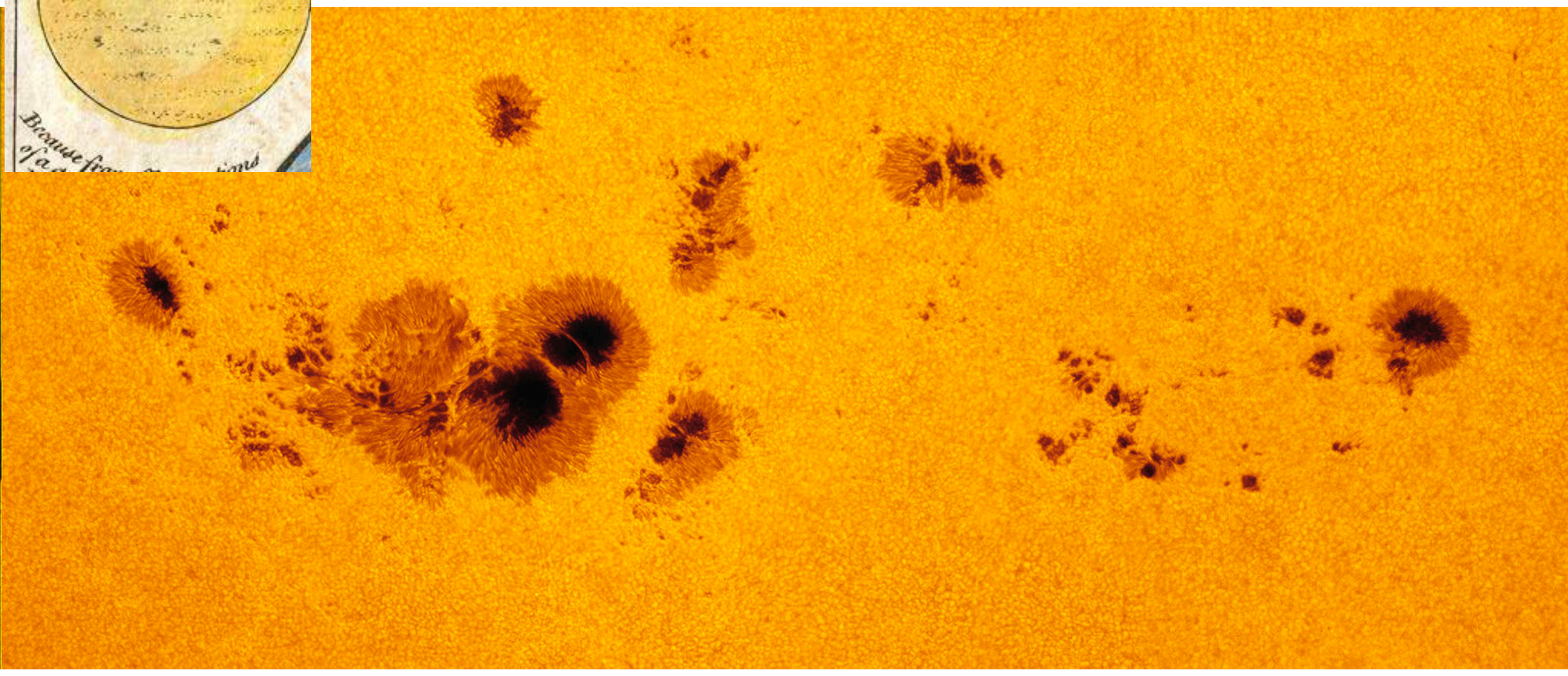
Homework #2: Plotting number of sunspots vs time and calculating the “running” or “moving” average

1794 observation

Modern observation



Homework #2: Plotting number of sunspots vs time and calculating the “running” or “moving” average

This is exercise 3.1 in the book. Due Monday Sept 30.

Exercise 3.1: Plotting experimental data

In the on-line resources[3] you will find a file called `sunspots.txt`, which contains the observed number of sunspots on the Sun for each month since January 1749. The file contains two columns of numbers, the first being the month and the second being the sunspot number.

a) Write a program that reads in the data and makes a graph of sunspots as a function of time.

b) Modify your program to display only the first 1000 data points on the graph.

c) Modify your program further to calculate and plot the running average of the data, defined by

$$Y_k = \frac{1}{2r+1} \sum_{m=-r}^{r} y_{k+m}$$

where $r = 5$ in this case (and the y_k are the sunspot numbers). Have the program plot both the original data and the running average on the same graph, again over the range covered by the first 1000 data points.

“Running” or “Moving” average

Common technique to smooth data

“Running” or “Moving” average

Index

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Data array

9	6	8	4	9	7	5	8	5	3	5	7	5	4	3	4	2	4	1	4

r = 5 (parameter given in problem)

for any given index i in the array, we want to calculate the average of the values within the window [i-r, i+r]. We will then save that value within a new array at index i.

In order to fit the entire window we should start at index 5 and finish at the 5th to last index

“Running” or “Moving” average

Index

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Data array

9	6	8	4	9	7	5	8	5	3	5	7	5	4	3	4	2	4	1	4

Start at index 5, calculate the average within the window [0,10] = 6.27

Moving average array

6.27									

“Running” or “Moving” average

Index

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Data array

9	6	8	4	9	7	5	8	5	3	5	7	5	4	3	4	2	4	1	4

Iterate to index 6, calculate the average within the window [1,11] = 6.09

Moving average array

6.27	6.09								

“Running” or “Moving” average

Index

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Data array

9	6	8	4	9	7	5	8	5	3	5	7	5	4	3	4	2	4	1	4

Iterate to index 7, calculate the average
within the window [2,12] = 6.09

Moving average array

6.27	6.09	6.0							

“Running” or “Moving” average

Index

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Data array

9	6	8	4	9	7	5	8	5	3	5	7	5	4	3	4	2	4	1	4

The last window is not centered on the last element of the array.

Moving average array

6.27	6.09	6.0							3.81

```
0     58.0
1     62.6
2     70.0
3     55.7
4     85.0
5     83.5
6     94.8
7     66.3
8     75.9
9     75.5
10    158.6
11    85.2
12    73.3
13    75.9
14    89.2
15    88.3
16    90.0
17    100.0
18    85.4
19    103.0
20    91.2
21    65.7
```

Sunspot data found here:
http://www-personal.umich.edu/~mejn/cp/data/sunspots.txt

Each line contains two numbers separated by a tab.

The first number is the month (counting months since January 1749)

The 2nd number is the number of observed sunspots.

We can read in this data using numpy loadtxt().

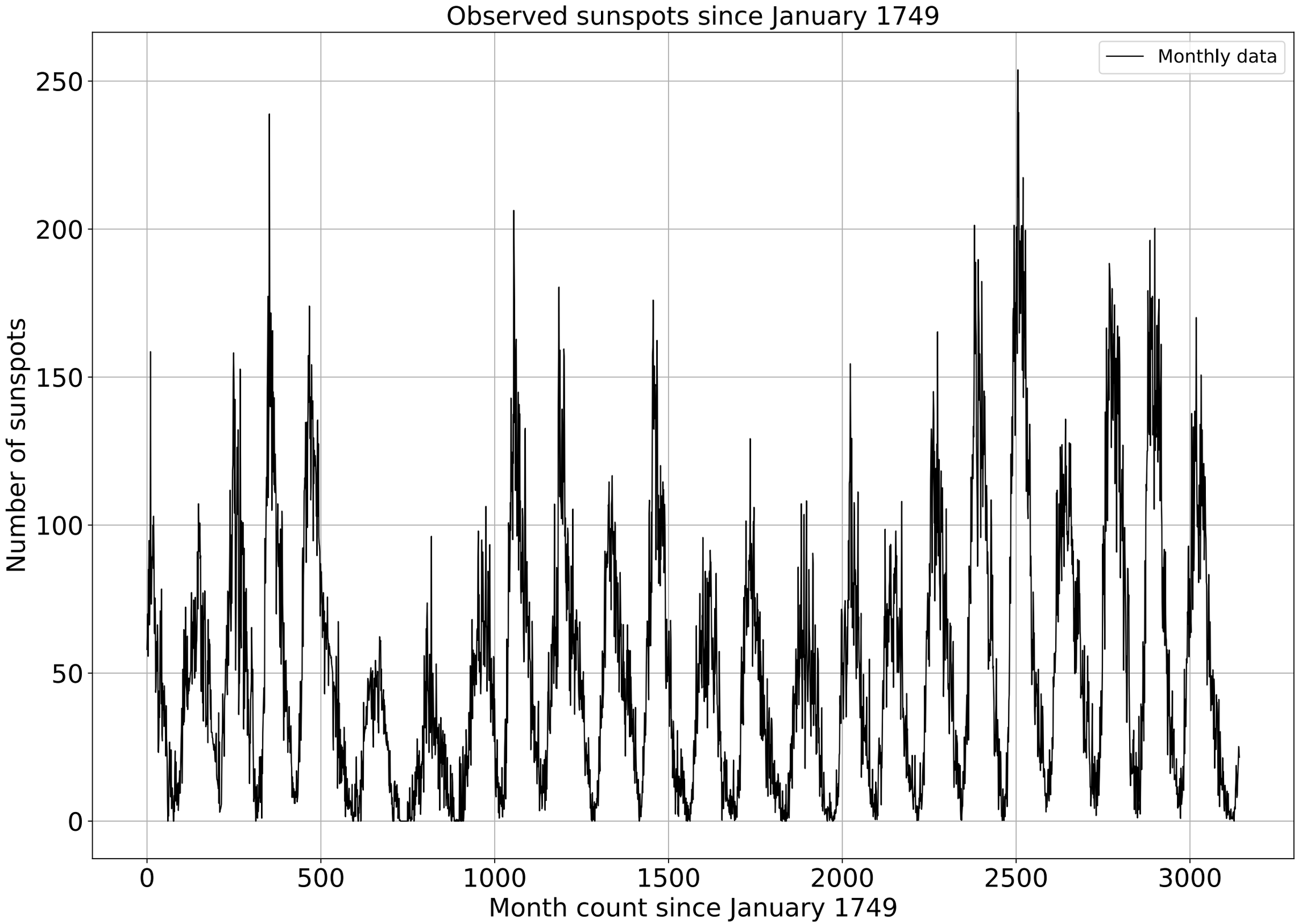
This will return a 2 x 3143 numpy array. You can use slicing to split this into two arrays.

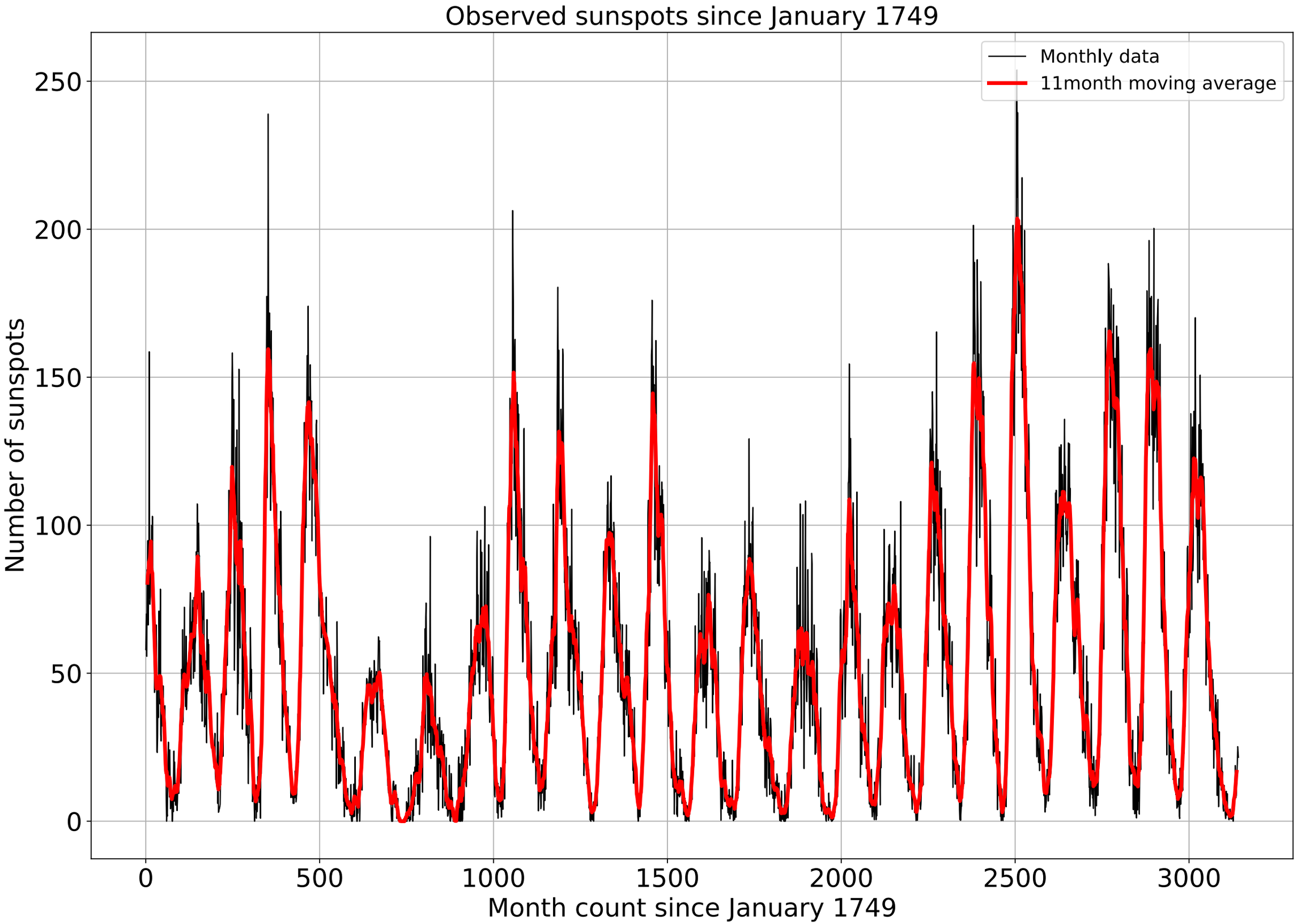
(see Notebook 05 in the scatter plot section for an example of reading in a different dataset [star magnitude vs temperature] or see Page 92 or Page 100 of the textbook)

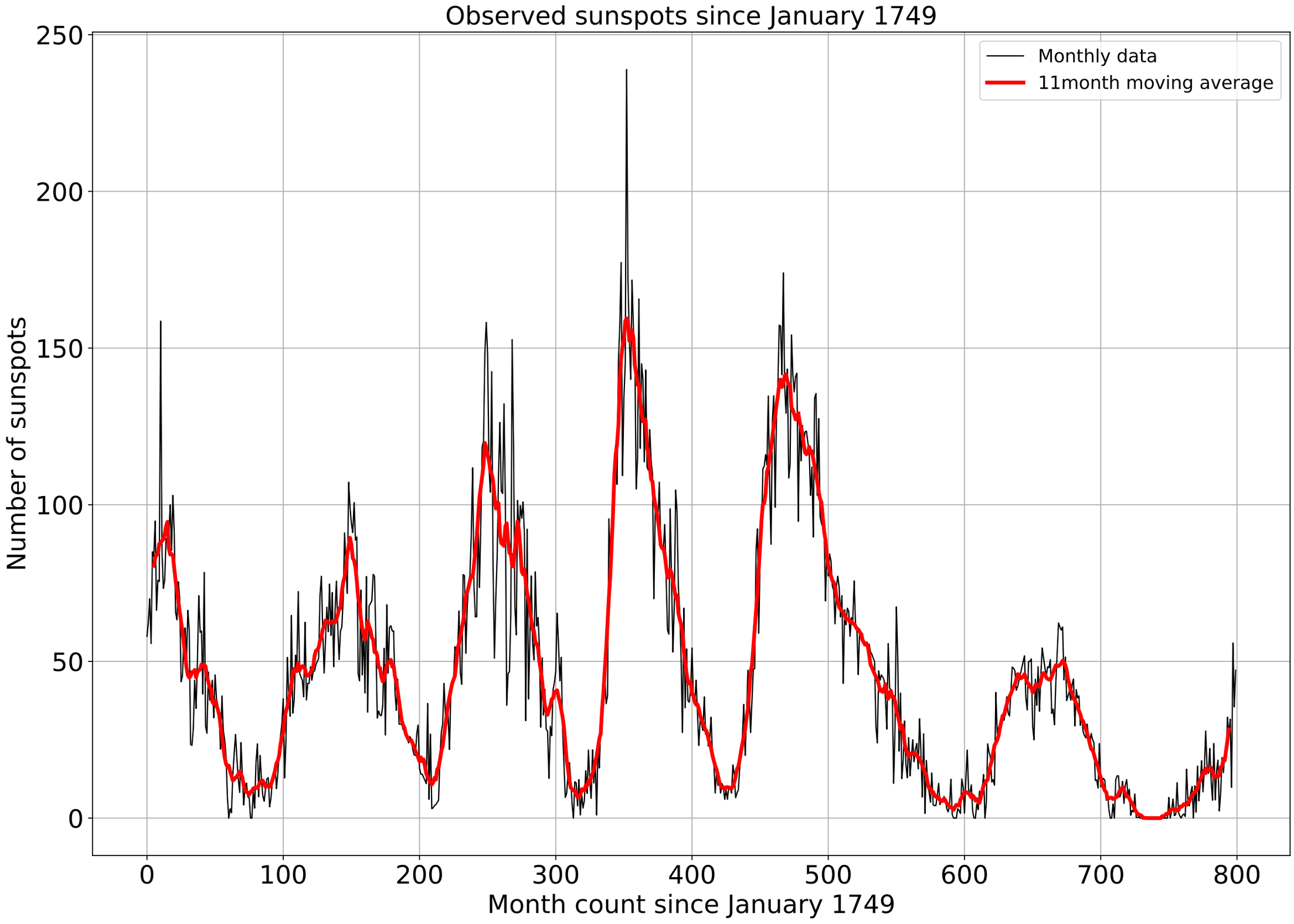
Once we have two numpy arrays, each with 3143 entries, we can plot them.

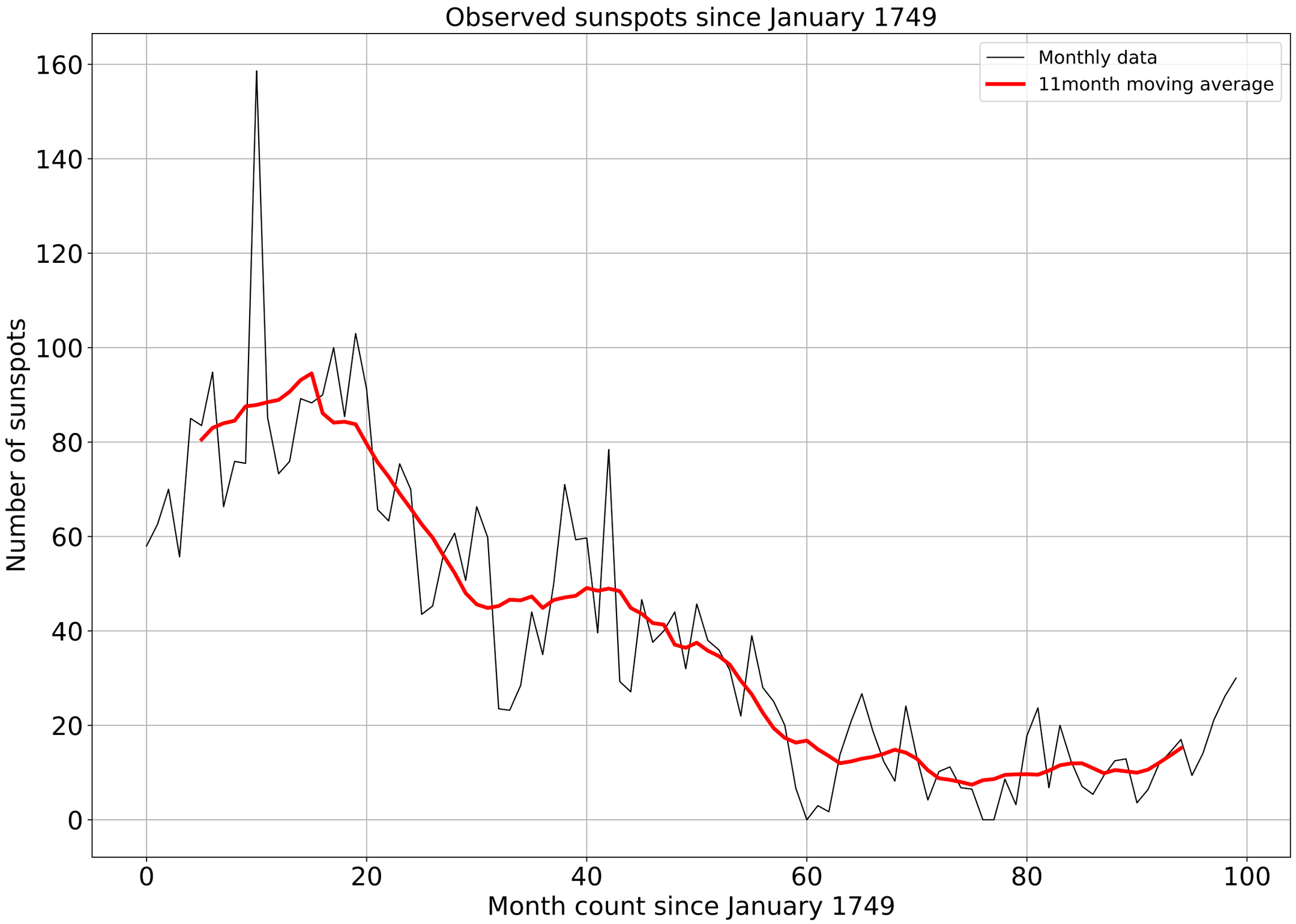
Plot the month on the x-axis and the number of sunspots on the y-axis.

Finally (the hard part): calculate the moving average for this data


Observed sunspots since January 1749
Monthly data
Number of sunspots
0
50
100
150
200
250
0
500
1000
1500
2000
2500
3000
Month count since January 1749


Observed sunspots since January 1749
Monthly data
11month moving average
Number of sunspots
250
200
150
100
50
0
0
500
1000
1500
2000
2500
3000
Month count since January 1749


Observed sunspots since January 1749
Monthly data
11month moving average
Number of sunspots
Month count since January 1749
0
50
100
150
200
250
0
100
200
300
400
500
600
700
800


Observed sunspots since January 1749
Monthly data
11month moving average
Number of sunspots
160
140
120
100
80
60
40
20
0
0
20
40
60
80
100
Month count since January 1749