JOURNAL OF CHEMICAL EDUCATION

Communication

pubs.acs.org/jchemeduc

Updating a Student-Generated Ice-Core Data Plot Exercise for Courses Investigating Climate Change Topics

Edward Maslowsky, Jr.*

Division of Molecular, Health, and Life Sciences, Loras College, Dubuque, Iowa 52001, United States

Supporting Information

ABSTRACT: Students prepare *Excel* graphs using the most recent available ice-core data for estimated temperatures and atmospheric carbon dioxide, methane, and nitrous oxide concentrations from the Antarctic for the past 800 000 years. These graphs are used to discuss the meaning and relationships of past data trends and their relevance to the topic of climate change.

KEYWORDS: *First-Year Undergraduate/General, Environmental Chemistry, Inquiry-Based/Discovery Learning, Atmospheric Chemistry, Laboratory Computing/Interfacing, Nonmajor Courses*

KEEPING CURRENT AND ADDING ICE-CORE DATA SOURCES

Several of the eight exercises from a course module previously described in this *Journal*[1] are used in our course on climate change for nonscience majors. In one of these exercises, students generate and compare *Excel* plots of glacial−interglacial atmospheric carbon dioxide and methane concentrations and estimated temperatures changes from ice-core data for approximately the past 200 000 years. Similar data plots are found in *Chemistry in Context*[2] from data for the past 400 000 years and the ACS Climate Science Toolkit[3] from data for the past 650 000 years. However, results from the European Project for Ice Coring in the Antarctic (EPICA) at its Dome C location in the East Antarctic now allow access to ice-core data that span approximately the last 800 000 years.[4] The additional data allow for the confirmation of previous trends noted from the less complete data sets, and the establishment of new ones that were not found for the shorter time spans.

The rapid appearance of new information makes it necessary to constantly update and revise the material in a course on climate change to keep it complete and relevant. The ice-core data for this entire 800 000 year period provide students with an important frame of reference for conditions on Earth before human influences on the environment became significant. The extended data also allow students to more clearly see other trends, including 100 000 year cycles; longer glacial than interglacial periods with both occurring over relatively long time spans; atmospheric carbon dioxide, methane, and nitrous oxide concentrations that were lower than they are today; and noticeable increases in the amplitudes of the variations (especially for the temperature data) about 450 000 years ago.

INCORPORATING THIS EXERCISE IN A COURSE

Using an inquiry-based teaching approach in which students access and plot the data themselves rather than referencing it in a text has the advantages of more actively engaging them in the material, helping them raise their comfort level in obtaining primary source material from the Internet, and in using the computer as a tool in manipulating and interpreting large amounts of scientific information that cannot be collected in a traditional laboratory setting. These plots allow students to observe both direct correlations and differences in trends in the estimated temperatures and atmospheric concentration of the three gases, and provide background information for discussing the nature and causes of these relationships

The National Oceanographic and Atmospheric Administration (NOAA) has compiled ice-core information from locations around the world.[5] This Communication describes an exercise in which students download and graph the most recent and complete ice-core data from this NOAA site from the Antarctic for the past 800 000 years on to *Excel* spreadsheets. It both updates and extends data used in the previously published exercise.[1] These plots are of glacial−interglacial estimated temperature changes and surface concentrations of not only carbon dioxide and methane, but also nitrous oxide, over a 800 000 year time span. The relationships of the atmospheric concentrations of the three gases to and their influence on the temperatures in the Antarctic are then analyzed. Although the nitrous oxide data are the least complete, the surface atmospheric concentration of this important greenhouse gas is increasing due to human activity, and the data show a glacial−interglacial concentration trend similar to that of carbon dioxide and methane.

This exercise is performed in a 2 h laboratory period by students working either individually or in groups of two, or as an out of class assignment. The student generated graphs produced from the 800 000 year data sets are shown in Figure 1. The results are discussed by the entire class in conjunction with assigned background reading material. The detailed exercise procedure is found in the Supporting Information.

Received: November 23, 2015
Revised: February 19, 2016

DOI: 10.1021/acs.jchemed.5b00947
J. Chem. Educ. XXXX, XXX, XXX−XXX

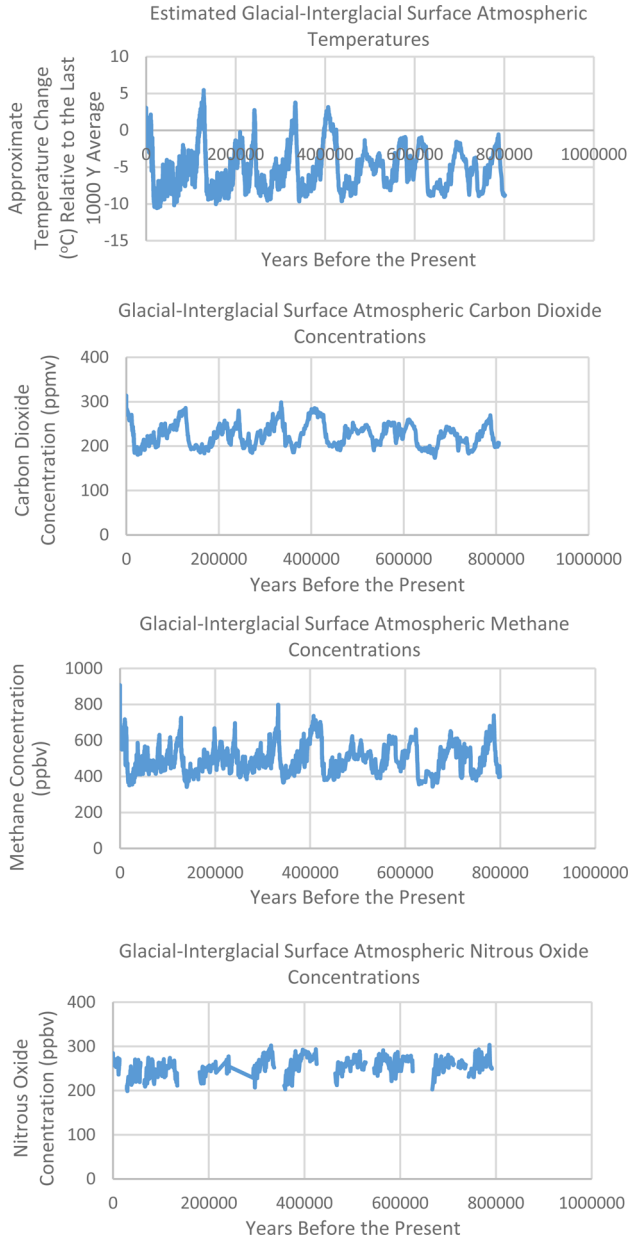

Figure 1. Graphs obtained by plotting Internet data for estimated Antarctic atmospheric temperature changes (°C) and atmospheric carbon dioxide, methane, and nitrous oxide concentrations for the past 800 000 years.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00947.

Additional information for instructors and a detailed description of the procedure used by students (PDF, DOCX)

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: Edward.Maslowsky@loras.edu.

Notes

The authors declare no competing financial interest.

■ REFERENCES

(1) Brzenk, R.; Moore, A.; Alfano, M. J.; Buckley, P. T.; Newman, M. E.; Dunnivant, F. M. Understanding the Greenhouse Effect: Is Global Warming Real? An Integrated Lab-Lecture Case Study for Non-science Majors. *J. Chem. Educ.* **2000**, *77*, 1602−1603.

(2) Middlecamp, C. H.; Mury, M. T.; Anderson, K. L.; Bentley, A. K.; Cann, M. C.; Ellis. J. P.; Purvis-Roberts, K. L. *Chemistry in Context: Applying Chemistry to Society*, 8th ed.; McGraw-Hill Education: New York, 2015; pp 111−116.

(3) ACS Climate Science Toolkit. www.acs.org/climatescience (accessed Jan 2016).

(4) Brook, E. Palaeoclimate: Windows on the Greenhouse. *Nature* **2008**, *453*, 291−292.

(5) List of ice-core data by location compiled by NOAA found by opening the http://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/ice-core site and then selecting List of Ice Core Datasets by Location Name under the heading Browse Datasets (accessed Jan 2016).

DOI: 10.1021/acs.jchemed.5b00947
J. Chem. Educ. XXXX, XXX, XXX−XXX