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Problem Set 1 – Airborne Fraction

The assignment explores the relationship between human emissions of CO_2 from fossil fuel and how much CO_2 is staying in the atmosphere. We will use the observed record of CO_2 from Mauna Loa as an approximation of average global CO_2 concentration. Global fossil fuel emissions estimates come from bottom up estimates reported by each country to the UN, and reported by the Global Carbon Project.

Data Files:
Global Fossil Fuel Emissions 1750-2022 from the Global Carbon Project
- Filename: National_Fossil_Carbon_Emissions_2023v1.0.xlsx
- https://globalcarbonbudgetdata.org/downloads/latest-data/National_Fossil_Carbon_Emissions_2023v1.0.xlsx

• Annual Mean CO_2 concentration at Mauna Loa 1959-2022 reported by NOAA
- Filename: co2_annmean_mlo.txt
- From this site: https://gml.noaa.gov/ccgg/trends/data.html
- https://gml.noaa.gov/webdata/ccgg/trends/co2/co2_annmean_mlo.txt

Python Notebook:
PS1_AirbrorneFraction.ipynb

Answer the following questions using the Python Jupyter Notebook:

PS1_AirbrorneFraction.ipynb

Read through the notebook to see the notes and code as well as suggestions for calculating the answers below.

Check the "accessing_JupyterHub.pdf" instructions file for information on how to access and run the code. In brief, you will login to the jupyter hub, and create a folder called "PS1_AirborneFraction" that contains (at a minimum) the python notebook file and the two data files. This will allow the notebook to run and have access to the data.

Questions
Please provide **narrative written descriptions** and supporting figures or numbers where appropriate. You can make specific calculations using the example code at the bottom of the notebook, or you can approximate answers from the graphs.

1. FF emissions have been increasing over time. Answer the following questions using **descriptive answers** supported by evidence from graphs or numbers you calculate.
    a. How have fossil fuel emissions been changing over the record? What are the notable features?
    b. How have fossil fuel emissions varied over the past 30 years?
    c. What do you think is causing these changes over time, or what else do you notice?
2. Cumulative Fossil Fuel Emissions

   a. What was the cumulative total of FF emission over the entire record?
   b. How much of the cumulative total was emitted since 1990?
   c. How much of the cumulative total was emitted since 2000?
   d. Reflect on the numbers from a-c.

3. Airborne fraction of CO_2. Assume the globally averaged CO_2 mixing ratio can be approximated by the concentration at MLO. Using a pre-industrial value for CO_2 of 280ppm, the airborne fraction of cumulative FF emissions (i.e. all emissions since 1750) is 0.57 (see calculation in last section of notebook). You can estimate these answers from the graphs provided. Using a pre-industrial value for CO_2 of 280ppm. What is the airborne fraction of **cumulative** FF emissions (i.e. all emissions since 1750)?
   a. What is the approximate average annual mean airborne fraction of FF CO_2 as measured at MLO for 1980-1990, for 1990-2000, for 2000-2010 and 2010 to the present? Comment on the stability or instability of this average over time. How does it compare to the cumulative airborne fraction?
   b. What is the variability of the airborne fraction in time relative to the mean value? A qualitative answer is fine. What does that tell us about processes controlling the airborne fraction?