Spatial and Temporal Variability of Carbon Dioxide: A Local-to-Global Perspective.

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Nasa Learn Program

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Data Sources

Airs (Aqua)

Atmospheric infrared Sounder; on NASA Aqua satellite. While not optimized for CO2, measurement, delivers mid-

Troposphere (5-9 km) readings with a scan swath of about 800 km. Covers entire planet each day.

TCcon

Total Column Carbon Observation Network; a series of 18 ground-

Based Fourier Transmitter spectrometers operated in a variety of locations. Can record several readings per minute. Used to measure the accuracy of measurements taken by SCIAMACHY.

NOAA

CO2 measurement program; conducted near the summit of Mauna Loa (3400 m)

asl, provides the longest continuous data on atmospheric carbon dioxide in the world. It was begun by C. D. Keeling at the Scripps Inst. of Oceanography in 1958.

Hardware

Figure 7: Airs instrument structure and function. Note that Airs is one component of the Aqua satellite, containing several different instruments.

Figure 8: Geographic distribution of CO2 measurements.

Student Interaction

While not directly involved in data analysis and research, sixth grade mathematics enrichment students from John Yeates Middle School had the opportunity to study Airs, TCCON, and NOAa data in tabular and graphical forms. Groups of students were given data sample and asked to generate questions and conclusions based on the data, as well as comments regarding the data’s format, ease of use, and realistic math concepts. This process was repeated four times during the session.

Many students had initial difficulty reading data, attributed mainly to map keys and/or to length of datasets. This underlies the need for teachers to periodically revisit graph interpretation and analysis, regardless of its presence or absence in data mathematics standards.

Results

1. Does CO2 vary temporally? Yes.

While data such as plant height, Leaves per stalk, and/or leaf/stalk current are but a few reasons why CO2 varies temporally, while Figure 1 displays a “snapshot” of CO2 concentration in one month, Figures 2, 3, and 4 show thecontinued/its variability.

2. Does CO2 vary spatially? Yes.

Carbon dioxide varies according to zone, altitude, and location, according to the site’s characteristics. Figure 3, generated by northern and southern hemisphere means (AIRs), reflects the demographic differences between these hemispheres; there are more people in the North, hence more industrial activity, fossil fuel consumption, and a balance of unusual CO2 with the indigene flora.

CO2 values, the differences exhibited by the AIRs instrument and the TCCON system (Figure 6) show spatial variability. By design, AIRs takes measurements in the mid-troposphere (5-9 km asl), while TCCON readings are drawn from samples in the lower troposphere (0-5 km asl). It must be noted as well that these layers markedly differ in their stability, with low-troposphere being the weaker and more graphically weather permeable. Similarly, the data gathered at NOAA’s Mauna Loa Observatory, while taken at a high altitude (3,400 m), displays the same seasonal variability that the AIRs instrument collects, though their methods and volume of data differ (Figure 2, 8).

3. Does the data support temporal and spatial variability? Yes.

The data are well-correlated, evidenced by Figures 5 and 6. The descriptions of each measuring system display distinct differences, and the data are slightly different as well. However, the correlation graphs also display positive linearities of 0.5 and 0.3, respectively, denoting a strong correlation between the two datasets collected (values > 0 show negative correlation; values > 0 show positive correlation). In short, the data collected, by their different processes and locations, are showing the same upward trend indicative of the steady increase in CO2 that has been observed since the onset of the Industrial Revolution.

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Next steps

Knowing that different CO2 measurement system/data correlate well to each other, and that CO2 varies spatially and temporally, the next question that begs asking relates to public perception, action planning, and environmental stewardship: what is the best way to communicate CO2 data to the public? Is there a formula that can account for low- and mid-troposphere CO2 data and their temporal and spatial differences to produce a sensible value to enhance public knowledge and effect change in human practices?

Carbon dioxide, a naturally occurring trace gas comprising about 0.039% of Earth’s atmosphere, has gathered considerable attention in recent decades for its ability to store thermal (IR) energy contributing to the phenomenon called the Greenhouse Effect. This compound, combined with the effects of water vapor, methane, CFCs, and ozone, among others, is the cause of Earth’s radiation budget to produce higher global temperatures, local weather extremes, and changes to planetary ecology.

With historical evidence supporting atmospheric CO2 concentrations of no more than 300 parts per million volume (ppmv) in the last 800,000 years, an increase of 100 ppmv since the onset of the Industrial Revolution is statistically significant. Despite its importance in photosynthesis, its molecular stability, combined with the use of fossil fuels, changes in land use, and population growth contribute to increased atmospheric concentrations and ocean acidification.

From an academic perspective, understanding the temporal and spatial variability of carbon dioxide will provide valuable insight into how the carbon cycle works on micro and macro scales. By examining data collected from ground stations and satellite systems, correlations can be made that validate their readings and show how carbon dioxide moves through the atmosphere over time, as well as showing differences in concentrations in different parts of the atmosphere.