Fitting Exercise 2 PHY224

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In the second fitting exercise we are given seasonal data for the CO2 content of the atmosphere for 100 years in parts per million (ppm). using a sinusoidal function with a quadratic growth factor:

$$f(t) = at^2 + bt + c + d\sin(2\pi t + \phi) + e\sin(4\pi t + \psi)$$

with parameters $a = 0.014, b = -53.21, c = 51620, d = 2.952, e = 0.8\overline{26}, \phi = 0.33, \psi = 2.211$, the data can be approximated into a sinusoidal quadratic function as shown below
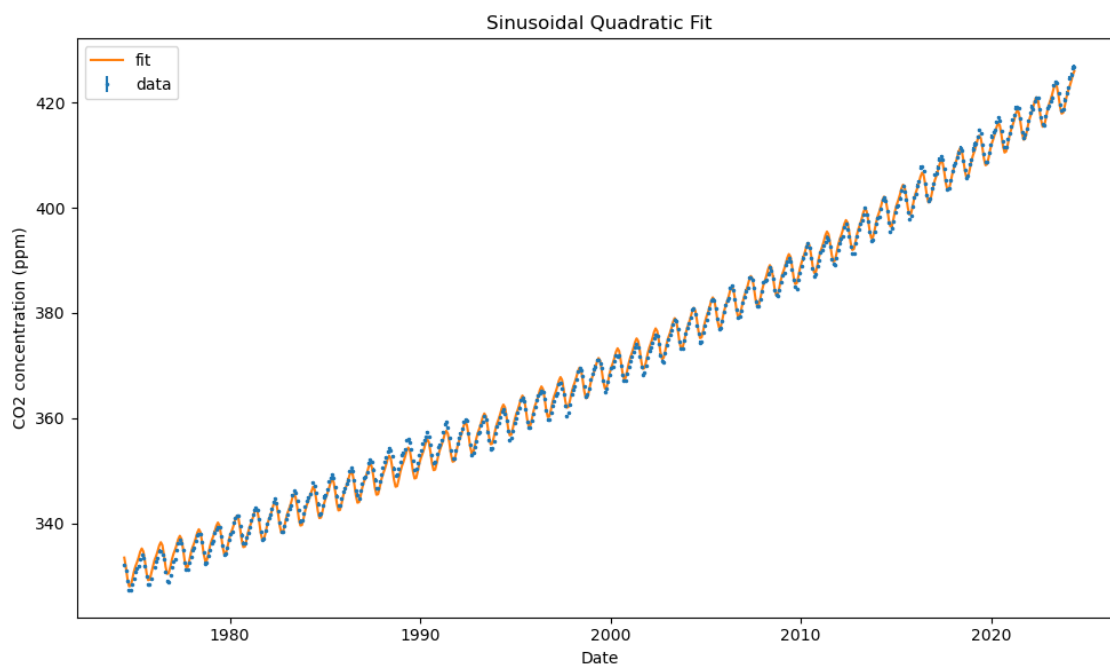

Figure 1: Sinusoidal Quadratic Fit of CO2 Data

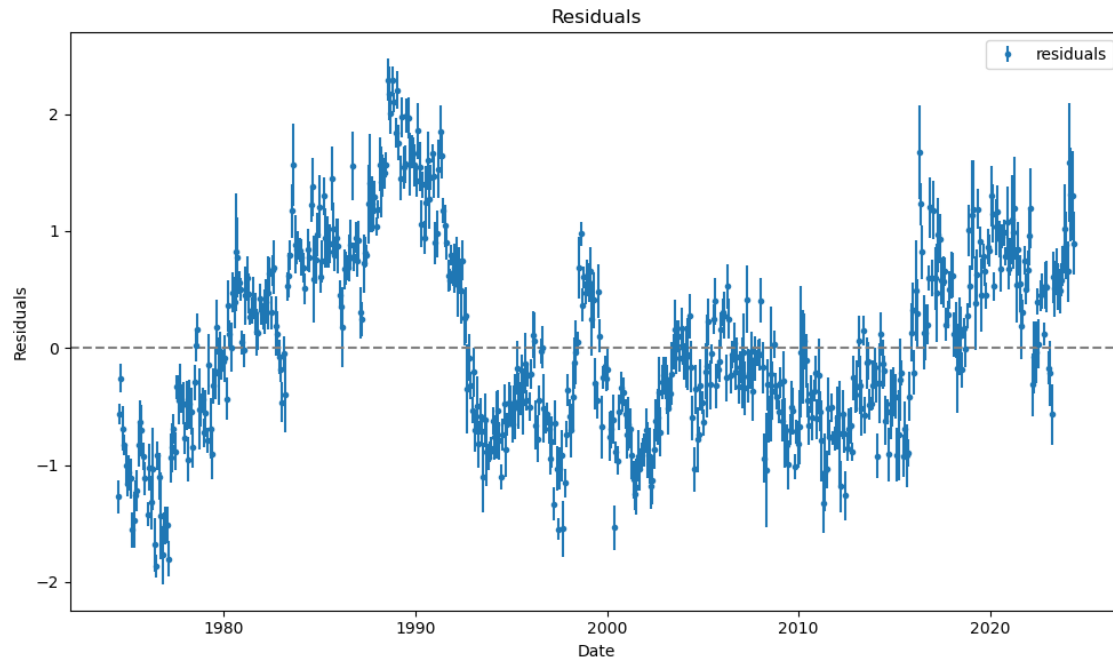The residuals of this graph relative to the data are shown below.

Figure 2: Residuals of the Fit

Using the data and these residuals, a χ^2 value of 27.54 is obtained which is quite accurate to the data set, due to the reduced chi squared of around 0.034, which indicates high accuracy to the data-set, but could also indicate an overfitted model.

Questions

a) Which month has the highest CO_2 emissions? does it change over time? how does this compare to the growing seasons on Earth?

the month with the highest CO_2 emissions tends to occur at the end of the winter months, normally in May. it steadily rises to this peak from the beginning of the winter, and then slowly falls off to a trough in the summer, around september. this is mainly due to plants in the northern hemisphere dying and being snow covered, being less able to absorb atmospheric CO_2 during photosynthesis, among many other lesser factors at play.

b) When will the predicted CO_2 models pass twice the pre-industrial amount of 285ppm?

some simple extra code to operate on the model indicates that this is going to happen on 2071-09-24, or the 24th of September, 2071.

c) how long will it take for the CO_2 maximum in 2000 to be passed by the CO_2 minimum in the future.

according to another addendum to the code linked, the date found here would be roughly october of 2022, which has already passed as of writing this.