NOAA Earth System Research Laboratory
Global Monitoring Division
Issue 6: Spring 2011

The Cooperative Global Air Sampling Network Newsletter

Greetings to our cooperating partners and network affiliates!

The attached figure shows carbon dioxide (CO_2) and $\delta^{13}C$ (the ratio of ^{13}C to ^{12}C) as a time series for your site. The red line shows the smoothed curve fit to the data and the blue line shows the overall trend with the seasonal cycle removed. For the sites started more recently or sites that do not have a lot of data, these curves might not be shown. For more information on this figure please read the following articles.

Radiocarbon and Stable Isotopes of Carbon Dioxide

There are three isotopes of carbon atoms - all three participate in the same chemical reactions - the only difference between them is that they have slightly different masses. The heaviest is carbon-14 (written as ^{14}C), followed by carbon-13 (^{13}C), and the lightest, most common isotope is carbon-12 (^{12}C, almost 99% of all carbon atoms). The most active carbon reservoirs on earth, the terrestrial biosphere (land plants, animals and soils), the oceans, and fossil fuels (coal, oil, natural gas) slightly favor different isotopes so the relative proportion of the three isotopes is different in each. By examining the isotopic mixture in the atmosphere, and knowing the isotopic fingerprint of each reservoir, atmospheric scientists can determine how much carbon dioxide (CO_2) is coming and going from each reservoir.

^{14}C, also known as radiocarbon because it is radioactive, decays over time to become ^{12}C, leaving no ^{14}C in ancient organic matter (fossil fuels). When fossil fuels are burned the CO_2 emitted to the atmosphere contains no ^{14}C. By measuring the amount of ^{14}C in the air samples you collect, we can calculate what proportion of the CO_2 in the sample comes from fossil fuels. The ^{14}C isotopic composition of air is expressed as the ratio $\Delta^{14}C$. The smaller the $\Delta^{14}C$ value in a measured sample, the fewer ^{14}C atoms are in it, and the more of its CO_2 is from fossil fuel emissions. Figure 1 shows that the amount of $\Delta^{14}C$ in the earth's atmosphere is decreasing due to the combustion of fossil fuels.

Unlike ^{14}C, ^{13}C and ^{12}C are stable isotopes, so their abundance does not change over time due to radioactive decay. But the ratio of ^{13}C to ^{12}C ($\delta^{13}C$) in the atmosphere does change because land based plants have a slight preference for $^{12}CO_2$ over $^{13}CO_2$ during photosynthesis. During summer, as plants consume CO_2, the atmosphere contains relatively more ^{13}C. In winter, plant respiration dominates and atmospheric CO_2 increases while $\delta^{13}C$ decreases. In addition, fossil fuels (originally plants) contain relatively more ^{12}C, so as fossil fuels are burned atmospheric CO_2 increases while $\delta^{13}C$ decreases. These effects are shown in Figure 2. Measuring these isotopic tracers adds greatly to our understanding of the global carbon cycle. For more information on this topic please visit:
http://www.esrl.noaa.gov/gmd/outreach/isotopes/.

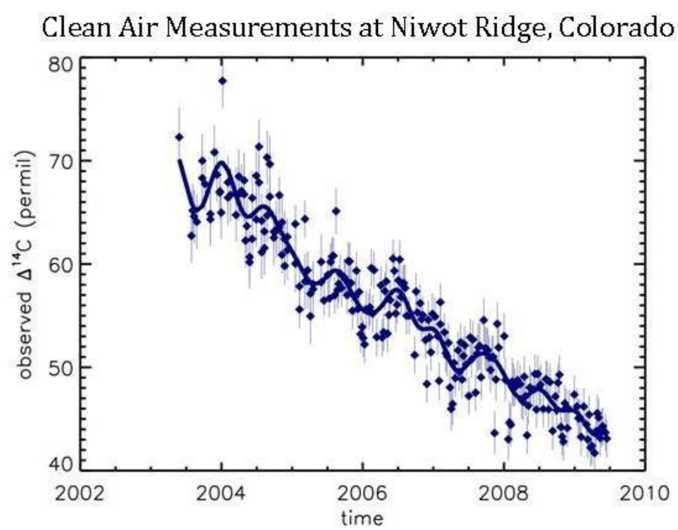

Figure 1: The trend in $\Delta^{14}C$ at Niwot Ridge, Colorado. The decreasing trend comes from the ^{14}C depleted CO_2 emitted from burning fossil fuels.

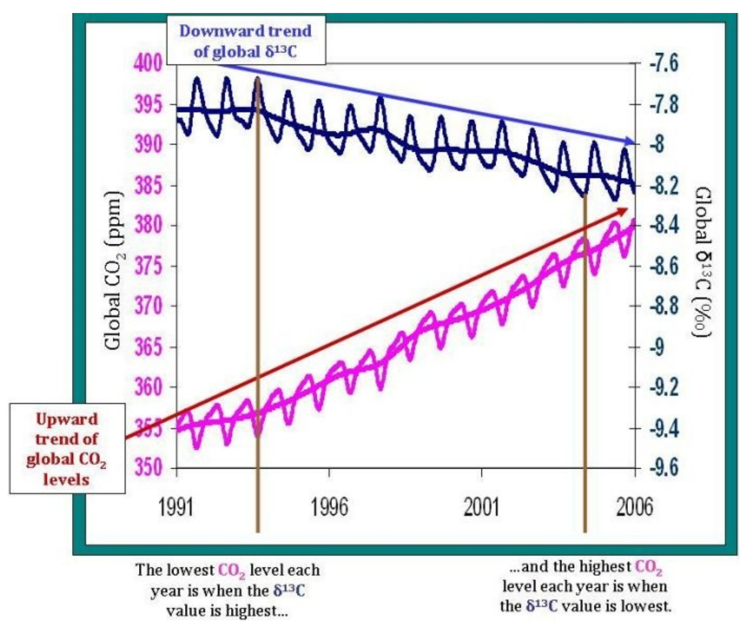

Figure 2: A comparison of global total atmospheric carbon dioxide trends and global $\delta^{13}C$ trends both annually and seasonally.

Sampling Tips

- **Please send back broken flasks -** most can be repaired and parts can be reused.
- **Please use the flasks in the order you receive them (oldest ones first) -** this will help keep our records up to date and your site supply accurate.

Trends

Included with this newsletter is a plot showing carbon dioxide (CO_2) and $\delta^{13}C$ (the ratio of ^{13}C to ^{12}C) for your site. It is clear from this figure that CO_2 is rising over time. Since the industrial revolution in the 1800s, CO_2 levels have gone up from 280 ppm to almost 390 ppm today and are higher than at any time in the past 800,000 years. Figure 3 shows global carbon emissions and the contributions of some of the largest emitting countries.

Currently, atmospheric CO_2 levels continue to rise at an accelerating rate as humans burn fossil fuels. Table 1 shows current trends of CO_2 and its isotopes. In human terms, the CO_2 emitted by the combustion of fossil fuels remains "forever" due to the stability and longevity of CO_2 within the atmosphere and oceans. This will have significant implications for our planet, as the resulting radiation imbalance from the Enhanced Greenhouse Effect will noticeably alter the global climate for centuries to millennia. For more information on the trends and current CCGG data, please visit:
http://www.esrl.noaa.gov/gmd/ccgg/trends/

Measurement	Trend	Why?
Global CO_2 Levels	↑	CO_2 is currently being released from burning fossil fuels faster than it is taken up either on land or in the ocean.
Global $\Delta^{14}C$	↓	The percent of atmospheric CO_2 that comes from fossil fuel emissions is increasing.
Local $\Delta^{14}C$	↓ Highly Variable	Highly polluted areas have lower $\Delta^{14}C$ values from fossil fuel burning. This value varies greatly depending on the quantity of fossil fuels emitted on a short time scale.
Global $\delta^{13}C$	↓	Fossil fuels add CO_2 to the atmosphere that has less ^{13}C. This addition of CO_2 is more than the amount of CO_2 removed by the terrestrial biosphere and the oceans.

Table 1 (above): Trends of different measurements from NOAA CCGG sampling program.

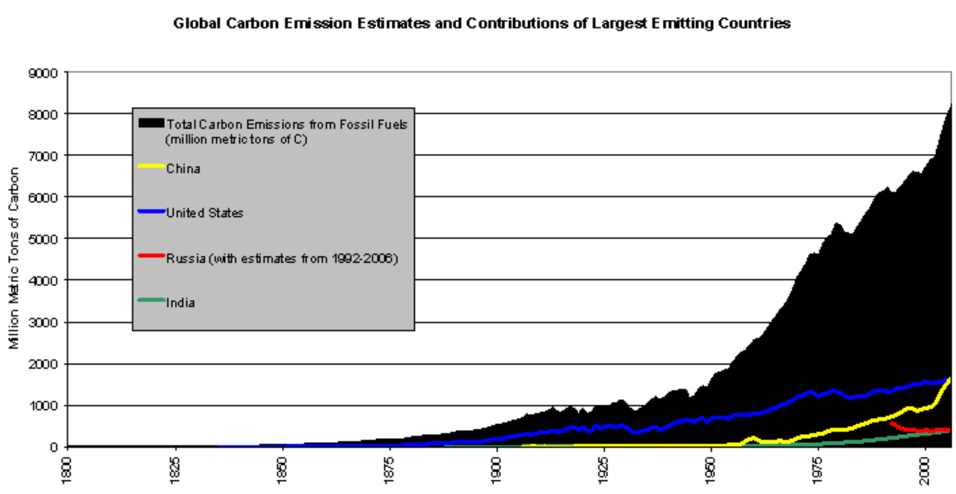

Figure 3 (left): Carbon emissions. Source: Boden, T.A., et. al. . 2009. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Dept of Energy, Oak Ridge, Tenn., U.S.A.

Contact/Shipping Address:
Phone: 303-497-4728
Fax: 303-497-6290
Email: ccggflask@noaa.gov

Attn. Molly Heller
NOAA/GMD-1
325 Broadway
Boulder, CO 80305 USA

Interested in learning more about GMD's projects? Check out these Web links:

GMD home page: www.esrl.noaa.gov/gmd

CCGG home page: www.esrl.noaa.gov/gmd/ccgg

Cooperative Air Sampling Network: www.esrl.noaa.gov/gmd/ccgg/flask.html

Interactive Data Visualization: www.esrl.noaa.gov/gmd/ccgg/iadv