

## **SIO 115 Homework 2 (due Friday 24 January 2020): *Ice ages and ice cores***

*Please submit your homework according to the guidelines on the course website. You will be graded on your writing style as well as the content of your answer.*

In Q1 of this homework you will analyze ice core data from North GRIP in Greenland and Dome C in Antarctica. The data is freely available on the NOAA-paleo website, but for convenience, they are interpolated to the same timescale,

Download the files `icecore_isotope_data.txt` and `NHinsol.txt` from the class website.

The columns of the data set are as follows:

- C1. Time, in year before 1950, commonly referred to as year BP (before present)
- C2.  $d^{18}O$ , from NorthGRIP in per mil<sup>1</sup>
- C3.  $dD$  from Dome C, in per mil<sup>2</sup>

On your plots, don't forget to label the axes, the curves if there are more than one, and to include units.

You can use Excel to do everything that is asked, but if you know of a more powerful graphing or computing software (MATLAB, R, python, igor...), it might be easier. In Excel, you can open the text file, and go to 'Data<text to column' and follow the process to have each column of data in the right place. If you decide to use MATLAB, you can find a script to get started on the course webpage (`core_template.m`).

### **1. The temperature record.**

- a. Oxygen isotopes are used as a proxy for temperature in ice cores. Explain in a few sentences how this proxy works. (3)
- b. In Greenland ice cores, temperature in °C can be reconstructed from  $d^{18}O$  following the equation  $T=3.05 d^{18}O+75.4$  (Cuffey et al., 1997). At Dome C, the corresponding equation is  $T=(\delta D-5.5)/6.2$  (Jouzel et al., 2007). Calculate temperature for each site from the available data, and plot both curves against time on the same graph, taking care to label each curve. You may use two different y-axes if you want. (3)
- c. Write on the graph an arrow representing time with a point towards the present (past → present). Identify (on the graph) a) the last glacial maximum; b) the deglaciation; c) the Holocene; d) an example of abrupt climate change. (4)

### **2. Milankovitch cycles**

- a. The file `NHinsol.txt` is from the World Data center<sup>3</sup>. Graph each of these along the same x-axis used in previous parts of the HW. The first column is years before present. The other columns contain the amount of solar energy

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<sup>1</sup> Original data source: <https://doi.org/10.1594/PANGAEA.586886>

<sup>2</sup> Original data source: <https://doi.org/10.1594/PANGAEA.683655>

<sup>3</sup> Available at: [https://www1.ncdc.noaa.gov/pub/data/paleo/climate\\_forcing/orbital\\_variations/insolation/](https://www1.ncdc.noaa.gov/pub/data/paleo/climate_forcing/orbital_variations/insolation/)

received (in  $W m^{-2}$ ) at a given latitude for a given month per forcing due to the Milankovitch cycle. [2]

- i. Which latitude and time of year correlates best with Antarctic temperatures? [1]
  - ii. Greenland temperatures? [1]
  - iii. Why is the insolation at this latitude and time of year so important for global ice volume? [2]
- b. “King Tide” or the day of the year when the tidal range is greatest, usually occurs just a little after northern hemisphere winter solstice (this year it was on New Year’s Day for California) what parts of the Milankovitch cycle control the timing and magnitude of “King Tide?” [1]
- c. Suppose you were an archeologist, and someone wanted you to look at a 10,000 year old cave painting portraying people following the North Star: based on your knowledge of the Milankovitch cycles, why might you be suspicious? [1]
- d. The following picture (source: Wikimedia Commons) is from a highway in Northeast Mexico. The numbers on the signs by the side of road refer to the year when the location of that sign marked the location of the Tropic of Cancer.



- i. Which part of the Milankovitch Cycle is documented here? [1]
- ii. Given that the strength of the seasons is decreasing in part due to this part of the Milankovitch cycle: was this picture taken facing north or south? [1]

**References:**

- Kurt M Cuffey and Gary D Clow. Temperature, accumulation, and ice sheet elevation in central Greenland through the last deglacial transition. *Journal of Geophysical Research: Oceans*, 102(C12):26383–26396, 1997.
- Jean Jouzel, Valerie Masson-Delmotte, Olivier Cattani, Gabrielle Dreyfus, Sonia Falourd, Georg Hoffmann, Benedicte Minster, J Nouet, Jean-Marc Barnola, Jerome Chappellaz, et al. Orbital and millennial Antarctic climate variability over the past 800,000 years. *Science*, 317(5839):793–796, 2007