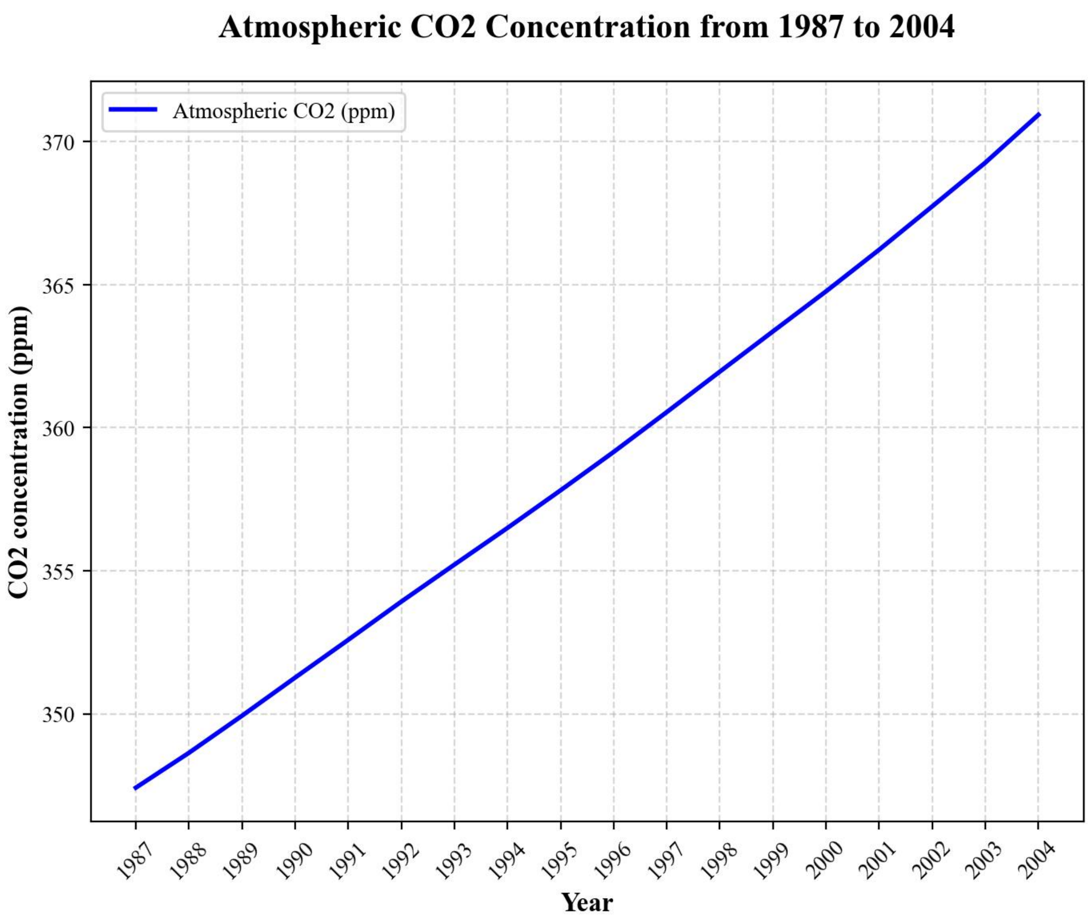
PS5.ipynb

1.1

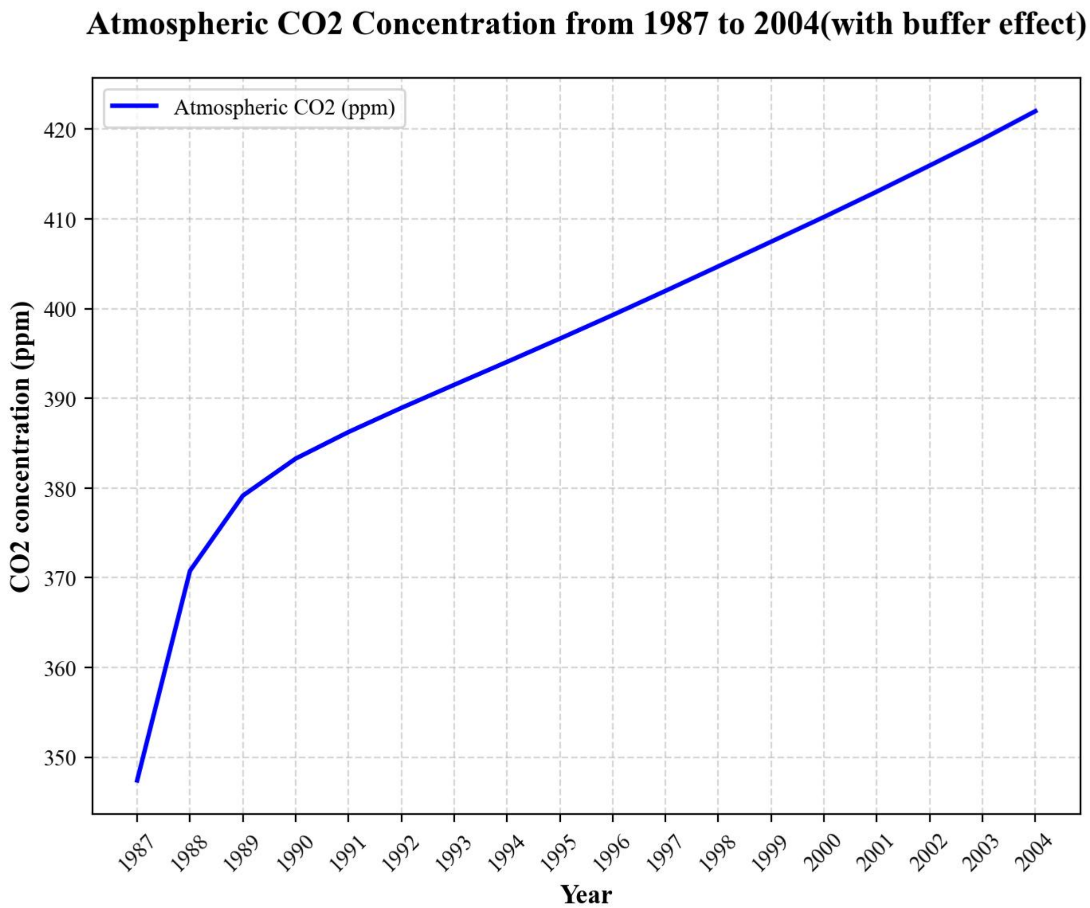
Data on fossil fuel emissions are loaded from the Excel file ("Global_Carbon_Budget_2016_v1.0.xlsx"). The data includes emissions from different years and different types of fuel. Because of the special format of Excel tables, line 9 is actually the column name, so the code sets line 9 as the column name of the DataFrame. Select the data from row 10, keeping the Year ("Year"), Total emissions ("Total"), and Cement emissions ("Cement") columns. Then select the data from 1987 to 2004 as requested by the question. Fossil fuel emissions are calculated and converted from their original units to ppm. The establishment of the model and the selection of the coefficient are all based on the content of the paper, and it is not necessary to elaborate here.

Hint:According to the original description, the data of γ should be derived from carbon dioxide emitted from fossil fuel combustion, so the emission of cement production is subtracted from the data in dataframe, which will lead to a slight difference between the figure drawn in 1.3 and the original. The main difference is that the observation data are not as volatile as in the paper. This is because it is impossible to accurately estimate how much carbon dioxide from fossil fuel combustion is absorbed by the oceans and land.



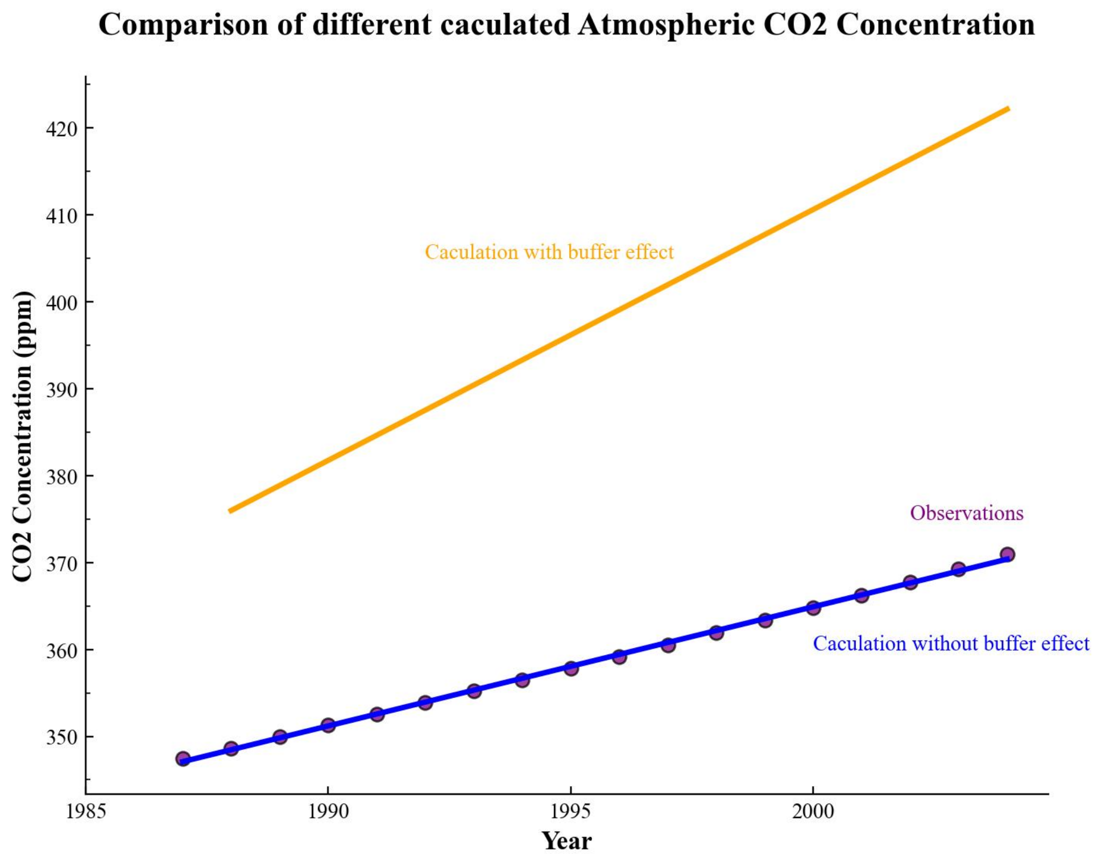
1.2

Ocean buffering is added to more accurately model changes in atmospheric carbon dioxide (CO2) concentrations. The difference between 1.2 and 1.1 is that the differential equation and various parameters therein are changed according to the content of the paper.



1.3

As described in 1.1, although there are some slight differences from the picture in the paper, the calculation process should be problem-free. First, the np.polyfit function is used to perform a one-time polynomial fit (i.e., a linear fit) for both sets of data. The first set is the CO2 concentration data (N1_ppm) without taking into account the ocean buffering effect, and the second set is the data taking into account the ocean buffering effect (N1_ppm_1_2). Returns the coefficient of the fitted line. Then, the np.polyval function is used to calculate two fitted lines according to the fitting coefficients. The process of drawing is to set the scale line, notes and other contents in detail according to the content of the paper.



Bonus

In bonus, a more complex atmospheric CO2 model, called the "seven box model", is built on request and the model results are analyzed at different beta values. Fossil fuel emissions data were loaded from the CSV file "global.1751_2014.csv", with data from 1751 to 2004 selected. These figures include total carbon emissions and carbon emissions from cement production. Emissions data from land use change were then loaded from the "Global_Carbon_Budget_2016_v1.0.xlsx" file. Again, data from 1751 to 2004 were selected. Model building and parameter setting are based on the content of the paper to write, here is not much to describe. In the subsequent solution of the differential equation, two different β values (0.38, 0.5) were brought in for calculation according to Figure 4 of the paper. The process of drawing is also referred to Figure 4 in the paper, setting the scale line, notes and other contents in detail. Due to the lack of data from the 1998 dataset cited in the paper (mainly because they did not find the part of the 1998 dataset they predicted), the scatter plot was not drawn.