# Can sunspot activity be seen in the Keeling curve

## Introduction

The Keeling curve is the graph describing the concentration of CO2 concentration of the atmosphere measured at the summit of Mauna Kea in Hawii. Data has been collected continuously since 1958. Within the curve the earth can be seen “breathing” in yearly cycles. In the northern summer the growth in vegetation fixes CO2 removing it from the atmosphere whilst in winter decomposition releases it. Added to this cycle is a monotonic increase in atmospheric CO2 due to the burning of fossil fuels and deforestation.

The flux of solar energy at the earth’s surface waxes and wanes with the sunspot cycle, the number of solar storms on the sun’s surface. We are currently approaching a minimum in the sunspot cycle and so that might be associated with a decrease in the uptake of CO2 from the atmosphere, exacerbating the effects of climate change. The sunspot cycle has a period of approximately 11 years and so I decided to examine if such a period can be observed in the Keeling curve.

## Data

The keeling curve data were obtained from this source:

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## Methodology

The data were loaded into a pandas dataframe and examined in the raw. The data were plotted as months since March 1958. The data, therefore, spanned almost 6 periods of sunspot activity.

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Figure 1: Raw CO2 concentrations measured on Mauna Kea

In order to smooth the data a 12 month rolling mean was created and added to the data frame. This had the effect of removing the 12 month period from the data set.

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Figure 2: Smoothed CO2 concentrations. A rolling mean of 12 monthly periods was taken to remove the seasonal variation in atmospheric CO2 concentration.

These smoothed data were then examined using a function fitting procedure and frequency analysis as described in the results section.

## Results

A second order polynomial was fitted to the smoothed data.

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Figure 3: A polynomial fit (blue) to the smoothed CO2 concentrations.

The polynomial fit function was then removed from the data give the residuals that might represent the unexplained variance in the CO2 data.

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Figure 3: Residual CO2 concentrations after the removal of the polynomial fit.

There is definitely some structure to the residuals that appears periodic so the frequency amplitude spectrum was calculated.

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Figure 4. Frequency amplitude spectrum of the residuals.

There is a discrete peak in the frequency amplitude spectrum at a frequency of 17.07 cycles per 731 months, a period of approximately 43 months.

## Discussion

The periodicity of the residuals did not support the hypothesis that the cyclical nature of sunspot activity could be seen in the Keeling curve. The period of sunspot activity is approximately 11 years, a period not seen in the Keeling curve.

## Conclusion

The Keeling curve does exhibit periodicity which is worthy of further analysis but it cannot be attributed to the sunspot cycle.