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PHYS 220
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HW3 Report

Part A: Read the dataset and plot the time series of the CO2 concentration. Observe that the dataset has a trend, and it shows a seasonal cycle in CO2 concentration.

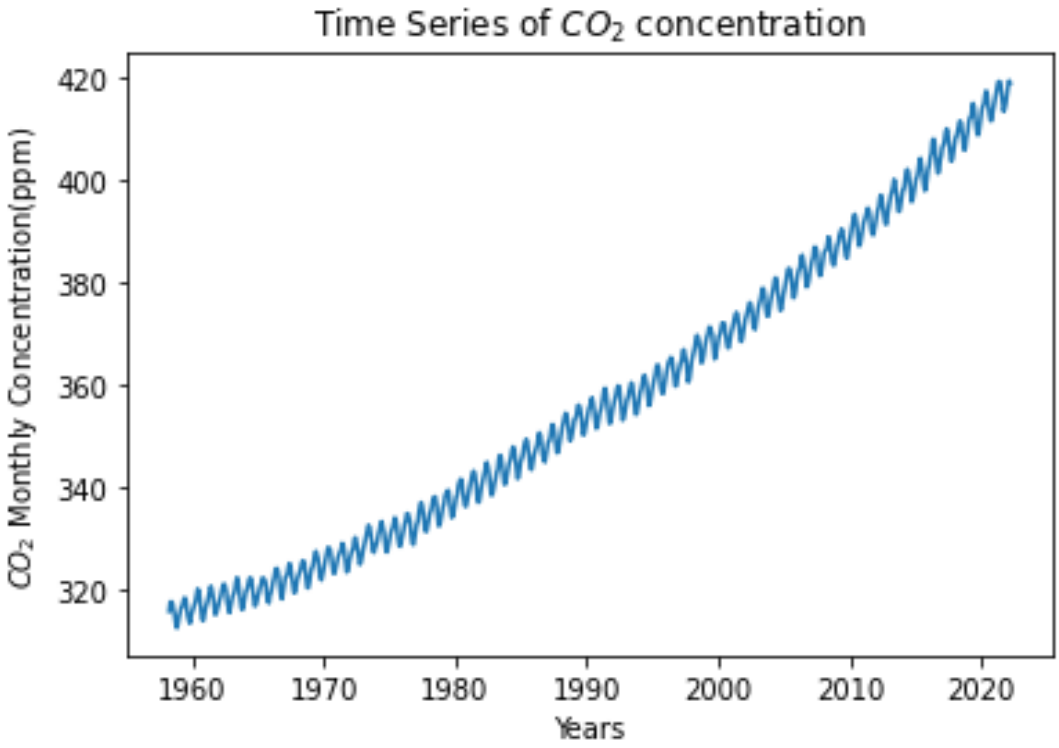

Figure 1: Time series of CO2 concentration

The plot above shows the CO2 concentration dating back to 1958. We can see that CO2 concentration in the world has significantly increased over the past 60 years or so. The plot also show the oscillation that occur in the concentration, which shows the seasonal cycle where the concentration is high for certain months and lower during other months.

Part B: Write a program that transforms the dataset from time domain to frequency domain. Make a plot of the spectrum of frequencies.

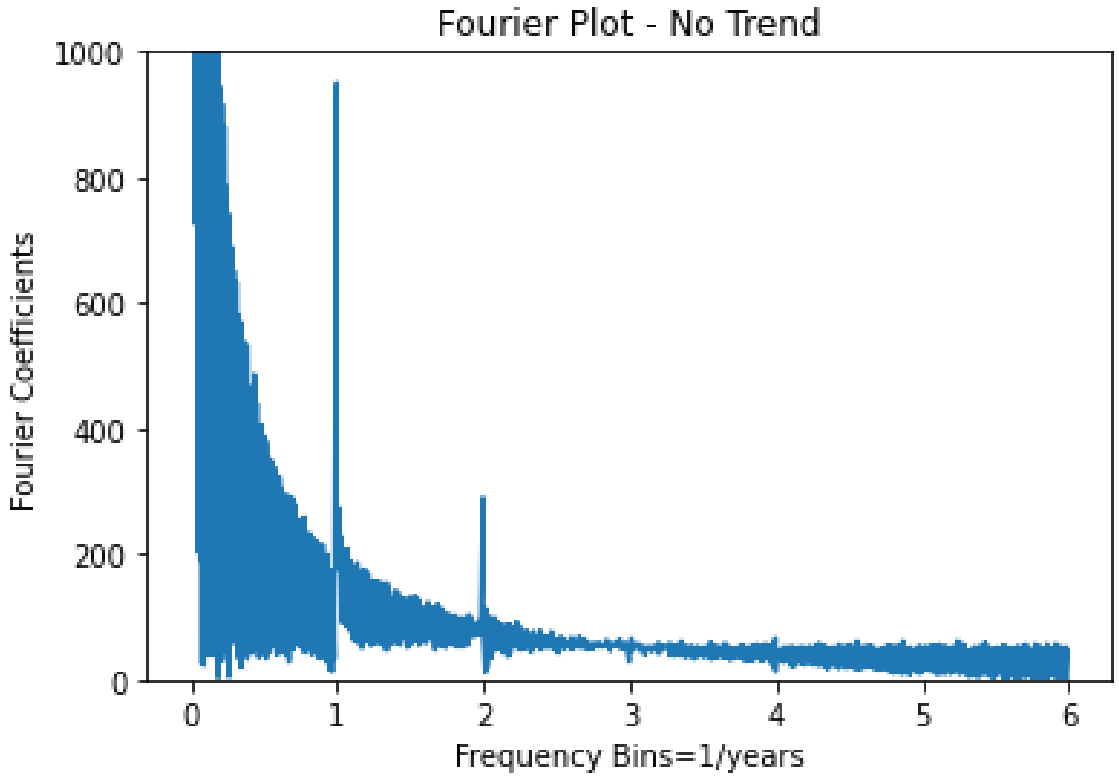

Figure 2: Spectrum of frequencies Plot

The plot above shows the transformation of the data set form time domain to frequency domain to create the spectrum of frequencies. The program calculates the Discrete Fourier Transform sample frequencies which the frequency bins in cycle per unit of the sample spacing. For our program we used 1/12 which represents the sampling rate of 12 due to the number of months in a year similar to the dataset ingested into the program.

Part C: Remove the seasonal cycle of the data by zeroing the appropriate values in the frequency domain and transforming back. Make a plot of the spectrum of frequencies to show

you have removed the peaks. For comparison, after the transforming back to time domain, make a second plot of the filtered and unfiltered data together in the same graph.

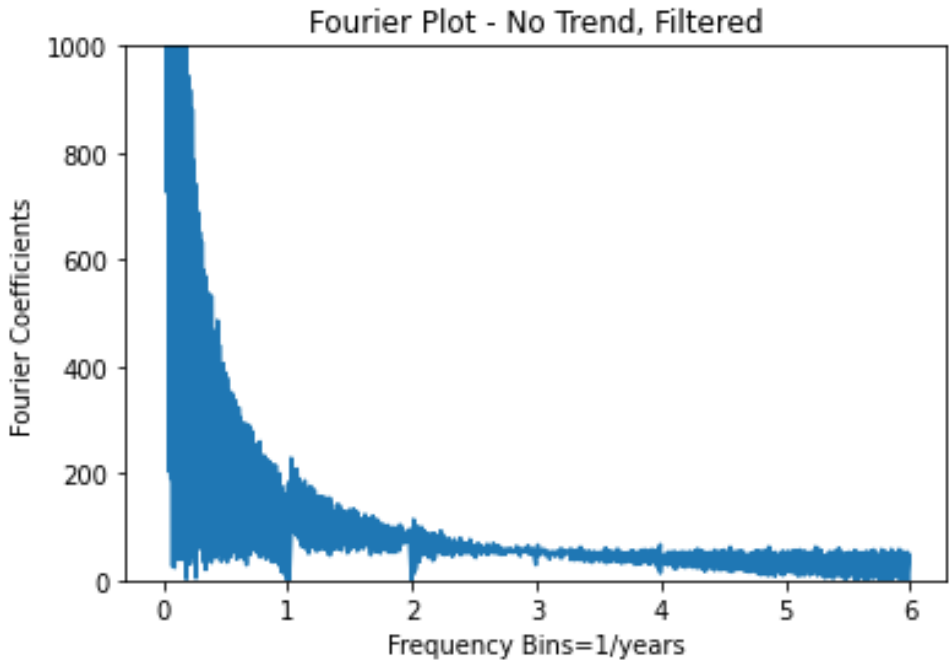

Figure 3: Filtered Fourier transformation

Figure 3 shows the Fourier transform from Part B after filtering out the peaks that are shown in Figure 2. This was done by using the *numpy.where* function to find the the peaks in a given range and zero out those peaks. Another approach would be to simply compare each point to it's neighbors and zero it out if the difference between it's neighbors is too large which is the method used for the Part D.

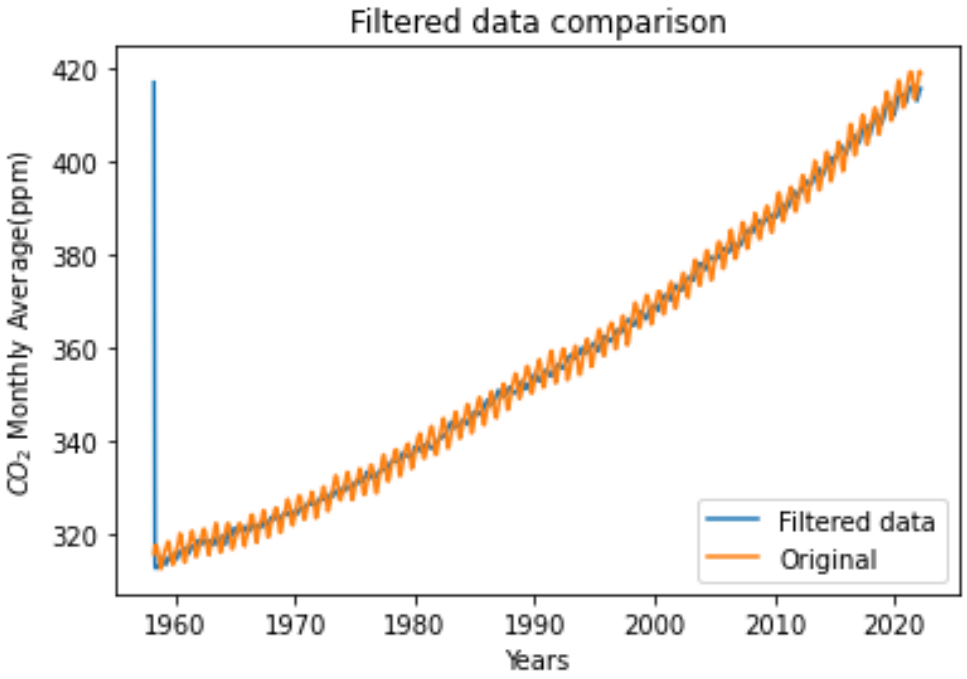

Figure 4: Comparison of filtered data to original data

The plot above show how the filtered data matchs up with the original fourier transformation. Clearly, the filtered data is insync with the original data but simply has the seasonal cycles filtered out. This clearly shows the significant increase in CO2 concentration around the world over the past 60 years or so.

Part D: Repeat part b) and c) but remove the long term trend from the data before filtering it

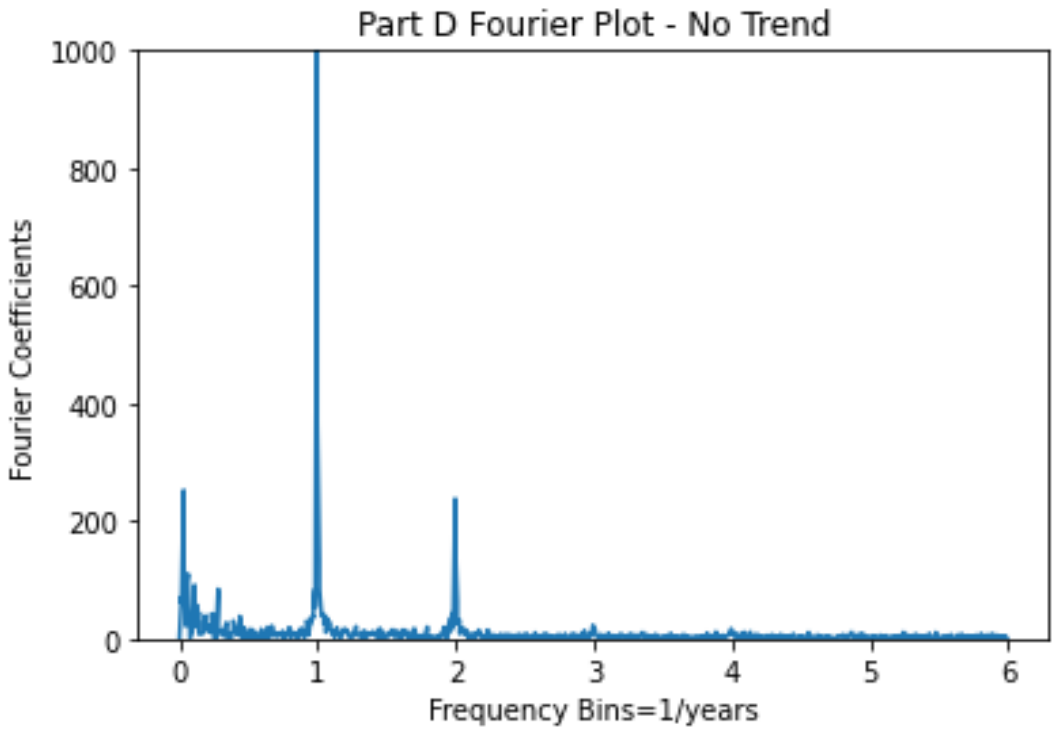

Figure 5: Fourier Transformation with no trend

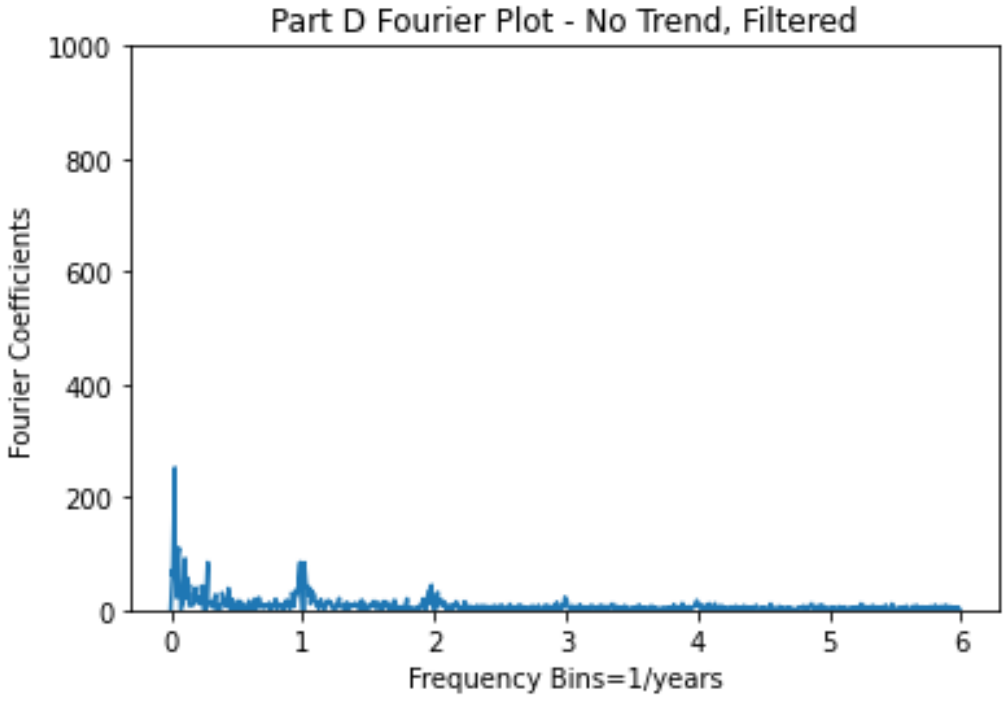

Figure 6: Fouriter transformation with no trend filtered

The two plots above show the original Fourier transformation plot after removing the long term trend and the filtered Fourier transformation plot after removing the long term trend. We were able to do this using the *np.ployfit* and *np.polyval* functions to fit a quadratic regime and subtract it from the data, and then adding it back after filtering. We can see how in Figure 6 we reduced the noise that was shown in Figure 5.

Part E: What is the estimate rate of increase of CO2 concentration per year? Compare and comment the differences of both approaches.

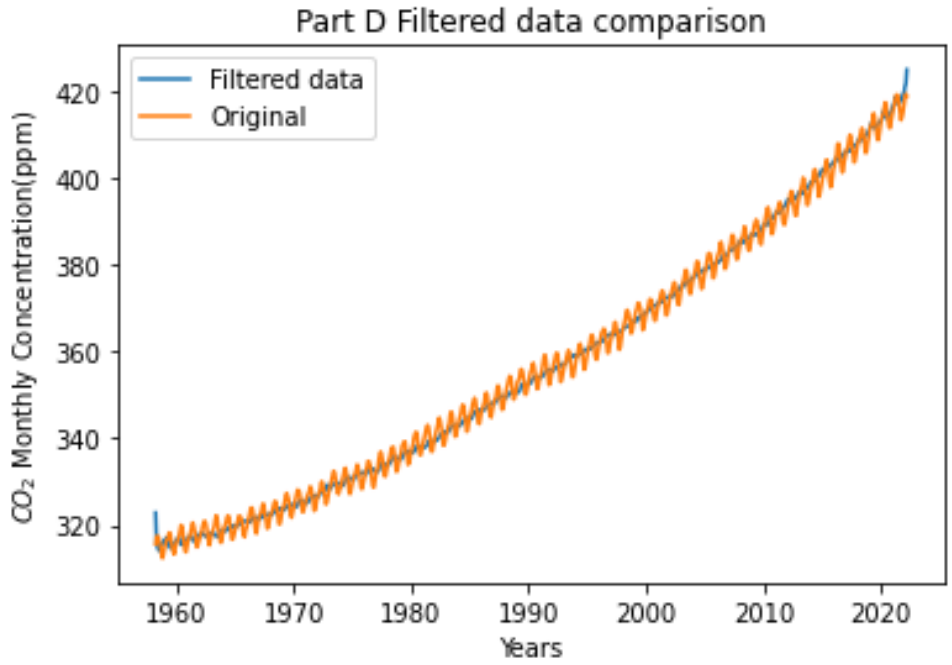

Figure 7: Comparison of filtered data to original data with no long term trend

To calculate the rate of increase of CO2 concentration per year we would need to take the slope of the filtered data with the long-term trend removed. The slope for Figure 7 is about 1.622 which means over the past 64 years the CO2 concentration has increased by about 1.622 ppm per year. Comparing this to Figure 4 where we did not remove the long term trend, the rate of increase comes to 1.58 ppm per year which is similar to the value we got for Figure 7.