Name ________________________

Lab 11 – Analyzing Climate Datasets

Objectives

- Assess how trends in CO_2 concentrations compare to sea surface temperature trends
- Analyze data on modern (800,000 year) air temperature trends from ice core data
- Determine how rates in temperature change relate to mass extinction events
- Learn basic data processing and visualization techniques in Python

Instructions

Today you will be analyzing data using Python. So that you do not need to download the program onto your own computer, you will be running the program in the Cloud through Binder. To access the analysis portal, go to https://mybinder.org/v2/gh/ebake310/GEOSC107_Climate-Data_Binder/HEAD. When you first load the Binder, it may take a few minutes as it prepares the Python environment. A Python notebook has already been started for you and contains an example to help guide your analyses. Read through the example, then start coding your own analyses. Make sure to not accidentally delete code that is already written for you.

Part I: Greenhouse gas records at Mauna Loa, Hawaii

In 1957 Dave Keeling, who was the first to make accurate measurements of CO_2 in the atmosphere, chose a site high up on the slopes of the Mauna Loa volcano as a long-term CO_2 monitoring site because he wanted to measure CO_2 in air masses that would be representative of the Northern Hemisphere and the globe. That goal has not changed. We still want to eliminate the influence of CO_2 absorbed or emitted locally by plants and soils, or emitted locally by human activities. The Mauna Loa observatory is surrounded by many miles of bare lava, without any vegetation or soil, providing an opportunity to measure “background” or “baseline”” air.

1. Write the line of code you used to import the CO_2 dataset.

2. Plot CO_2 concentration since scientists began recording the atmospheric concentration. Right click on the figure and choose the top option “Copy Output to Clipboard” and then paste the figure into a Word document. Label the figure as Part I.

3. Describe any patterns in the data you have plotted.

4. Make a hypothesis as to why CO_2 concentrations vary over the year.

Part II: Plot average surface temperature of Earth's ocean since 1880 with the data uncertainty

Techniques for measuring sea surface temperature have evolved since the 1800s. The earliest data were collected by inserting a thermometer into a water sample collected by lowering a bucket from a ship. Today, temperature measurements are collected more systematically from ships, as well as at stationary and drifting buoys. Due to denser sampling and improvements in sampling design and measurement techniques, newer data are more precise than older data. The earlier trends shown by this dataset have less certainty because of lower sampling frequency and less precise sampling methods.

5. Plot the average sea surface temperature anomaly through time and the uncertainty associated with the data. Right click on the figure and choose the top option "Copy Output to Clipboard" and then paste the figure into your Word document. Label the figure as Part II.

6. Describe the trend(s) shown in the graph of the sea surface temperature anomaly.

7. How do the trends in global average sea surface temperature anomaly compare to the trends in CO_2 and methane concentrations? What role does this data suggest greenhouse gases have in controlling global ocean temperatures?

Part III. Ice Core Data

The third dataset you will work with is one of the largest modern climate records we have: 800,000 years of temperature proxy data collected from an ice core of an ancient ice sheet in Antarctica. This NOAA dataset has Deuterium-based air temperature estimates, recorded as the temperature anomaly (temperature difference from the average of the last 1000 years). Deuterium is a type of hydrogen isotope with two neutrons, and the relative proportion of two types of hydrogen isotopes (^{2}H:^{1}H) in ice can be used to make estimates of past temperature conditions.

8. Plot the air temperature anomaly data through time. Right click on the figure and choose the top option "Copy Output to Clipboard" and then paste the figure into a Word document. Label the figure as Part III.

9. How have air temperatures changed over the past 800,000 years?

10. Knowing that the orbital cycles are on 100,000, 41,000, and 26,000-year cycles, which orbital cycle do you think is most affecting air and water temperature? Explain.

11. Periods of very negative temperature anomalies correlate well with large scale glaciations, where ice covers much of the northern parts of the northern hemisphere. Do glaciations build up slowly or quickly? Do they go away slowly or quickly? Justify using the figure from Part III.

Part IV. Temperature Change & Mass Extinctions

Judging from the fossil record, the baseline extinction rate of is about one species per every one million species per year. However, at times in the past, rates of extinction have soared. These are called mass extinctions, when huge numbers of species disappear in a relatively short period of time. Paleontologists know about these extinctions from remains of organisms with durable skeletons that fossilized. Recent studies estimate that there are about eight million species on Earth, of which at least 15,000 are threatened with extinction.

12. Make a plot that displays the temperature change data, the rate of temperature change, and the extinction rates through time over the last 4.5 billion years. Right click on the figure(s) and choose the top option "Copy Output to Clipboard" and then paste the figure into a Word document. Label the figure as Part IV.

13. You have finished the Python portion of the lab! Export your Python notebook from Binder by going to 'File' -> 'Save and Export Notebook As...' -> 'HTML'. **Save this HTML file to your computer, then print it and use it to answer the final questions below**.

14. Label the five mass extinctions on the printed figure from Part IV. Myr stands for million years ago. Use the table below to help locate the five mass extinction events on the graph.

Table 1. List of the 5 major mass extinction events over Earth's history.

Age	Time	Details
End Cretaceous	66 Myr	Extinction of many species in both marine and terrestrial habitats including pterosaurs, mosasaurs and other marine reptiles, many insects, and all non-Avian dinosaurs. The scientific consensus is that this mass extinction was caused by environmental consequences from the impact of a large asteroid hitting Earth in the vicinity of what is now Mexico.
Late Triassic	199 Myr	Extinction of many marine sponges, gastropods, bivalves, cephalopods, brachiopods, as well as some terrestrial insects and vertebrates. The extinction coincides with massive volcanic eruptions along the margins of what is now the Atlantic Ocean.
End Permian	252 Myr	Earth's largest extinction event, decimating most marine species such as all trilobites, plus insects and other terrestrial animals. Most scientific evidence suggests the causes were global warming and atmospheric changes associated with huge volcanic eruptions in what is now Siberia.
Late Devonian	378 Myr	Extinction of many marine species, including corals, brachiopods, and single-celled foraminiferans, from causes that are not well understood yet.
Late Ordovician	447 Myr	Extinction of marine organisms such as some bryozoans, reef-building brachiopods, trilobites, graptolites, and conodonts as a result of global cooling, glaciation, and lower sea levels.

15. Which factor is most predictive that a mass extinction will occur based on your figure from Part IV?

16. What are the rates of global temperature change for the five mass extinctions that have occurred in the past? Record the extinction rate in families per million years for each event.

Mass Extinction Event	Extinction Rate (Families/Myr)

17. Earth's average global temperatures have risen about 1.2˚C since the pre-industrial era (1750s). What is this rate converted to ˚C per million years? How does this compare with the rates of temperature change that led to mass extinctions in the past?

Reflection Question

Share any final thoughts you have after working through these datasets. Thoughts could be related to either what you have learned from the data, how you felt about working in Python, or anything else about today's lab.