**Lab and Homework 1: Reconstructing climate and ice sheets**

***Provide all answers in a text document or PDF (using e.g. Word, LateX, Jupyter NB), along with your code and/or Excel sheet(s), and send everything to me via a personal message on Slack (preferably) or email before February 10, 1.30 pm. Any files you submit should be named FirstName\_LastName\_HW1 (e.g. Jan\_Lenaerts\_HW1).***

1. **Marine records**

Download the stacked benthic record from Zachos et al. (2001) – paper available in Dropbox folder - via [*ftp://ftp.ncdc.noaa.gov/pub/data/paleo/contributions\_by\_author/zachos2001/zachos2001.txt*](ftp://ftp.ncdc.noaa.gov/pub/data/paleo/contributions_by_author/zachos2001/zachos2001.txt)*,* and answer the following questions. For this analysis, you can use your favorite programming language (e.g. Python, Matlab, NCL, R, Excel,…).

1. Plot the record as a time series (with time (first column in data file, in units ‘Ma’ (=million years)) on the horizontal axis, and the benthic δ18O (sixth column in data file) on the vertical axis), such that time runs backward to the right (which is usual in the paleoclimate community). Show a figure of the time series below.
2. Describe the general evolution of δ18O with time over the last ~67.5 million years (focusing on the general trend). What does that tell us about the change of ice volume over time? How do you know?
3. Around 34 million years ago, there was a sudden shift in δ18O, caused by the so-called Eocene-Oligocene extinction event. What do you think explains this sudden shift?
4. Focus your time series to the last 5 million years, and show a figure of your time series below. You should see a combination of a gradual, long-term trend superposed on a series of strong alternations between high and low δ18O levels on 105-106 year time scales. What do you think explains (1) this gradual trend, and (2) the strong, higher-frequency cycles?
5. **Ice core records**

Download the data of the GISP2 (interior Greenland) ice core (Grootes et al., 1993 – paper available in Dropbox folder) via [*ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/greenland/summit/gisp2/isotopes/gispd18o.txt*](ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/greenland/summit/gisp2/isotopes/gispd18o.txt), and answer the following questions. For this analysis, you can use your favorite programming language (e.g. Python, Matlab, NCL, R, Excel,…).

1. Plot the evolution of δ18O for the entire time series (you can ignore the 999999 numbers at the bottom). Show a figure of the time series below. Note: time (units of ‘yr BP’ where BP = before present and present is the year 1950, by convention) is in the third column, and δ18O is in the second column of the data file.

Download the data of the Dome Fuji (interior East Antarctica) ice core (Grootes et al., 1993 – paper available in Dropbox folder) via [*https://www1.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/domefuji/df2012isotope-temperature.txt*](https://www1.ncdc.noaa.gov/pub/data/paleo/icecore/antarctica/domefuji/df2012isotope-temperature.txt)*,* and answer the following questions. For this analysis, you can use your favorite programming language (e.g. Python, Matlab, NCL, R, Excel,…).

1. Plot the evolution of δ18O for the first core (“Dome Fuji 1st core water isotopes (18O and 2H) data”). Show a figure of the time series below. Note: time (in units ‘kilo years before 2000’, where kilo years = 1000 years) is in the fifth column, and δ18O is in the sixth column of the data file.
2. Show in the figure from Question 2b. when the ice core suggests that ice ages occurred, and when interglacial periods occurred. In one or two sentences, briefly justify your answer. Briefly discuss the differences in typical length of an ice age and interglacial. Do we currently experience a glacial or interglacial period?
3. Plot the GISP2 and Dome Fuji record together in one plot for the overlapping period. Show a figure of this comparison below, and briefly discuss and explain the similarities and differences between the two time series.
4. Plot the Fuji record together with the marine δ18O record (Question 1) for the overlapping period. Show a figure of this comparison below, and briefly discuss and explain the similarities and differences between the two time series.
5. An international ice-core project that started in 2019 (see <https://www.beyondepica.eu/en/>) aims to extend the existing East Antarctic climate records back in time, and to retrieve 1.5-million-year-old ice. What conditions (in terms of location, climate, etc.) do you think need to be satisfied to enable the retrieval of ice this old? Try to list at least three conditions.