# PS5

Note: Yu Zhe gave me lots of help, and I'm very grateful to him.

## 1.1

```
import pandas as pd

# ff means fossel fuel carbon emission
ff = pd.read_csv('global.1751_2020.csv')

# select data of 1987-2004
ff.loc[(ff['Year']>=1987) & (ff['Year']<=2004)]

# initial carbon contents in PgC
atmC = 740
atmC_copy = 740
oceC = 900

list_atmCO2 = []
list_year = []

for i in range(18):

    # select each year
    index = ff.iloc[236+i]

    # calculate γ and transfer its unit to PgC
    # γ is carbon emissions from fossil fuel comsumption
    gamma = (index['Total carbon emissions from fossil fuel consumption and cement production (million metric tons of C)'] - index['Carbon emissions from cement production']) / 1000

    # calculate carbon contents each year in the atmosphere and the surface of the ocean respectively
    atmC = atmC - 105/740 * atmC + 102/900 * oceC + gamma
```

```
        oceC = oceC + 105/740 * atmC_copy - 102/900 * oceC
        atmC_copy = atmC

        # calculate atmospheric CO2 level in ppm each year
        atmCO2 = atmC / 2.13
        year = 1987 + i

        list_atmCO2.append(atmCO2)
        list_year.append(year)
        i += 1

# create a pandas series
series_atmCO2_withoutBufferEffect = pd.Series(list_atmCO2, index=list_year)
series_atmCO2_withoutBufferEffect
```

The output is:

```
1987    348.630047
1988    349.924711
1989    351.255856
1990    352.567821
1991    353.891078
1992    355.153956
1993    356.429623
1994    357.713454
1995    359.046179
1996    360.436941
1997    361.834626
1998    363.213484
1999    364.641389
2000    366.121565
2001    367.596334
2002    369.123826
2003    370.802330
2004    372.556663
```

## 1.2

```
# initial carbon contents in PgC
# Here I use N1, N2, N2_0 in the article to represent carbon contents
N1 = 740
N1_copy = 740
N2 = 900
N2_0 = 821
# ξ
xi = 3.69 + 1.86 * 0.01 * (740 / 2.13) - 1.8 * 0.000001 * (740 / 2.13) * (740 / 2.13)

list_atmCO2 = []
list_year = []

for i in range(18):

    # select each year
    index = ff.iloc[236+i]

    # calculate γ and transfer its unit to PgC
    # γ is carbon emissions from fossil fuel comsumption
    gamma = (index['Total carbon emissions from fossil fuel consumption and cement production (million metric tons of C)'] - index['Carbon emissions from cement production']) / 1000

    # calculate atmospheric CO2 level in ppm each year
    N1 = N1 - 105/740 * N1 + 102/900 * (N2_0 + xi*(N2-N2_0)) + gamma
    atmCO2 = N1 / 2.13

    xi = 3.69 + 1.86 * 0.01 * atmCO2 - 1.8 * 0.000001 * atmCO2 * atmCO2
    N2 = N2 + 105/740 * N1_copy - 102/900 * (N2_0 + xi*(N2-N2_0))
    N1_copy = N1
    year = 1987 + i

    list_atmCO2.append(atmCO2)
```

```
        list_year.append(year)
        i += 1

# create a pandas series
series_atmCO2_withBufferEffect = pd.Series(list_atmCO2, index=list_year)
series_atmCO2_withBufferEffect
```

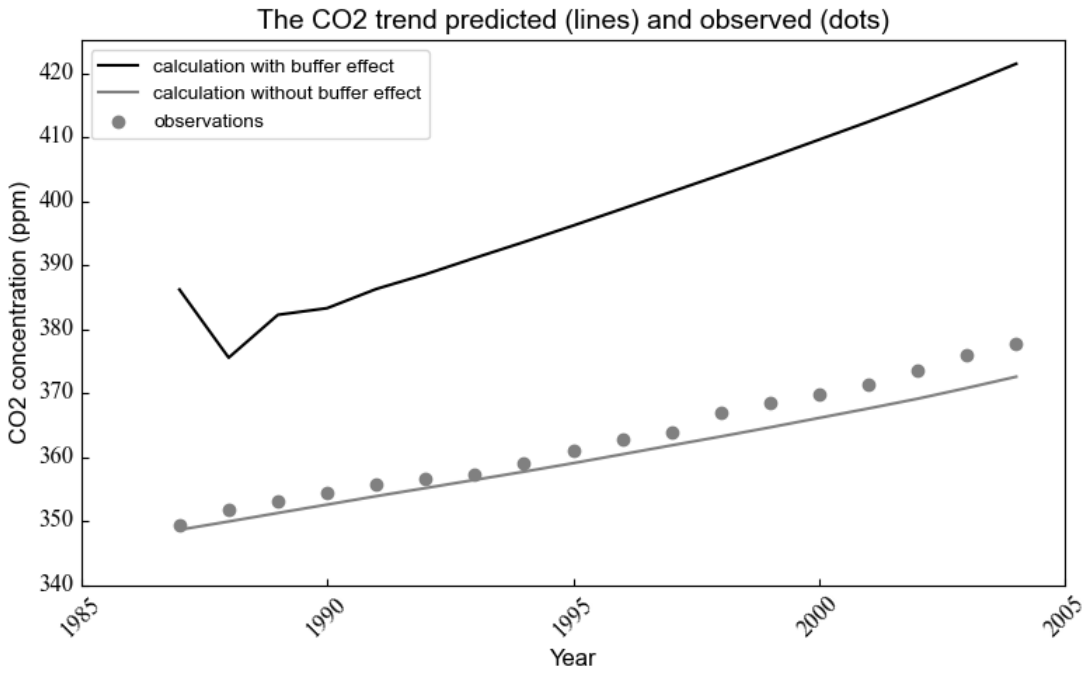
The output is:

```
1987    386.186604
1988    375.535973
1989    382.234874
1990    383.274132
1991    386.277107
1992    388.572018
1993    391.127948
1994    393.614240
1995    396.188448
1996    398.817574
1997    401.472430
1998    404.126639
1999    406.846784
2000    409.630682
2001    412.428679
2002    415.301866
2003    418.342870
2004    421.484025
```

## 1.3

```
# load observed values at Mauna Loa
observation = pd.read_csv('Mauna Loa CO2 annual mean data.csv')
observation_slice = observation.loc[(observation['year']>=1987) &
(observation['year']<=2004)]
observation_slice

import matplotlib as mpl
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np

# Set the font
plt.rcParams['font.sans-serif'] = ['Times New Roman']
plt.rcParams['axes.unicode_minus'] = False

# Set the figure
plt.figure(figsize=(8,5), dpi=100)

# Plot lines
plt.plot(series_atmCO2_withBufferEffect, 'k-', label='calculation with buffer effect')
plt.plot(series_atmCO2_withoutBufferEffect, color='gray', linestyle='-',
label='calculation without buffer effect')
plt.scatter(observation_slice['year'], observation_slice['mean'], color='gray',
marker='o', label='observations')

# Adjust xy axis ticks
plt.xticks(ticks=np.arange(1985, 2010, 5), fontsize=12, rotation=45, ha='center',
va='top')
plt.yticks(ticks=np.arange(340, 430, 10), fontsize=12, rotation=0, ha='right',
va='center')

# Tick parameters
plt.tick_params(axis='both', bottom=True, top=False, left=True, right=False,
                direction='in', which='major')
```

```
# x and y labels
plt.xlabel('Year', fontproperties='Arial', fontsize=12)
plt.ylabel('CO2 concentration (ppm)', fontproperties='Arial', fontsize=12)

# Add title and legend
plt.title('The CO2 trend predicted (lines) and observed (dots)', fontproperties='Arial',
fontsize=14)
plt.legend(loc='best', prop={'family':'Arial', 'size':10})

# Show plot
plt.tight_layout()
plt.show()
```



## Bonus

The following result has some bugs but I couldn't find bugs in the code. (；′⌒`)