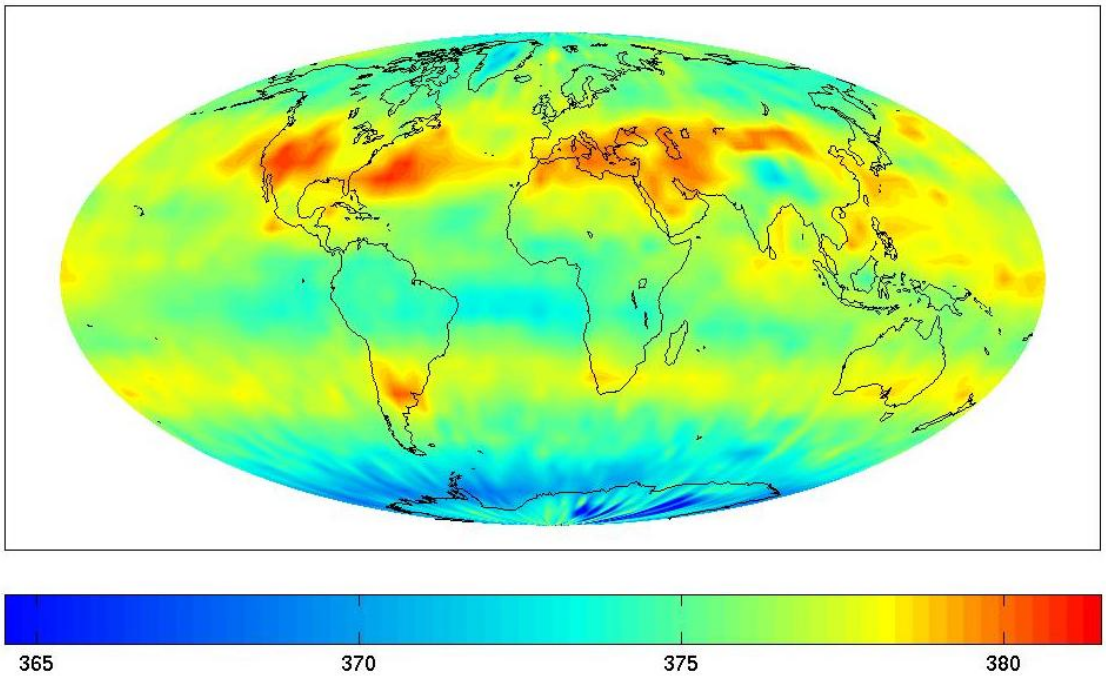
# NASA Satellite 'Sees' Carbon Dioxide




The Atmospheric Infrared Sounder (AIRS) instrument on NASA's Aqua spacecraft has been used by scientists to observe atmospheric carbon dioxide. The above map shows the concentrations of atmospheric carbon dioxide in units of 'parts per million', and range from 363 ppm (dark blue) to 380 ppm (red). The data was obtained in July 2003, and the gas is at an altitude of 8 kilometers. The map shows that carbon dioxide is not evenly mixed in the atmosphere, but there are regional differences that change in time. For example, the red 'clouds' move in time and change size and shape.

**Problem 1** - From the color bar, about what is the average concentration of carbon dioxide across the globe, in ppm, not including the orange or red areas?

**Problem 2** - What is the difference in ppm between your answer to Problem 1, and the highest levels of concentration?

**Problem 3** - At these altitudes, atmospheric winds generally blow from west to east (left to right on the map). What geographic regions are nearest the highest concentrations of carbon dioxide in this map?

**Problem 4** - The average mass of carbon dioxide in the atmosphere, at a concentration of 1 ppm equals 15 tons per square kilometer. From an estimate of the areas contained in the red regions, and your answer to Problem 2, how much excess carbon dioxide is contained in these clouds in units of gigatons (1 billion tons)? (Note, the area of the United States is about 9 million square kilometers)

# Answer Key

**Problem 1** - From the color bar, about what is the average concentration of carbon dioxide across the globe, in ppm, not including the orange or red areas?
Answer: Most of the areas are yellowish, but the rest is light blue, so according to the color bar, the concentrations is about 375 ppm…very roughly.

**Problem 2** - What is the difference in ppm between your answer to Problem 1, and the highest levels of concentration? Answer: The darkest reds are near 382 ppm, so the difference is about 7 ppm.

**Problem 3** - At these altitudes, atmospheric winds generally blow from west to east (left to right on the map). What geographic regions are nearest the highest concentrations of carbon dioxide in this map? Answer: Western United States, the East Coast of the US, and regions in the Mediterranian and mid-East, some of which are 'downwind' from Europe.

**Problem 4** - The average mass of carbon dioxide in the atmosphere, at a concentration of 1 ppm equals 15 tons per square kilometer. From an estimate of the areas contained in the red regions, and your answer to Problem 2, how much excess carbon dioxide is contained in these clouds in units of gigatons (1 billion tons)?

Answer: Students can use maps of these regions in which areas are preserved, called Equal-Area maps. The map in this problem is of this type. The area of the US is 9 million square km, so we estimate that the two US red zones are about 10 million square km, and the European-Asian areas are about the same area as the US. The region in South America is about 2 million square km. The total area is 22 million square km.

At 1 ppm, the total mass is 1 ppm x 22 million x 15 tons per square kilometer = 330 million tons. But since the additional carbon dioxide equals a concentration of 7 ppm, the total mass is 7 x 330 million tons or 2.3 gigatons.

**Teacher Note:** Most studies suggest that human activity add about 25 gigatons per year. Since the NASA map represents an average over a month, we see that our very crude estimate of 2.3 gigatons/month x 12 months = 28 gigatons/year which is close to more detailed estimates. This similarity may, however, be accidental since certain approximations had to be used in deriving our estimate that would not be made in the more careful studies. Also, the satellite only observed the carbon dioxide at an altitude of 8 kilometers, not all of the additional carbon dioxide down to sea-level.