ***saw-tooth effect*** of the graph indicates.
5. When is the CO_2 concentration the highest- winter or summer- and why?
6. When did the NOAA monitoring network begin and where is it based?
7. How are monthly averages determined? Why are they important?
8. What types of monitoring activities are there in the NOAA/ESRL network?
9. Which of the sites are fully operational baseline observatories?
10. Which gases does NOAA monitor? Why?
11. Once air samples from planes and ground locations are taken where do they go?
12. Why do you think that tall towers have been added to the monitoring program?
13. What happens to the data from the monitoring network? Why?
14. Where were the first attempts at CO_2 monitoring located and why where they discontinued?
15. Why is it necessary for monitoring sites to be in remote locations?
16. Why is Mauna Loa considered an ideal location?
17. How does the fact that Mauna Loa is an active volcano affect the quality of the monitoring effort? Explain.
18. Does the data from the NOAA network and other observatories agree?
19. Why does the ***saw-tooth effect*** vary from location to location?
20. How valuable is the data from Mauna Loa and the Keeling Curve?

Part 2: Monitoring CO_2 at Mauna Loa, Hawaii

1. Why are air samples collected from towers 130 feet high?
2. What is the purpose of the pump?
3. What types of tubing is used? Why?
4. When the air enters the system what is its first stop? What happens there?

5. What is used to cool the air?
6. Why is water vapor removed from the air sample?
7. What is step 2 in the analysis process? What happens there?
8. Which part of the analyzer warms the air?
9. Why is infrared energy used to heat the gas sample?
10. Which instrument connected to the analyzer actually measures the CO_2? How does it know the amount of gas in the sample?
11. What is connected to the analyzer to make sure the gas values are correct?
12. What is the purpose of the valves?
13. Which is the last step in the process? What does it provide?
14. Where does the data from the computer eventually go?
15. How should computer readouts for CO_2 levels from 2015 compare with those from 1958?
16. Mauna Loa is an active volcano. How could this prove to be problem? What could be done to clear up or lessen the problem?
17. What type of training would people who work at places like Mauna Loa, Barrow and the other observatories need to do their jobs well?
18. Why is it necessary to use air samples with known concentrations of CO_2 in the chamber before the sampling process begins?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