Assignment 4 Determining and removing drawbacks of exponential and running mean Task 2

Group 6:

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Part I Comparison of the traditional 13-month running mean with forward-backward exponential smoothing for approximation of 11-year sunspot cycle

```
clc;
clear;
close all;
```

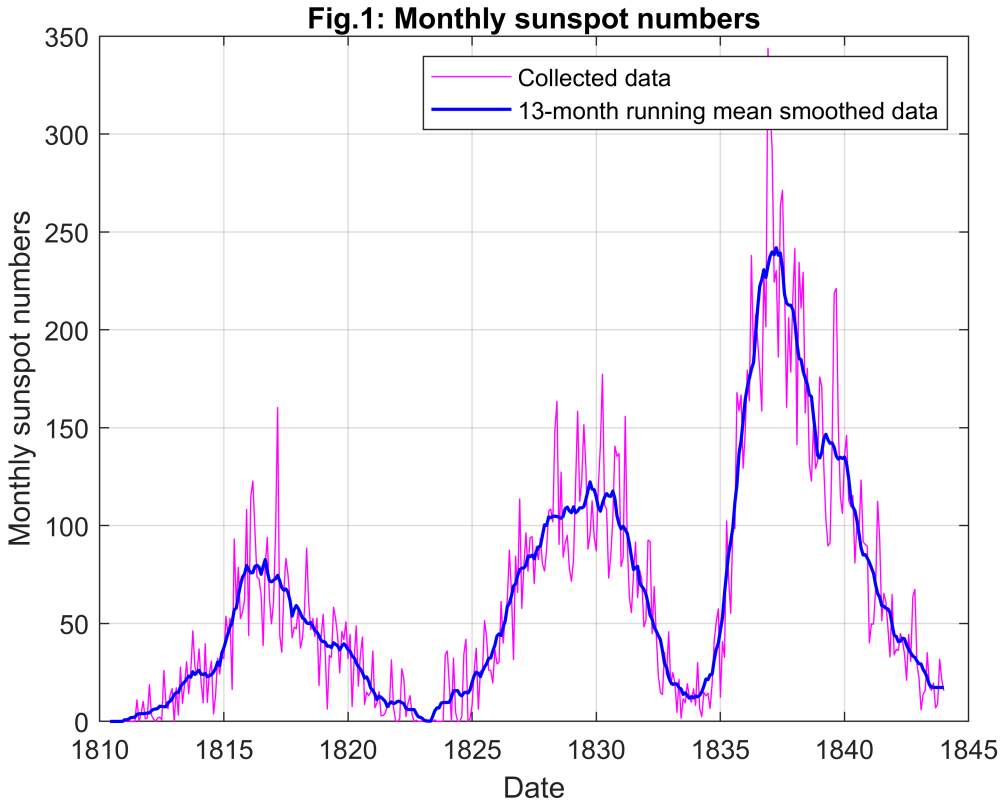
Task 1: Download data

```
load("data_group6.mat");

year=data(:,1);
month=data(:,2);
sunspot=data(:,3);

time=year+(month-1)./12;
```

Task 2: 13-month running mean smoothing

```
M=13;
win=floor((M-1)/2);
no = length(sunspot);
X_rm=zeros(no,1);
for i=win+1:no-win
   sumZ =sum(sunspot(i-win:i+win,1));
   X_rm(i,1)=1/M*sumZ;
end
X_rm(1:win,1)=sum(sunspot(1:win,1))/win;
X_rm(no-win+1:no,1)=sum(sunspot(no-win+1:no,1))/win;

figure
plot(time,sunspot,'m')
hold on
```

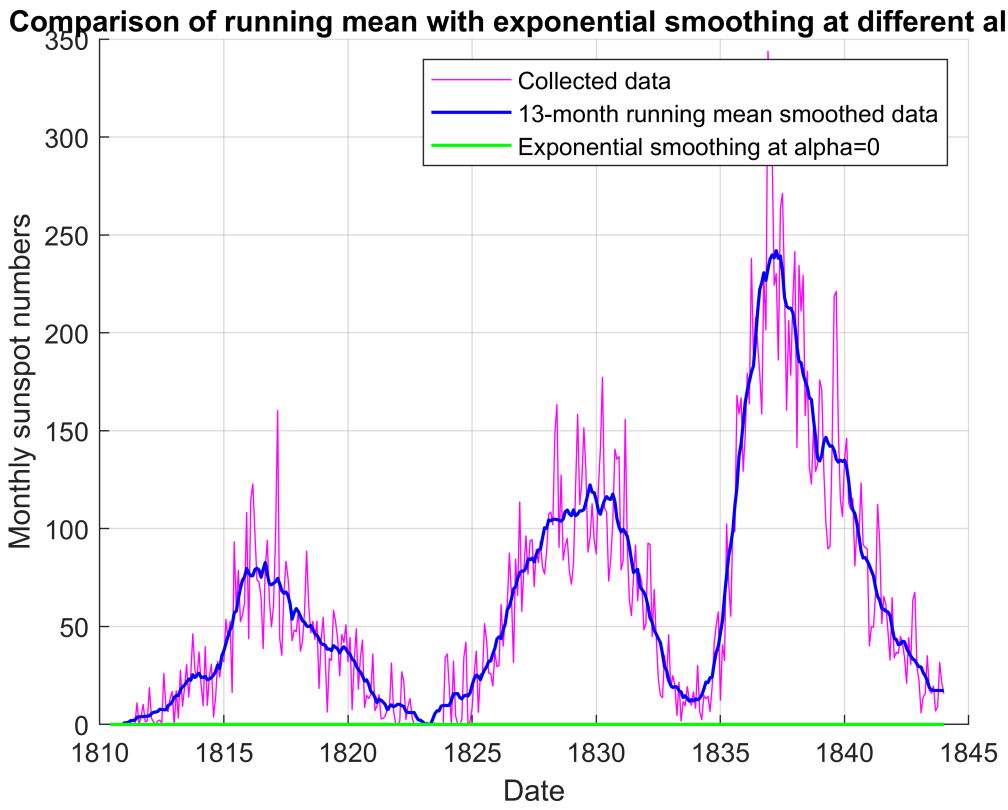
```
plot(time,X_rm,'b','Linewidth',1.2)
legend('Collected data','13-month running mean smoothed data')
title('Fig.1: Monthly sunspot numbers')
ylabel('Monthly sunspot numbers')
xlabel('Date')
grid on
```



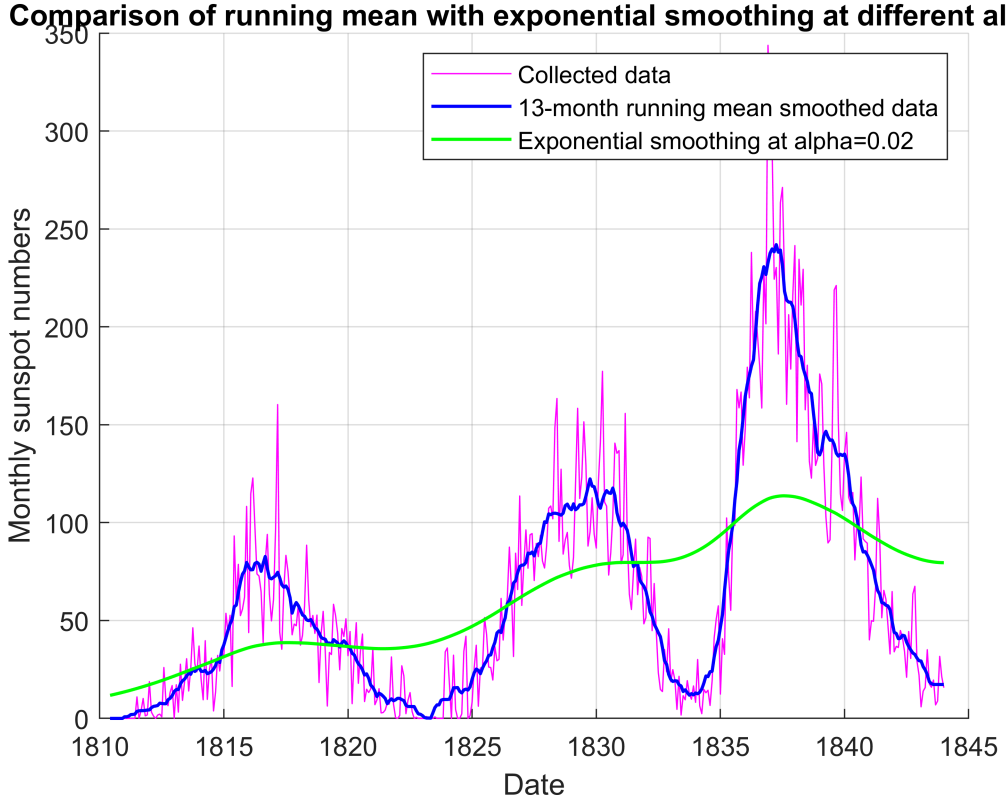
Task 3: Make forward-backward exponential smoothing

```
% All Alpha
for alpha = 0:0.02:0.5
    X_es = sunspot;
    for i = 2:no
        X_es(i) = X_es(i-1)+alpha*(sunspot(i)-X_es(i-1));
    end

    X_br = X_es;
    for i = no-1:-1:1
        X_br(i) = X_br(i+1)+alpha*(X_es(i)-X_br(i+1));
    end


    figure
    subplot()
    hold on
    plot(time,sunspot,'m')
    plot(time,X_rm,'b','Linewidth',1.2)
    plot(time,X_br,'g','Linewidth',1.2)
```

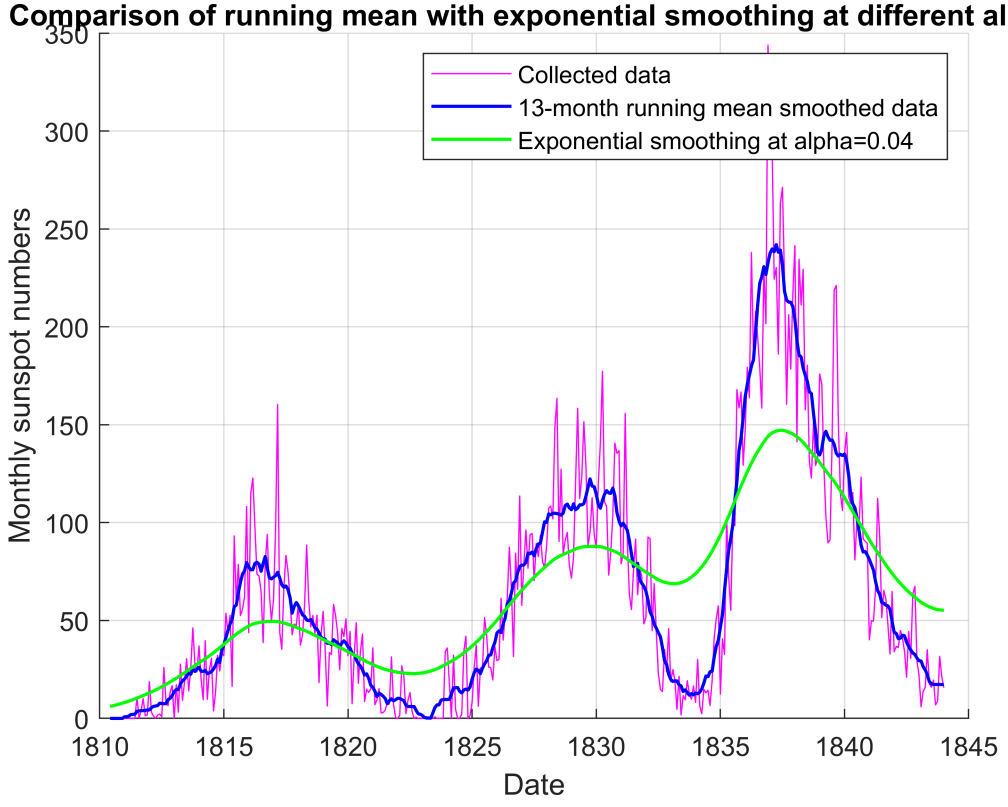
```
    title('Comparison of running mean with exponential smoothing at different alpha')
    legend('Collected data','13-month running mean smoothed data'...
        ,['Exponential smoothing at alpha=',num2str(alpha)]')
    ylabel('Monthly sunspot numbers')
    xlabel('Date')
    hold off
    grid on

    d_es=0;
    for i=1:no
        d_es = d_es + (sunspot(i,1)-X_br(i,1))^2;
    end

    out1 = ['Deviation indicator for Exponential mean at alpha= '...
        ,num2str(alpha),' is ',num2str(d_es)];
    disp(out1)

    v_es=0;
    for i=1:no-2
        v_es = v_es + (X_br(i+2,1)-2*X_br(i+1,1)+X_br(i,1))^2;
    end

    out2 = ['Variability indicator for Exponential mean at alpha= '...
        ,num2str(alpha),' is ',num2str(v_es)];
    disp(out2)
end
```



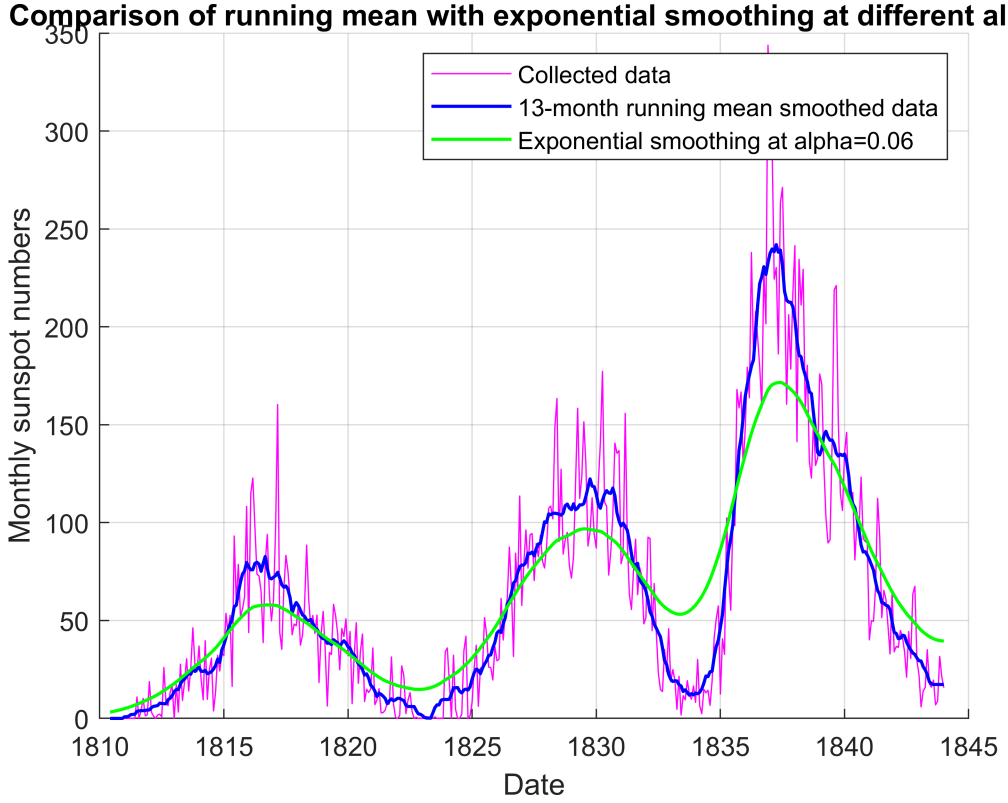

```
Deviation indicator for Exponential mean at alpha= 0 is 3232464.27
Variability indicator for Exponential mean at alpha= 0 is 0
```



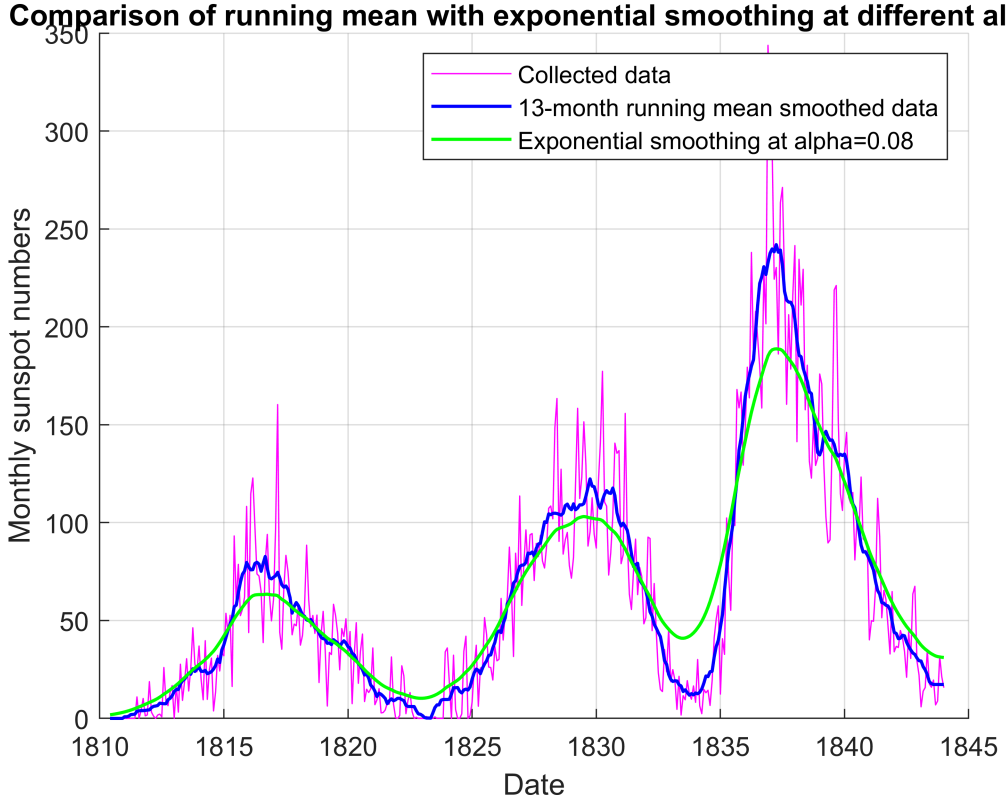

```
Deviation indicator for Exponential mean at alpha= 0.02 is 923495.3407
Variability indicator for Exponential mean at alpha= 0.02 is 0.15315
```



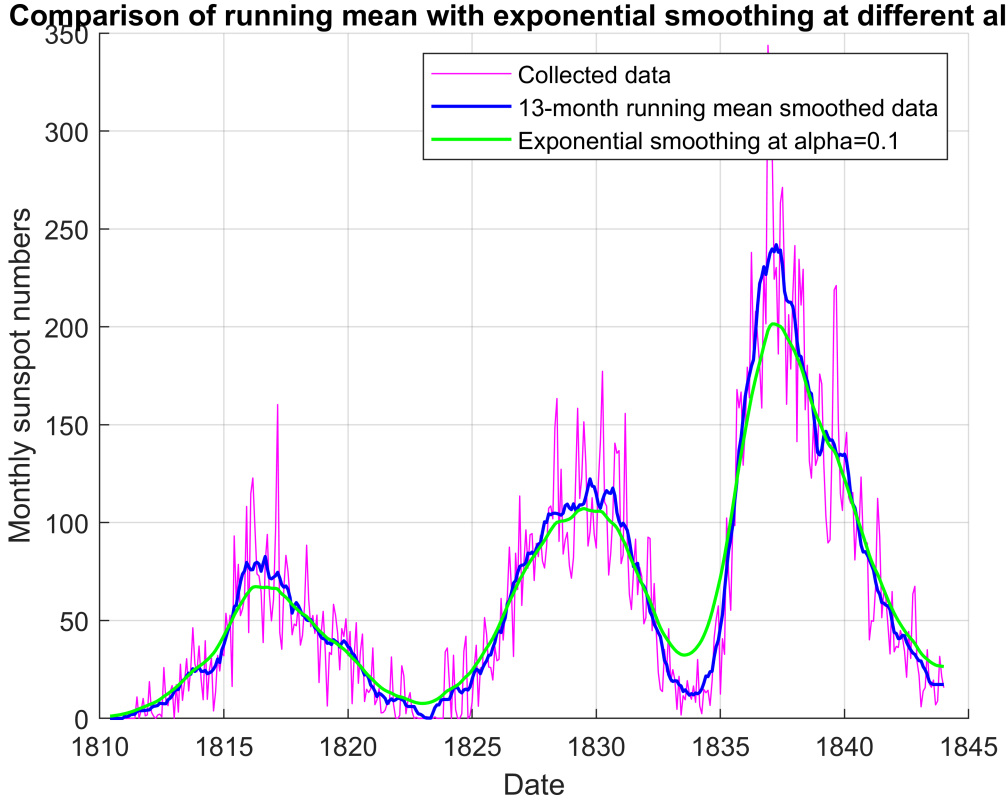

```
Deviation indicator for Exponential mean at alpha= 0.04 is 573911.0381
Variability indicator for Exponential mean at alpha= 0.04 is 1.5898
```



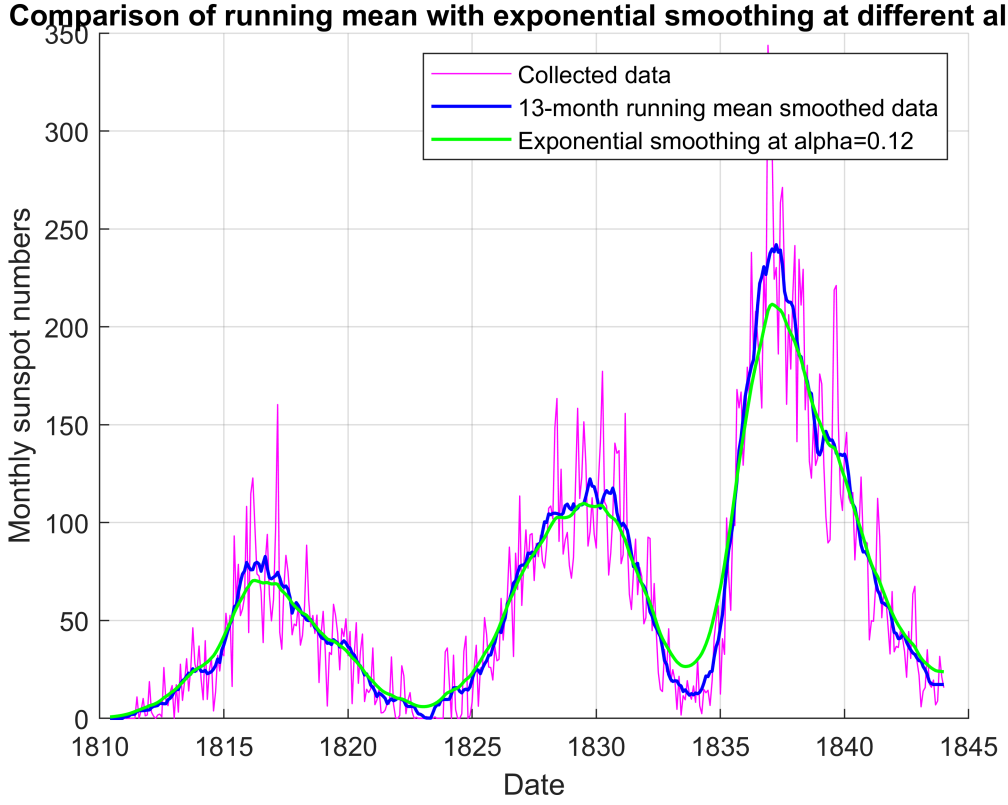

```
Deviation indicator for Exponential mean at alpha= 0.06 is 385302.621
Variability indicator for Exponential mean at alpha= 0.06 is 5.6429
```



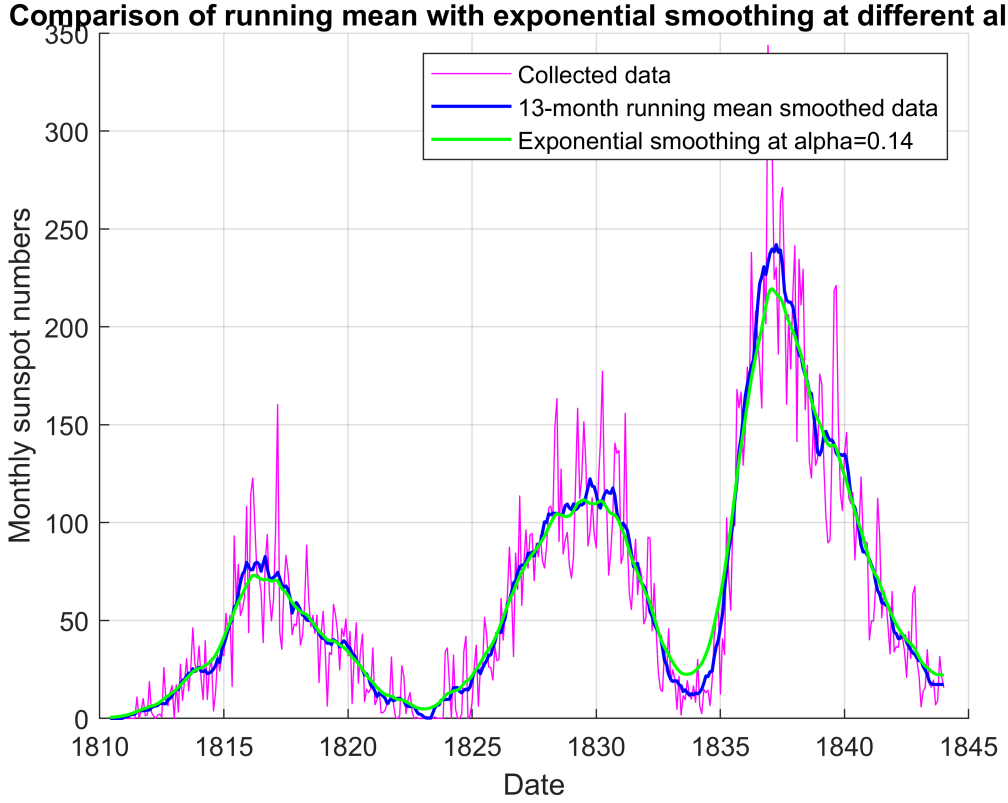

```
Deviation indicator for Exponential mean at alpha= 0.08 is 293101.1462
Variability indicator for Exponential mean at alpha= 0.08 is 14.1724
```



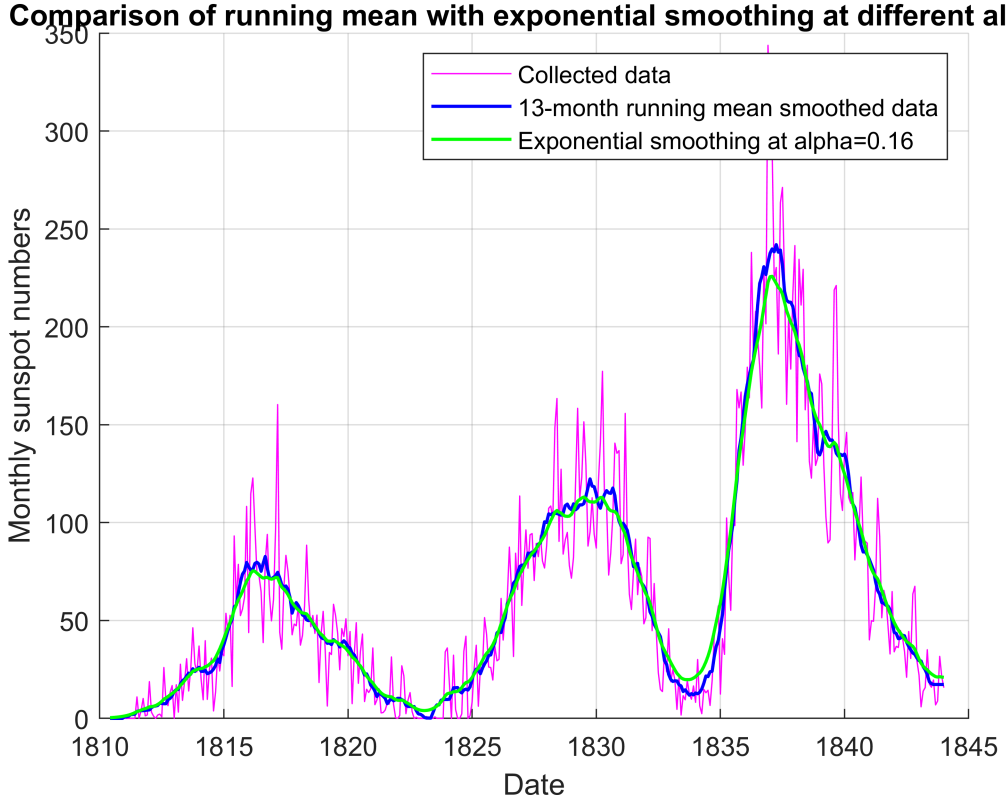

```
Deviation indicator for Exponential mean at alpha= 0.1 is 245410.1153
Variability indicator for Exponential mean at alpha= 0.1 is 30.283
```



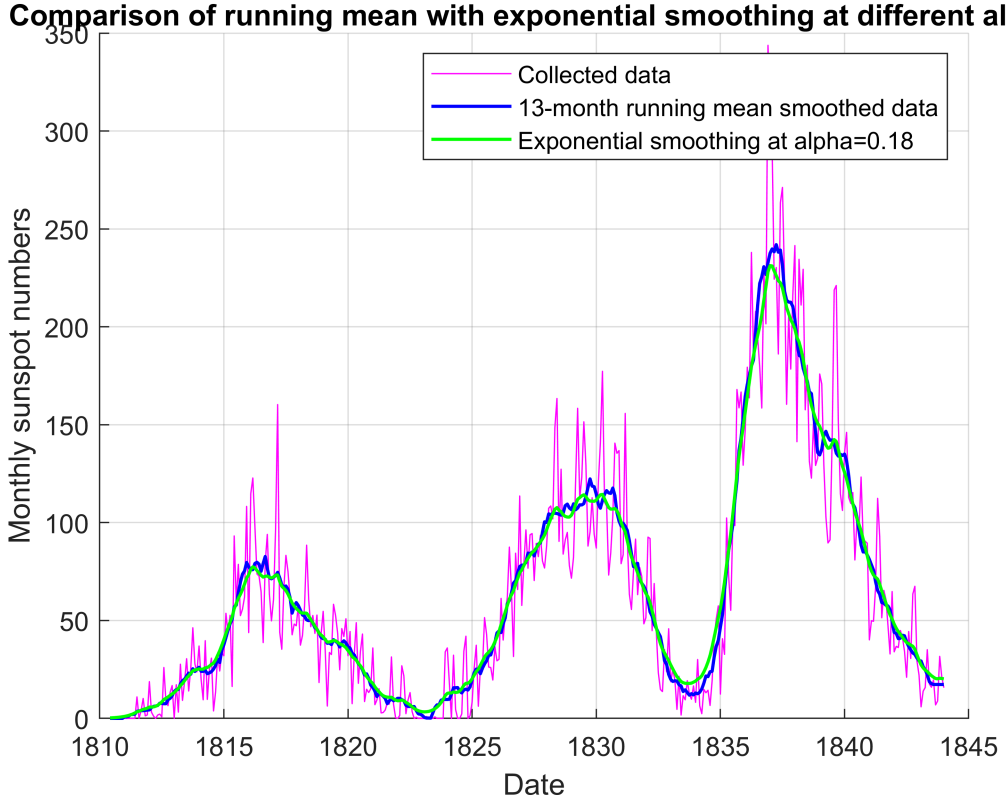

```
Deviation indicator for Exponential mean at alpha= 0.12 is 218245.1318
Variability indicator for Exponential mean at alpha= 0.12 is 58.4215
```



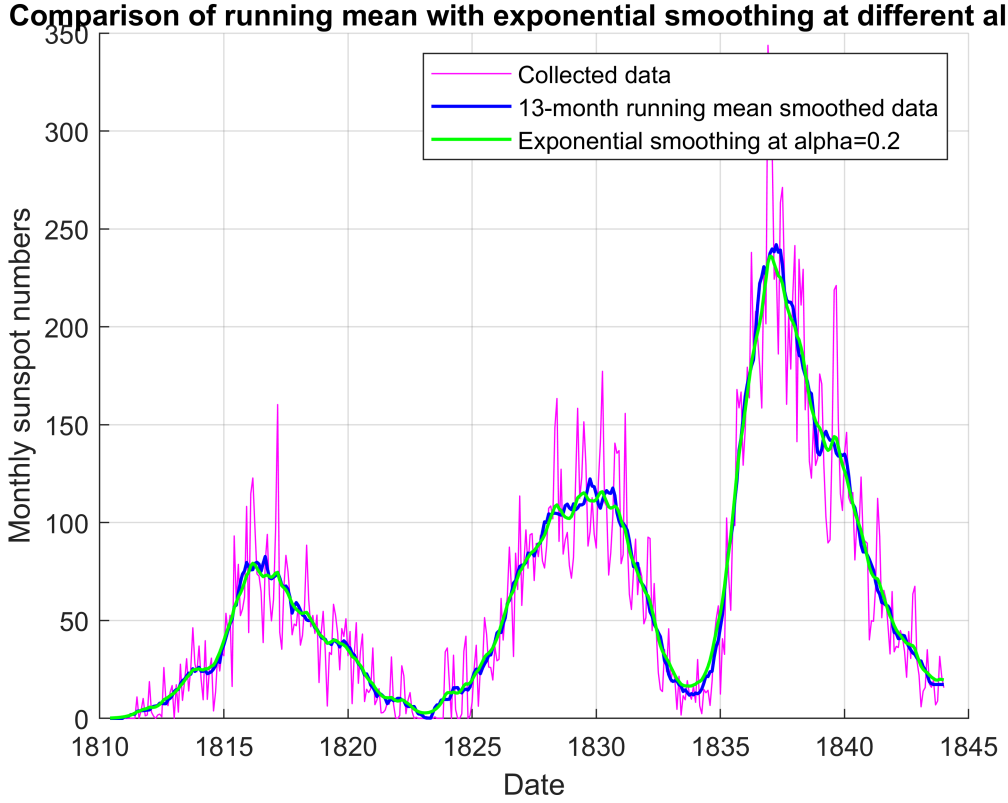

```
Deviation indicator for Exponential mean at alpha= 0.14 is 201069.6227
Variability indicator for Exponential mean at alpha= 0.14 is 104.4174
```



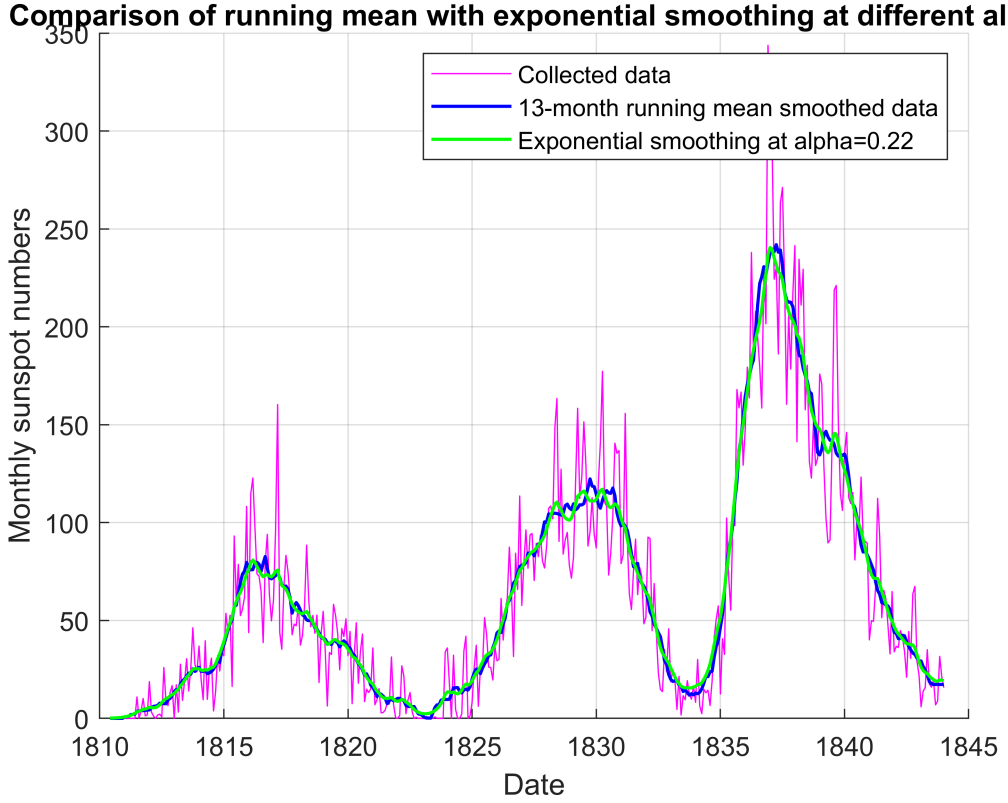

```
Deviation indicator for Exponential mean at alpha= 0.16 is 189036.7807
Variability indicator for Exponential mean at alpha= 0.16 is 175.5511
```



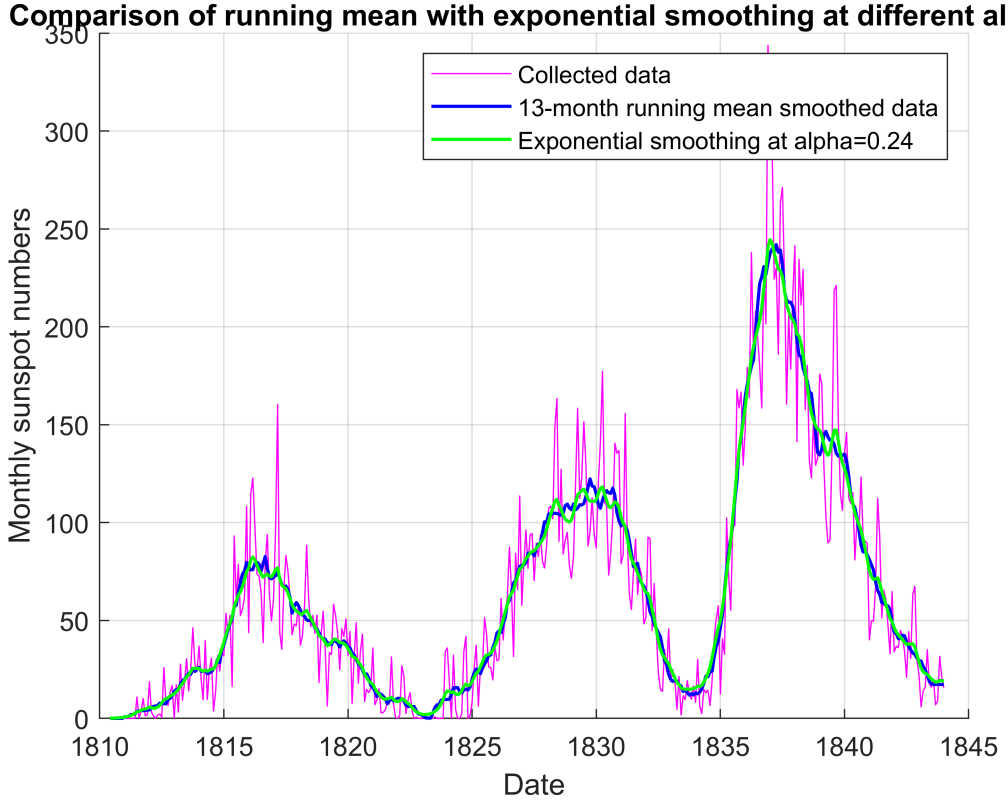

```
Deviation indicator for Exponential mean at alpha= 0.18 is 179777.741
Variability indicator for Exponential mean at alpha= 0.18 is 280.6397
```



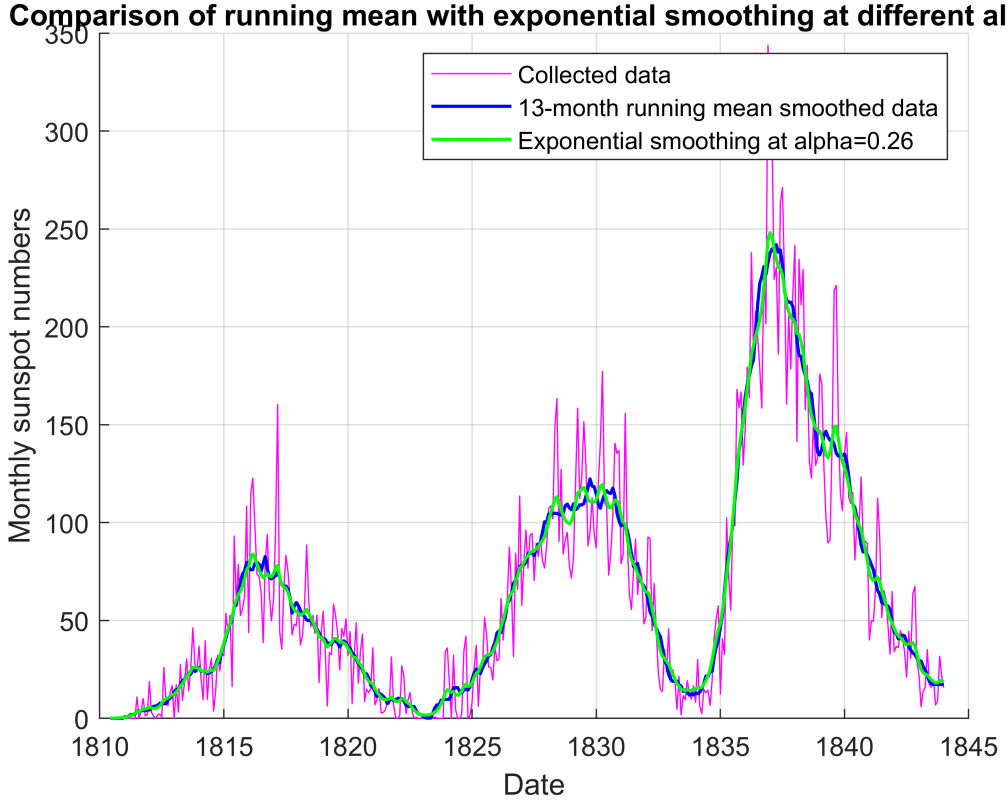

```
Deviation indicator for Exponential mean at alpha= 0.2 is 172069.6468
Variability indicator for Exponential mean at alpha= 0.2 is 430.1345
```



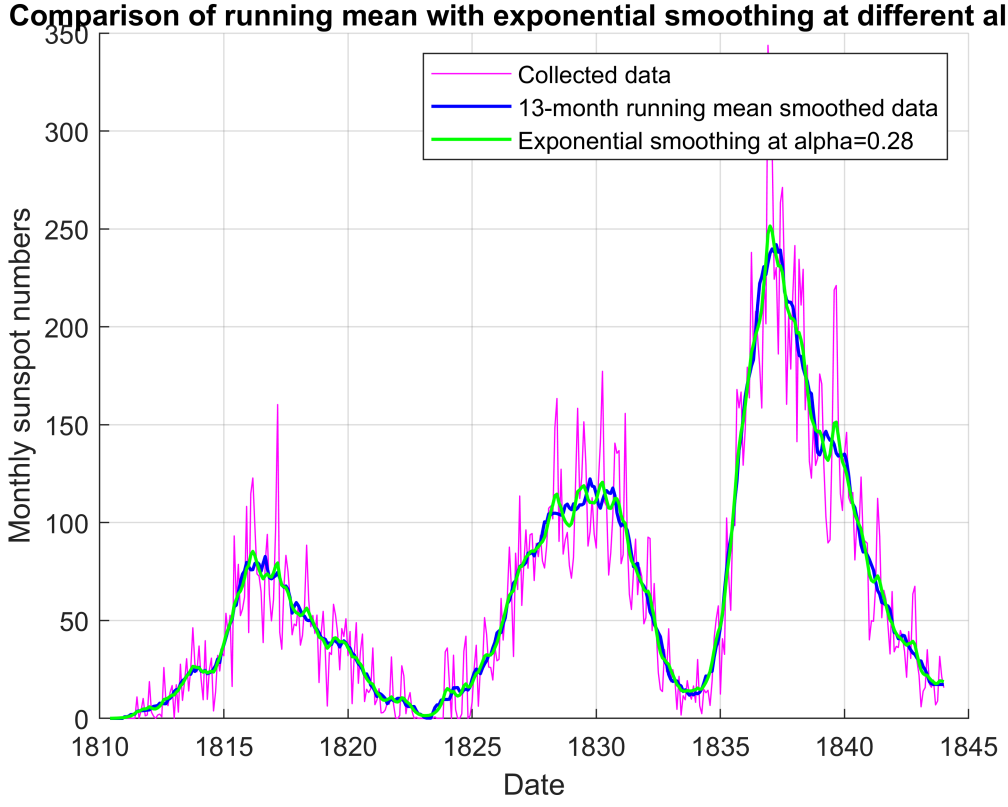

```
Deviation indicator for Exponential mean at alpha= 0.22 is 165252.8079
Variability indicator for Exponential mean at alpha= 0.22 is 636.2328
```



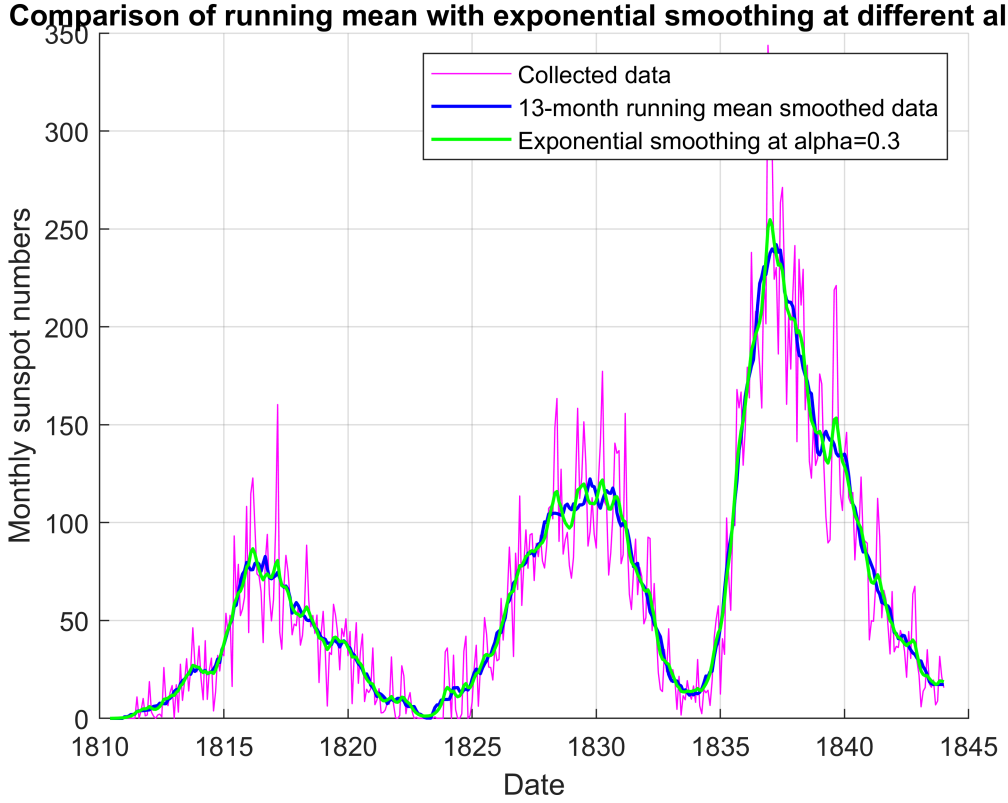

```
Deviation indicator for Exponential mean at alpha= 0.24 is 158959.3669
Variability indicator for Exponential mean at alpha= 0.24 is 913.0049
```



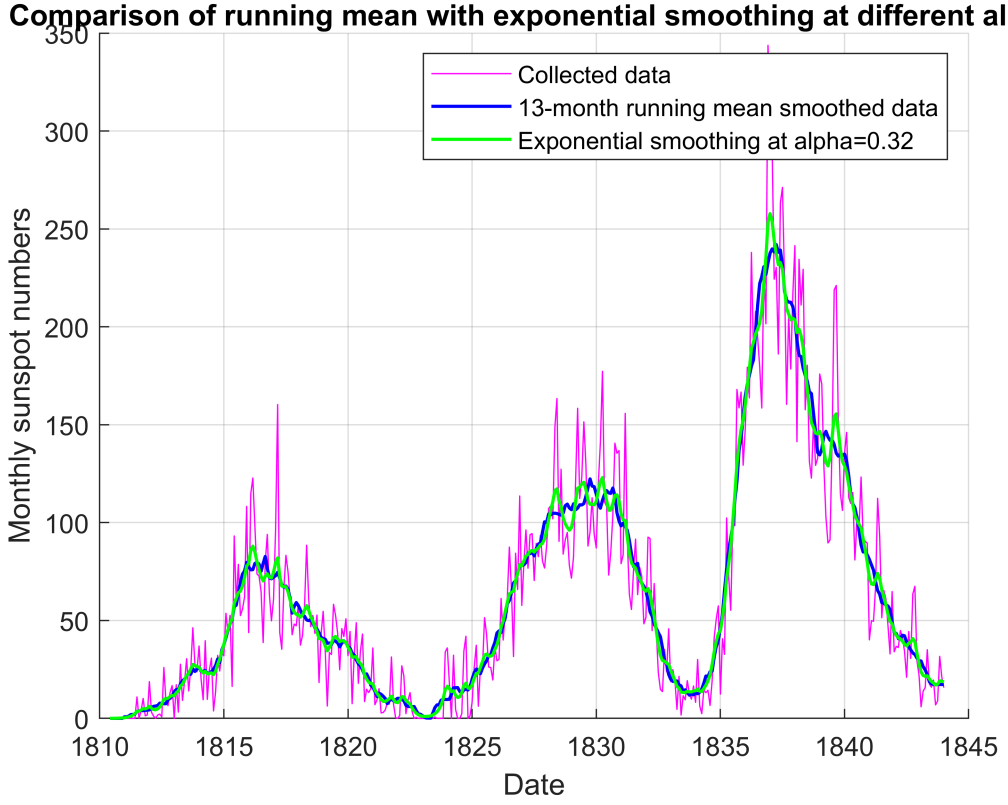

```
Deviation indicator for Exponential mean at alpha= 0.26 is 152979.4506
Variability indicator for Exponential mean at alpha= 0.26 is 1276.5395
```



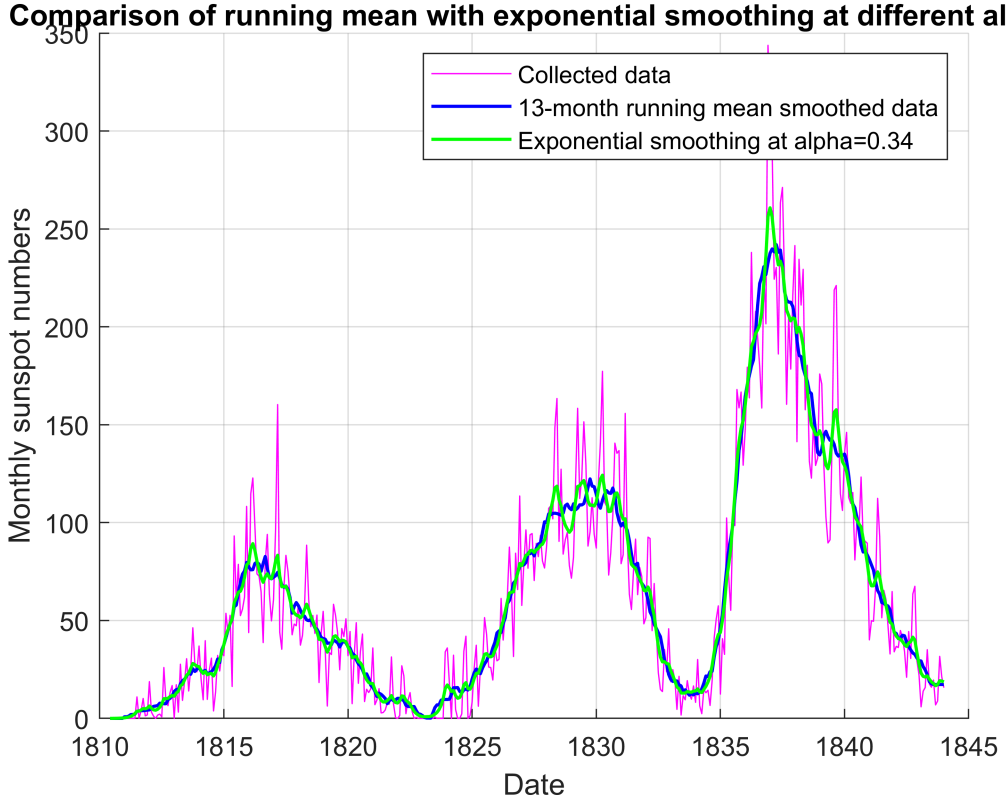

```
Deviation indicator for Exponential mean at alpha= 0.28 is 147191.7403
Variability indicator for Exponential mean at alpha= 0.28 is 1745.1099
```



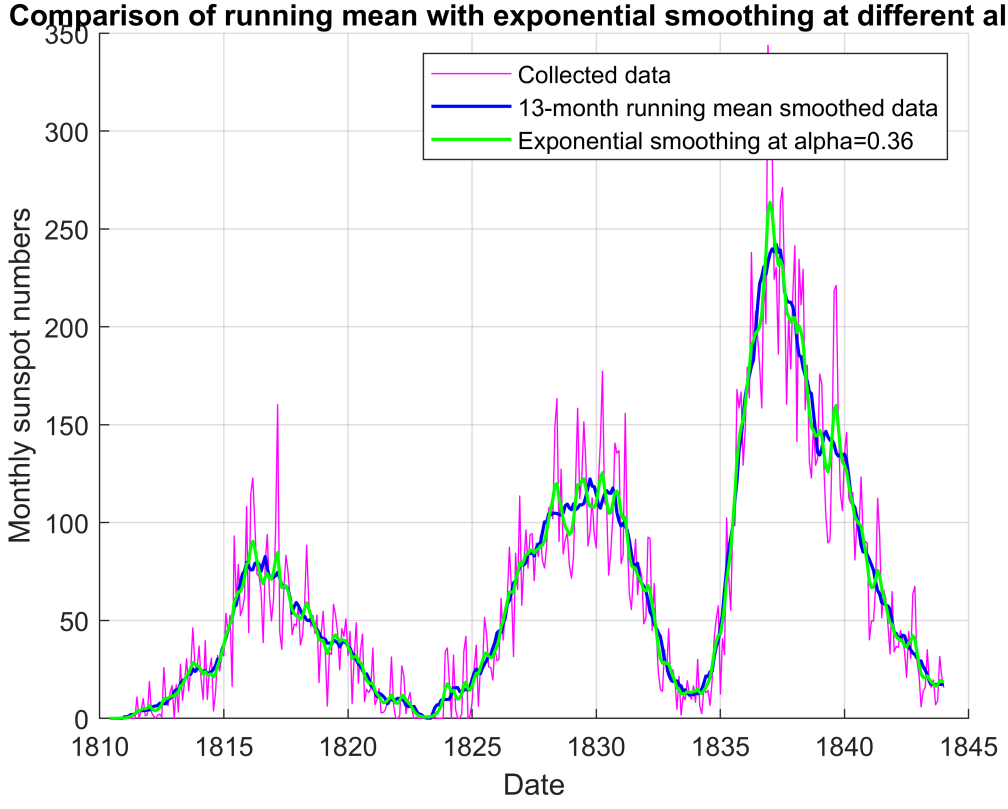

```
Deviation indicator for Exponential mean at alpha= 0.3 is 141525.9185
Variability indicator for Exponential mean at alpha= 0.3 is 2339.362
```



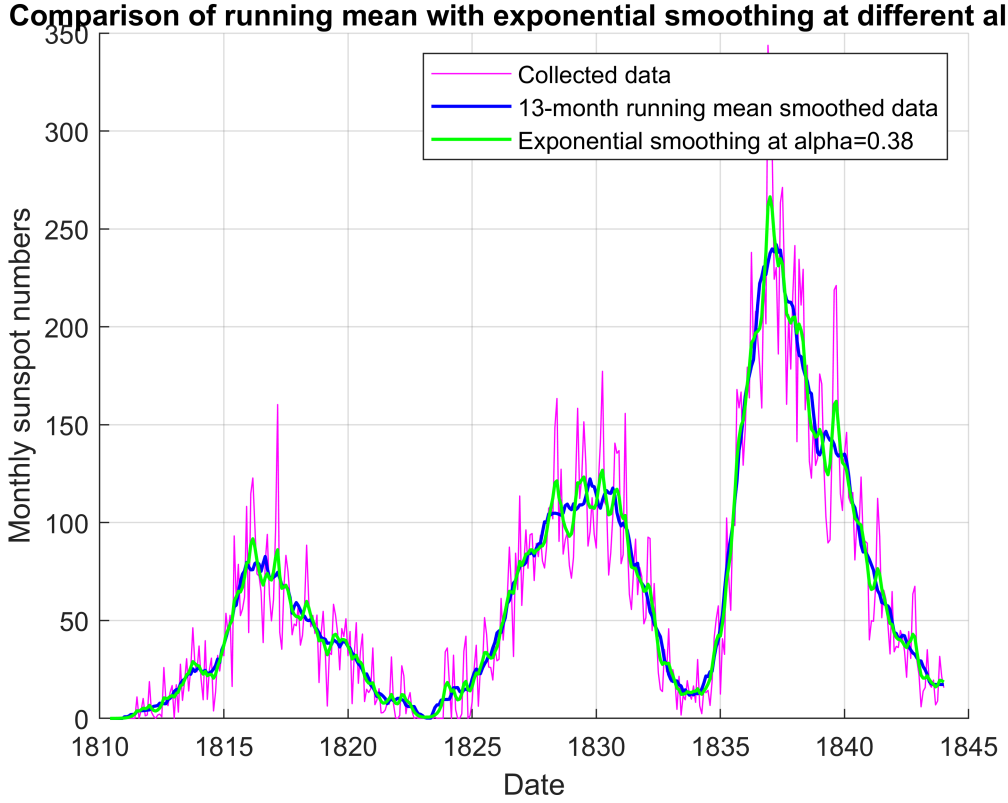

```
Deviation indicator for Exponential mean at alpha= 0.32 is 135941.6596
Variability indicator for Exponential mean at alpha= 0.32 is 3082.5273
```



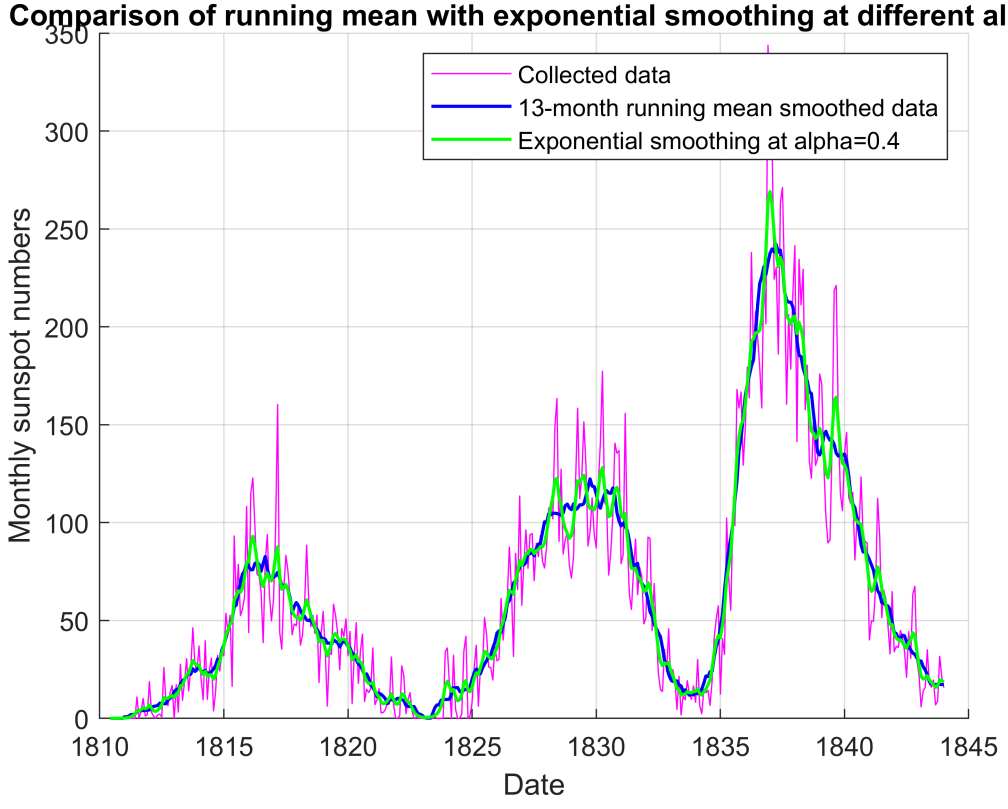

```
Deviation indicator for Exponential mean at alpha= 0.34 is 130416.5531
Variability indicator for Exponential mean at alpha= 0.34 is 4000.6648
```



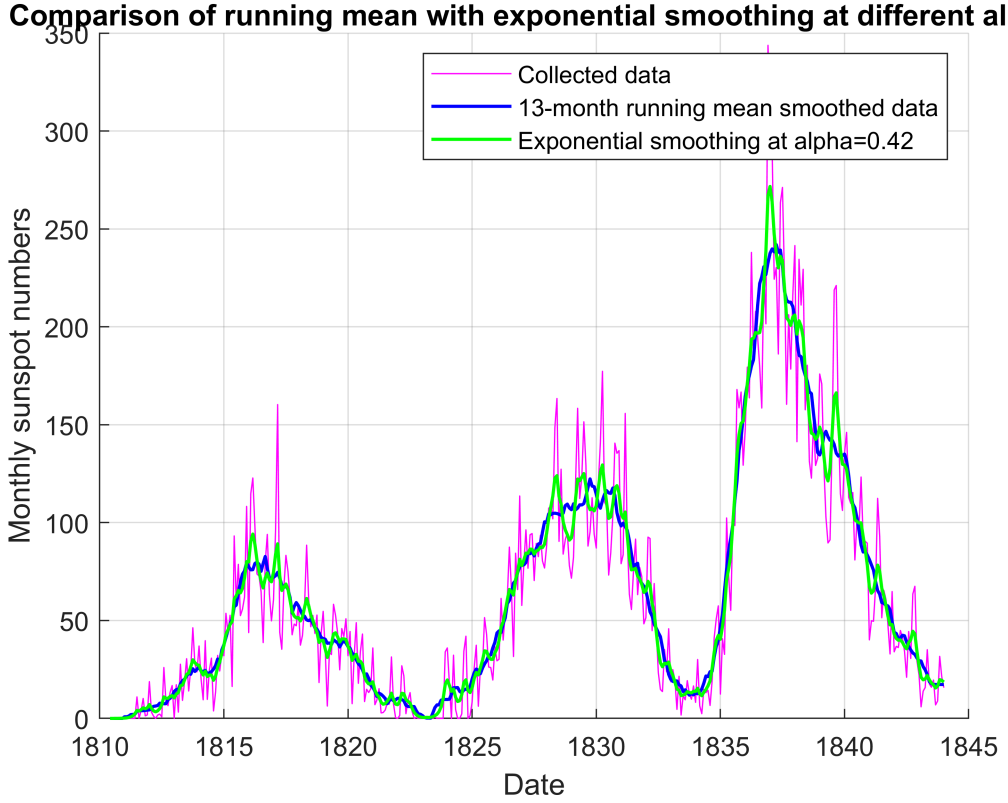

```
Deviation indicator for Exponential mean at alpha= 0.36 is 124939.0135
Variability indicator for Exponential mean at alpha= 0.36 is 5122.9353
```



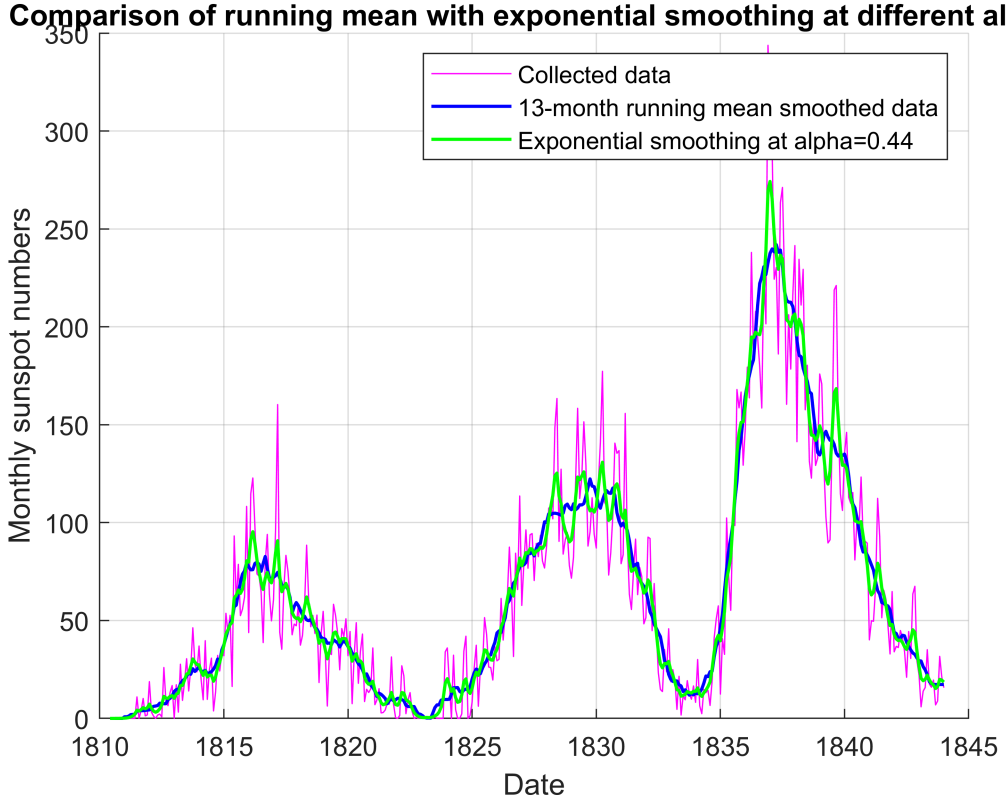

```
Deviation indicator for Exponential mean at alpha= 0.38 is 119504.0422
Variability indicator for Exponential mean at alpha= 0.38 is 6481.9136
```



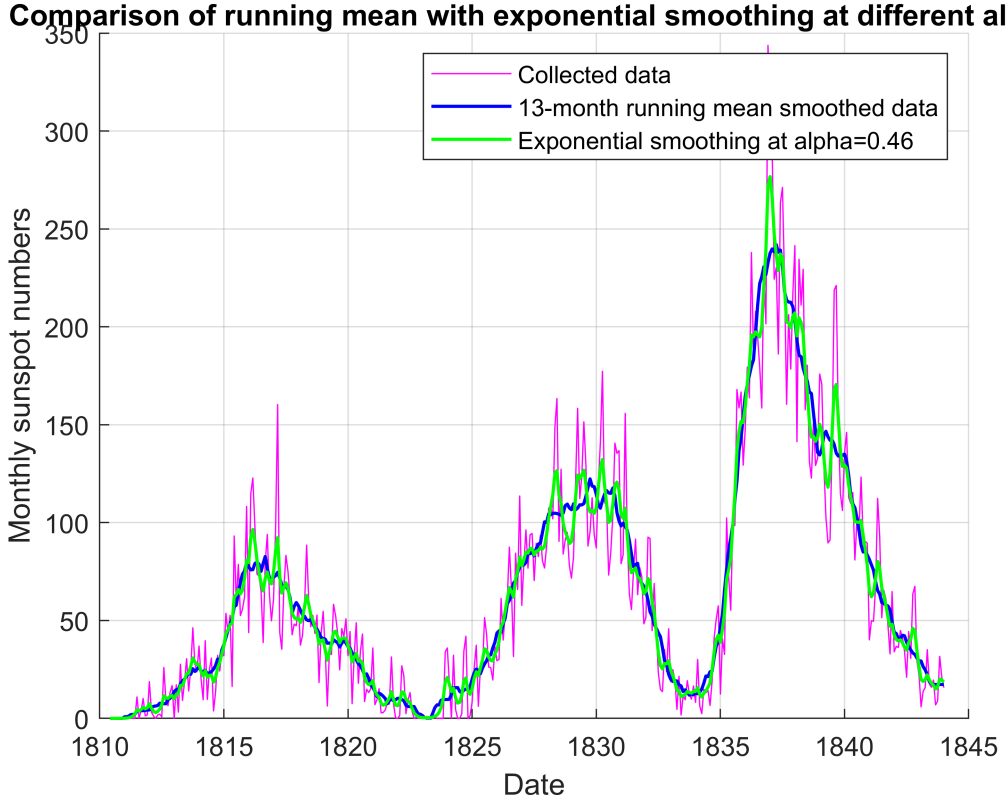

```
Deviation indicator for Exponential mean at alpha= 0.4 is 114110.6595
Variability indicator for Exponential mean at alpha= 0.4 is 8113.9451
```



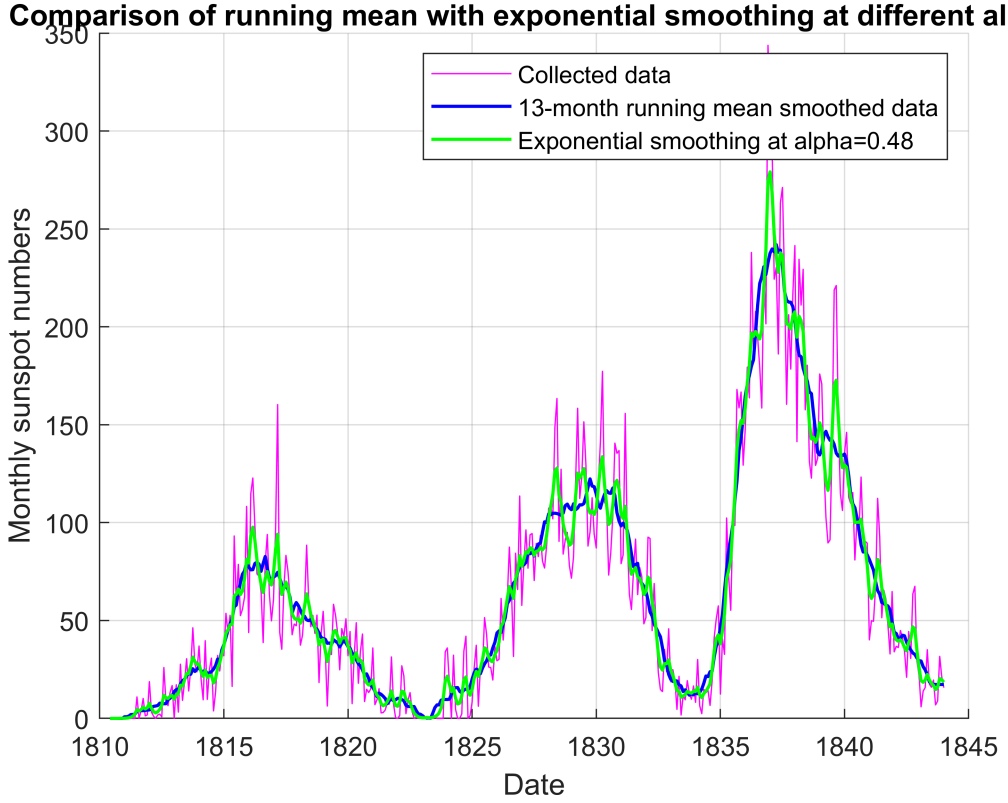

```
Deviation indicator for Exponential mean at alpha= 0.42 is 108760.3281
Variability indicator for Exponential mean at alpha= 0.42 is 10059.5542
```



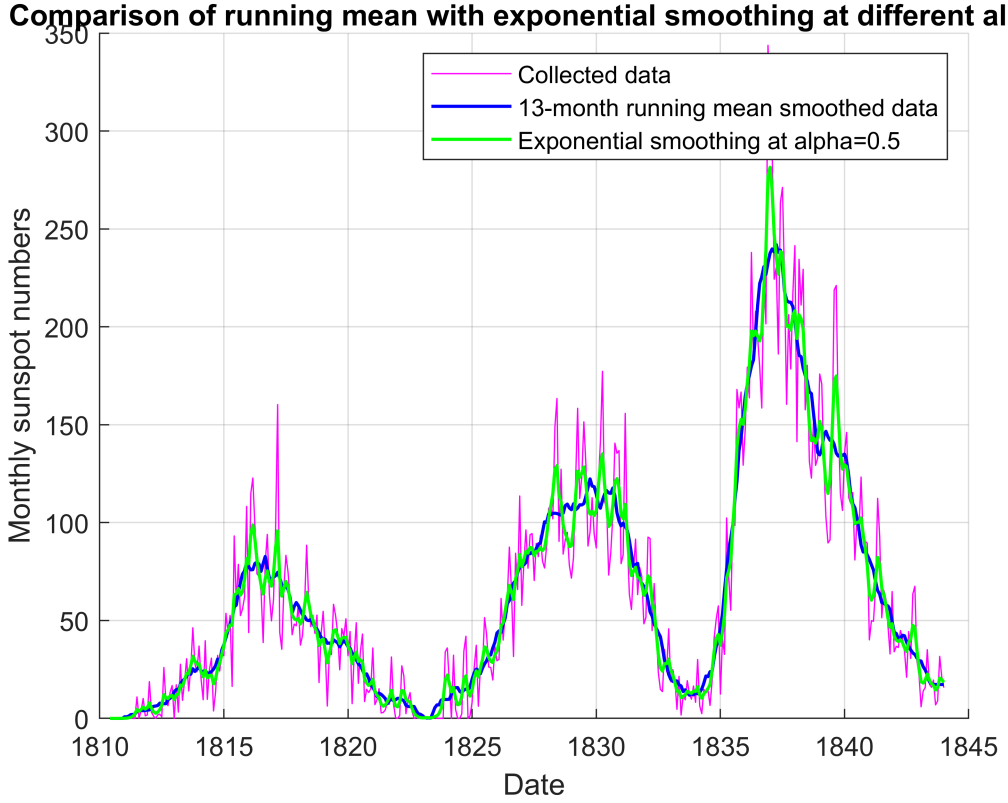

```
Deviation indicator for Exponential mean at alpha= 0.44 is 103455.9752
Variability indicator for Exponential mean at alpha= 0.44 is 12363.9121
```




```
Deviation indicator for Exponential mean at alpha= 0.46 is 98201.3825
Variability indicator for Exponential mean at alpha= 0.46 is 15077.3741
```




```
Deviation indicator for Exponential mean at alpha= 0.48 is 93000.8054
Variability indicator for Exponential mean at alpha= 0.48 is 18256.097
```




```
Deviation indicator for Exponential mean at alpha= 0.5 is 87858.739
Variability indicator for Exponential mean at alpha= 0.5 is 21962.7473
```

Great result for alpha = 0.18

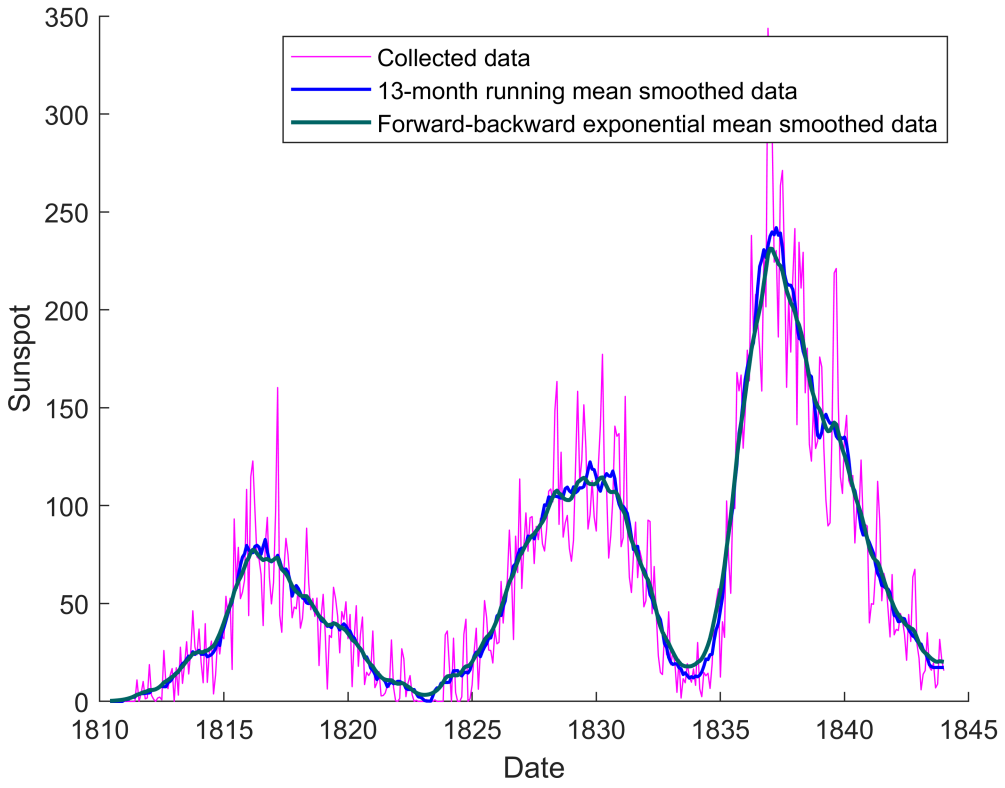
```
alpha = 0.18;

X_fr = sunspot;
for i = 2:no
    X_fr(i) = X_fr(i-1)+alpha*(sunspot(i)-X_fr(i-1));
end

X_br = X_fr;
for i = no-1:-1:1
    X_br(i) = X_br(i+1)+alpha*(X_fr(i)-X_br(i+1));
end

 d_es=0;
    for i=1:no
        d_es = d_es + (sunspot(i,1)-X_br(i,1))^2;
    end

    out1 = ['Deviation indicator for Exponential mean at alpha= '...
        ,num2str(alpha),' is ',num2str(d_es)];
    disp(out1)
```

```
Deviation indicator for Exponential mean at alpha= 0.18 is 179777.741
```

```
    v_es=0;
    for i=1:no-2
        v_es = v_es + (X_br(i+2,1)-2*X_br(i+1,1)+X_br(i,1))^2;
    end

    out2 = ['Variability indicator for Exponential mean at alpha= '...
        ,num2str(alpha),' is ',num2str(v_es)];
    disp(out2)
```

```
Variability indicator for Exponential mean at alpha= 0.18 is 280.6397
```

```
figure
hold on
plot(time,sunspot,'m')
plot(time,X_rm,'b','Linewidth',1.2)
plot(time, X_br,'Color',[0,0.4,0.4],'Linewidth',1.5)
legend('Collected data','13-month running mean smoothed data'...
    ,'Forward-backward exponential mean smoothed data')
ylabel('Sunspot')
xlabel('Date')
```



Conclusions:

- The 13-month running mean smoothing is plotted but as observed from it we can see a noisy response of the smoothened curve. To conpensate this noise we impliment the forward-backward exponential smoothing.

- For the forward-backward exponential smoothing, smoothing constant has been empically determined,comparing the plot for all the values of smoothing coefficent from 0 to 0.5 (after 0.5 the curve started to diverge). The best value for the smoothing coefficent observed was at 0.18.
- This smoothing coefficent reduced the noise and a more precise and smoothen trajectory is achieved. The deviation and variability coefficents are thus calculated for this smoothing coefficent.